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THE INFLUENCE OF THE RAILWAY INFRASTRUCTURE IN A COUNTRY'S ECONOMY

The case of Colombia, train railway Montelibano-Cartagena

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"Family is the shackle of society, to have an united family and taught at the service of the neighbour, is the first social labour, to get better society".

Julio Martín Mosquera.

"If you have an apple and I have an apple and we exchange these apples then you and I will still each have one apple. But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas."

George Bernard Shaw.

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To God for giving me far more than you could ever imagine or guess or request in your wildest dreams.

To my family who even being away in this long time without see them, made me feel like if I were never had left home.

To my father, whose words acts like unbelievable force that make me keep on feet in the most painful moments. Him, who acts like a "life sheriff" and taught me that the best gun is the head and the best bullets are the ideas.

To my mom who taught me that dreams are the way of the life and this infinite love to carry them out.

To my brother, my sister and Samy for giving to me a piece of them, to complete myself.

Abstract.

Colombia together Angola is between the countries with less capability to share wealth. For Latin American Countries Colombia is overcame just by Haiti. The Gini`s Index allocates Colombia in range 0.55-0.60, where 0 imply the higher capacity to share wealth and 1 the worst capability to do it.

Within Colombia's 32 counties there are: Cordoba, Sucre and Bolivar all three are together in the North. Them three also hold the most unbearable levels of poverty, together a small group of persons fulfilled of opulence. Oddly Cordoba`s nickel output cover 4% of the world market share which also represents 0.5% of the Colombian GDP. Sucre produces one of the highest volumes of cement and lime in the country, and Bolivar has the most efficient port of Colombia together an oil and gas refinery plant.

This thesis explain how can exist large levels of poverty when there is a large scales of resources and wealth. Likewise a rail line is proposed, looking for diversifying the transport logistics for people and freight. Therefore, to achieve a rise on the standard of life of the habitants of Cordoba, Sucre and Bolivar. This thesis also wield on how could be activate the economy on this 3 counties if a rail line turnkey project is build from Montelibano to Cartagena. The main objective is to show the effects of rail line in a country`s economy- The case of Colombia.

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NOMENCLATURE

(APP or PPP) Association "public-private" or Public private projects

(EAPI) Efficient allocation of public investment

(GDP) Gross domestic Product

(IRR) Internal rate of return

LCF Leveraged cash flow

(OECD) Organisation for Economic Co-operation and Development.

(O&M) operation and maintenance

(OA) Open Access

(USP) Unsolicited proposal

(NPV) Net Present value

(UCF) Unleveraged cash flow

UPME) Unidad de planeacion Minero Energetica / Energy Mining and planning Unit

1. Introduction.

If continents (or subcontinents) like Africa and South America respectively are owners of biggest reserves of most used natural resources, why do other countries like United States or Europe countries get higher levels of development?.

The reasons are several, the opinion and guess are thousand. To understand one of the main reasons about why the economy in those countries has been developed in a wrong way is the objective of this thesis. (Based on the idea of public expenditure, and transport infrastructure to be precise).

Historians usually claim that through the age the countries acquire the capability to understand better how to develop themselves. They consider that due to many experiences based on mistakes and success facts, older countries tend to have better economies. However, Israel, Egypt and Ethiopia are among the oldest countries (between 2500 and 3500 BC), but they are not necessarily good examples of good economies. 2

Furthermore some articles posit that to be a poor or rich country is a consequence[1] coming from weather. That thesis exert a narrow group of countries and regions not enough to prove this dissertation. As examples, they bring the centre of Colombia (the most flourishing region) and the North Caribbean coast (one of the poorer), the North of Spain against the South or the North of Italy against the South. For sure, it is a wrong notion, since it is not an issue regarding to the weather, actually is a topic related to proper public investment and good public expenditures based on new technologies. (Acemoglu & Robninson 2012)

Likewise there are those who consider that to have a country with weak or strong economy is an affair linked to geographical position, thus, to be in the South or North matters, and they assure that being on the South is meaning to be poorer. They seems to be right, for instance lets compare, the city of Nogales which is divided in two by a wire fence into North and South Nogales.

If you stand by the fence and look toward North, you see Nogales (Arizona), which belongs to Santa Cruz County. The average income of a household is about 30,000 USD a year. Statistics reveals that most teens attend to high school and most adults have high school. The life at the South of the fence, just a few meters away, is quite different. Indeed, the

[1] Why cold wheather are richer thant warm ones and theory of Equatorial paradox. ttp://forbes.es/business/5469/por-que-los-paises-frios-son-mas-ricos-que-los-paises-calidos/

inhabitants of Nogales (Sonora) live in a relatively prosperous part of Mexico, but the income average of any householder is about one third of that they have in Nogales (Arizona). Most adults in Nogales (Sonora) do not hold a high school diploma and many teens do not attend to high school (Acemoglu & Robninson 2012). But for sure this notion is also wrong, to have a proper economy do not depend on a fence.

Actually prosperity on countries depend on the capacity and the willingness of his county to have to get inside to new technologies, capacity to invest capital in society, capability to acquire pertinent production and capital assets followed by social inclusion, ethics and honesty.

Investing on infrastructure (facility) and institutions (people as human resource) supported on new technologies, is one of the pillars to push up the economy ahead (if technology is adequate) since a better performance of technology to support products and services often brings more willingness to pay from the consumer, and also generate more efficiency in operation; it lets to achieve economies of scale and lowering operation costs, and increasing the generated valued, thus, benefit could be reinvested on society economy in order to run a virtuous circle.

Particularly this thesis is based on the idea that public expenditure (Gd) (Y = Cd + Id + Gd + X) (Dornbusch, Fischer & Startz n.d.) must be done in assets like the transport infrastructure which must be conformed by (1) Trains (railways), (2) car/trucks (streets and motorways), (3) airplane (airports), and (4) Ships (water). It is difficult to assert indisputable that one transport and its infrastructure is better than the other one, since, geographical conditions must be considered for each country and region, but what can be said is; **transport basically must be multimodal, without any marked domination of one system over the other. They must interconnected into a network which trough out nodes lets merchandise to arrive to any point of the country.**

The Argentina`s case embodies inconsistent conditions. Train transport cost half than lorry one, but the last one dominates the 90% of the transport (EL Clarin 2011), this is one of the paradoxes on the undeveloped economies. They often get afraid to incur in higher investment in order to avoid big debts, but neglect these projects imply a higher returns and society welfare on the future.

Colombian case is quite worrier, for 2015 the public expenditure on transport infrastructure was close to 82% in motorways meanwhile for railway it did not arrive to 2% (Colombian Transport in Numbers 2015).

From the strategic point of view, it implies a high degree of dependency of oil and gas, as energy font for transport merchandise and passenger, thus, transport demand elasticity is low. Hence, Colombian transport economy gets highly impacted due to instability of the oil and gas prices on global market.

Also it must be added: the bargaining power that is on hand of truck drivers is too much high. In 2016 a truck driver strike generated loss flow close to 30M$ in less than 45 days in Meta county (More than 30M USD in loss flow El Tiempo 2016), which is not even the most important county on the national economy.

2. State of Art

2.1 What happened in the countries around the world when train was used as an instrument for develops economies.

The information disclosed in the following paragraphs was mostly extracted from the book *"Why countries fail?"* which is an investigation of about 15 year in which (Acemoglu & Robninson 2012), evidenced that the main protagonist to develop economy of countries is technology and transport connection, between which train is the most important in the transport infrastructure. Their investigation also proves that railway has been the best catalyst of many economies through the time.

England: In England, there were several waves of innovation in this field. First channels, later roads and finally, the railway. In each of these waves, innovators were new and young men and this is a proof that investing in knowledge guarantee returns on development. Channels began to be developed in England after 1770, and by 1810 they had linked many of the most important manufacturing areas. Each time the industrial revolution was going ahead, the transport infrastructure got more important since it reduced the end costumer product price of new products like: cotton and necessary goods for manufacturing, such as coal. All of them were transported basically in the new machines fostered by steam, principally the train. (Acemoglu & Robninson 2012).

USA: The end of the American civil war began a rapid spurt of economic growth in the North. As rail, industry and commerce expanded, a small number of people, amassed a great fortune.

Sierra Leone: Although the railroad to the South was originally designed by the British to rule Sierra Leone, in 1967 its role was totally economic. It transported most of the country's exports: coffee, cocoa and diamonds. The farmers who grew coffee and cocoa were Mendes, and the railroad was the window to the world of Mendelandia.

2.2 What happened in the countries around when the railway was NOT implemented

Hungary: Governments actively blocked all the attempt of infrastructure technologies and infrastructure based investments such as railways than having acted as catalysts on the economy. (Acemoglu & Robninson 2012)

Austria: Opposition to the industry and rail steam-powered, was due to Francisco's concern for the creative destruction, which could be followed by the development of a modern economy. His priorities were to ensure the stability of the extractive institutions, and to protect the advantages of the traditional elites who supported it. Industrialization would undermine the feudal order by attracting labour from the countryside to the cities, but also Francisco recognized the threat posed by the great economic changes to his political power. Consequently he blocked industry and economic progress, setting the economic backwardness.

Russia: An opposition to the railroad, was followed by the opposition to industry, exactly as in Austria-Hungary, before 1842, there was only one railway in Russia; named Tsarskoe Selo, and ran from St. Petersburg to the imperial residences of *Tsarskoe Selo* and *Pavlovsk. Georg* Kankrin (Russian aristocratic) was opposed to the industry, and according to him there was not any reason to encourage the railroad. He argued that this could entail to a dangerous social mobility and emphasized "railroads are not always the result of a natural necessity, but rather an object of artificial necessity.

Mexico: The world economy was going very well in the second half of the nineteenth century. Innovations in transport such as the steamboat and the railroad led to an enormous expansion of international trade. That wave of globalization means that rich countries like Mexico (in that moment), had been able to export raw materials and natural resources to North America or Western Europe which was in the process of industrialization, but it did not happen, Mexico did not invest in new technologies and transport infrastructure (Acemoglu & Robninson 2012), now a days is stopped on time, and United States that was just onto process to get developed in that moment, is right now an economic refuge for big piece of Mexican society, which cannot even find a quality life on their own country .

Guatemala: The result of the domination of this elite was that Guatemala got trapped in a time tunnel in the midd-nineteenth century while the rest of the world changed rapidly. However, these changes would ultimately affect Guatemala. Transport costs were reduced

due to technological innovations such as steam train, railway and new types of ships much faster.

Peru: While Spain, although with some delay, adopted the technologies of steam energy, railways, electricity, mechanization and factory production, Peru did not, or at best, did so in a very slow and imperfect way. This technology gap continues today and is reproduced on a larger scale as new technologies; particularly those related to information technology; drive greater growth in many developed and some fast developing countries.

South Africa: Masire was an enterprising farmer in the fifties; he developed new farming techniques for sorghum and found a potential customer at Vryburg Milling, a company located across the border with South Africa. He went to the head of Lobatse railway station in Bechuanaland and tried to rent two wagons to transfer his crop to Vryburg. The stationmaster refused. Then he got a white friend to intervene. The stationmaster reluctantly agreed, but gave Masire a budget four times the rate he had for whites. Masire surrendered and came to this conclusion: "It was the practice of whites, not just the laws that forbade Africans to own land in their own right or to have trade licenses, which meant that blacks did not develop businesses in Bechuanaland '. Wrong practices on the country infrastructure is another way to keep underdevelopment

As first conclusion through the history states that does not mater the geographical position and the kind of society. When trains and new technologies are considered, it is possible to generate an industry mobility, it is the opportunity to take the durable goods and good of consumption to all point of a country at really low prices, generating higher benefits for the good's producer, higher willingness to pay for consumers and higher social welfare; even those portion of society away from the manufacturing focal point.

Likewise train is a means to move ahead, together and all regions of a country, and avoid precarious situations such as Latin America where there are areas poorer than the poorest of Africa, and richer as richest from developed countries

A second conclusion state, that those societies which avoided the public investment supported on new technologies and efficient transport like railways and train, has been fated to passive economies based on low life quality and depressed economies on comparison those ones that really decided to use the public expenditure to develop transport infrastructure like train.

3. General terms and conditions of Colombian transport infrastructure.

As it has been asserted before, train is the transport infrastructure, which has added more value to the most developed countries. It is hardly possible now days to talk about countries, which reached a high life quality without train participation. Chiefly United Stated the most prosperous economy in the world[2] and it was fostered thanks to Vanderbilt and Rockefeller participation on train. Although Rockefeller at the end changed his strategy of "merchandise mobilization" to pipelines; nevertheless his partition in trains was enough to propel the economy in those moments.

For sure, in Colombia it is an essential factor, but has been managed in a wrong way, then, the second best option has been to ignore it.
In following chapter is analysed the framework of the history and the problems looking always to demonstrate that Colombia is requiring an investment to push the economy up, for sure this investment has to be done in a profitable socio-economic project, able to generate value in order to sustain itself and generate a welfare on the society, this project is the "**glorious train"**.

3.1 Framework history and current statistic data of Colombian railway

Following paragraphs shows an analysed the history and financial and economical sceneries of how trains is the public investment, which will generate a growth on the Colombian Economy.

The first idea about to build a rail line in Colombia was prompted by Simon Bolivar, whose main idea was basically to link Pacific and Caribbean oceans through a railway. By law, 20 years after Simon Bolivar dies, in 1850 was ordered to build the first rail infrastructure on the country, the project was erected in the next 10 years.

In the second half of the XIX century, Colombia got a pronounced preference for railways instead of other means of transport structure. Since 1870, it was started the project executing of railways to cover those tracks which links big cities with fluvial ports, for first time it was thought that a multimodal and linked transport infrastructure was the best strategy to foster trading and achieve an efficient and low cost transport. Similar to the rest of Latin America the rails infrastructure was done with foreign founds.

[2] The DGP of united stated now a days is around 18,624 billions USD, around 52,787 USD per caipat https://tradingeconomics.com/united-states/gdp

The railway network was expanded quickly; at the end of the century it turned from 236km in year 1885 to 875 km in year 1910, and finally evolve to 2,700 km in year 1930. The national motorways for that days were close to 3,170 Km, thus, transport infrastructure railways fill up the 45% of land transport infrastructure, a proportional distribution of the cake, in which was mobilized the main raw products like dry coffee, coal, ore iron and other grains.

In 1961 it was started up the Atlantic Railway, furthermore it was finally achieved to integrate the all the isolated lines built on the last century, those ones built to link the most important cities and fluvial ports. Lastly in this particular moment, the railway from the South port in Buenaventura, to the North in Santa Marta, achieved 3.431 km.

In 1972, just after 10 years of operation activities started the decadency, first the Cauca's river overflow destroyed the rail lines which linked Medellin, Pacific and Caribbean zone. Until that moment and without to achieve the higher operation performance point, the train used to transport 12% of the entire national freight which in those days was close to 3 million tons.

In 1975, the crisis increased, this time technical, financing and administrative problems plus a poor management strategy[3], steers the company to the bankruptcy.

At the end the rail line transported just 852.000 tons from that 3M tons (it used to do in best times), it means just 4% of the national freight. (Colombian Phisic Infrastructure n.d.).

Exhibits 1 Shows the current conditions of railway in Colombia after more than 30 years of inactivity, it reveals that through the years some rail line, which were inactive but useful become into inactive and useless, since the lack of maintenance make the structure loses the capability to be used.

Exhibit 1. Actual State Of Rail Lines in Numbers

YEAR	Actives Rail lines (Km)			Concessioned rail lines (inactive)		Inactive rail line (nation)	TOTAL RAIL LINE INFRASTRUCTURE
	National	Private	TOTAL	Pacific	Atlantic		
2009	1.488	184	1.672	118	ND	ND	1.790
2010	1.039	184	1.223	118	ND	ND	1.341
2011	1.010	184	1.194	118	ND	ND	1.312
2012	756	184	940	118	ND	ND	1.058
2013	610	184	794	118	ND	1.787	2.699
2014	824	184	1008	118	674	1.729	3.529

Source: (Colombian Transport in Numbers 2015)

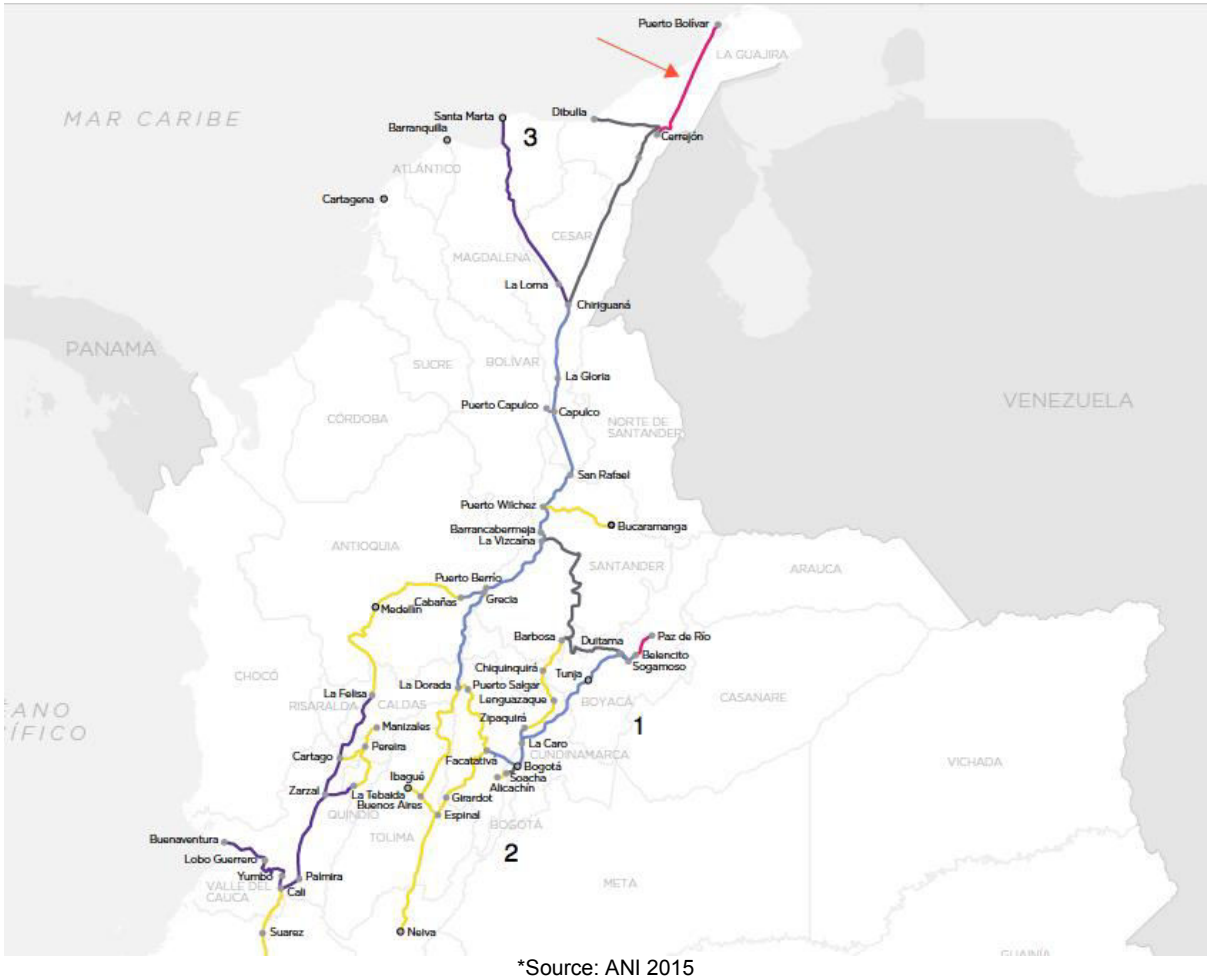
[3] For instance high payload service toward workers and conventional laws, driven the company to get higher cost than benefits

3.2 Most relevant events and significant data of Colombian railway

After some years Colombian government decided to recover the train, but it was a limited attempt. The new strategy was the privatization: two concessions were created. (1) "Atlántico" and (2) "Tren de Occidente". The first one was given to Fenoco, a group in which there was Spanish and Indian investment. This rail line goes through strategic places. (1)Starting on the centre of the country in Boyacá, (2) arriving to capital country city, Bogota, going into the north, close to the Magdalena river and (3) finishing on Santa Marta Port in the North of the country. This line has 1.493 Km.

Since this national line goes close to coal mine Drummond, this company enjoy from a zero opportunity cost, different from Cerrejón which had to built its own rail line. This fact make this national rail line more attractive and more rentable since it imply a saving cost for this company (Drummond).

Exhibit 2. Map of Colombian Railroad infrastructure



*Source: ANI 2015

Despite of the advantage which this line gives to coal companies and taking into account scenarios in which coal prices has been raised in like in 2006, Fenoco concluded that the line was not profitable, and decided to selling its share to government.

Finally the government gave the concession to Drummond, a company which their main activity is coal exploitation and exploration. (Colombian Phisic Infrastructure n.d.)

In the other hand there is "Tren de Occidente" (Pacific rail Line), this line was adjudged since 1998. It goes from Felisa in Quindio County to Cali and finally in Buenaventura Port. Unfortunately financing problems had decreased the opportunity to make growing it up, even when the line was mainly restructured, the poor investment over other aspects such as (1) telecommunication machines, (2) technology and (3) terminals, make the train hold stopped more time than the operative one. (Colombian Phisic Infrastructure n.d.)

Lastly, must be emphasised that there is another private line, made by coal mine company, set at the North of the country and totally independent from the National Rail ways system. This line takes coal from Cerrejón in Guajira county, until Puerto Bolivar, is around 150 KM and has a particularity, it was built under the technology of standard train gauge, it means can't be integrated to the national rails which are built under narrow design measures. (Indicated in exhibit 2 by the red arrow on the top)

Detriment on the railway transport infrastructure have been created and fostered mainly by the central government, which through years has been more interested on invest over motorways in an unbalanced way as will be shown in next chapters, and forgetting to invest in other infrastructures[4] which in long run generate higher contribution from the economic point of view.
Although central government has undertook some initiatives to go ahead with Trains Recovering Plan, the efforts have not been sufficient, and the Colombian train is right now a destroyed opportunity.

According to Carlos Rodriguez, Engineer from El Rosario University Colombia is one of the most lagged countries on train technology and infrastructure, getting the place 109/144.
The train technology is based on the narrow gauge, it generate on operations:
-Low stability
-Low capacity

[4] For instance, some references indicate that due to lack of maintenance over some rail lines in the Pacific railway that were in a good state, has lost their availability.

-High maintenance cost

For instance, in case of looking for new wagons, Colombia must to ask them in a special requirement, since the technology is old and just few companies produce this kind of trains. (Rodriguez Rosas 2013)

Regarding to the state of rail roads, now a day just 1.000 Km from 3.000 Km are operatives and 431 are not any more recoverable, this a (1) proof of deficiency, and the (2) reason why, when some companies (different from coal companies) see an opportunity to use train to transport their manufactured output, unfortunately in in the short run, they have to move back to lorry system. The inefficiency and the incapability of the train infrastructure always drive to a deficit, it means, what look like a cost reduction ends in a cost increasing, and decreasing scheduled payoff.

Between companies that get higher profit from rail transport, are those ones related to coal. A total of ~67 M tons of freight a year are transported in train, from which 66M tons are coal and the other 1M ton is related to other resources within which cement is the most representative.

Here appear the first alarms, which can generate misunderstandings. Despite of railways` low performance indicator in service operations, the train in Colombia is the second most important transport infrastructure, mobilizing around 26% of the total national freight.

Under a plain statistic analysis, seems reasonable to assert that: 26% (near to one fourth) of total national freight is transported on railroad infrastructure, is not a low number and many can boasting about it. But what is not say is that:

1. Mobilized freight is measured in tons, not in value mobilized. Lets talk in numbers. A tonne of Colombian coffee is value on the market around 3500 USD. Meanwhile a ton of coal in a good moment could arrive to 100 USD. In addition obtaining coal imply a less complex process than to obtain a coffee, therefore it is obtained in higher quantities.

2. This 26% of national train freight is conformed from 24% of coal plus another 2% conformed mainly by cement.

3. The rail line used to transport coal is not longer than 370 KM (around: 150 Cerrejón to Puerto Bolivar plus 230 Drummond) and it is set in a corner of the national territory in which

cannot be enjoyed by several manufacturers and it is short distance compared with the 900 km which must run the coffee from Manizales to Cartagena.
In a nutshell, those facts above show how Colombian transport infrastructure is propelled just by the geological randomness. The big quantities of coal and cement tons transported in train, is not a fact coming from the strategic investment in transport.

Then, to get an explanation in numbers; If a country transports 1 ton of coffee in truck and 1 ton of coal in train can be said that 50% of freight is transported in train. Then this country decides to increase the production of coal to 2 tons. It could be assert that 66% of the national freight is transported in train. It means, an increasing of 16 perceptual points in the transport infrastructure without do any invest any transport.

That's how works Colombian statistics on train infrastructure, is a big number but it is not a result of diversification of public expenditure, is just causality and randomness which give the luck/opportunity to have high volumes of natural resources. In other words, the poor infrastructure of Colombian rail line is covered and tapped by the high volumes (i.e coal). Thus, Colombia has trains because have coal, as soon the coal is not anymore a business the train statistics will disappear.

Based on it, assert that 26% of national freight is supported on train could be true just from the statics point of view but not from economic one, in which the society must be the most benefited it is just a eagerness.

3.3 Most relevant events and meaningful data of Colombian motorways

Colombian motorways infrastructure shortfall, *this infrastructure depend on, motorways, trucks and oil and gas. Why is it a risk for the national economy?*

According to the Private Council of Competitiveness 2013's report, the bad state of the road infrastructure causes delays in the delivery times to the ports generating surcharges.

The poor and defective state of motorway infrastructure affects freight transport, reducing, at the same time, the country logistics efficiency. This condition becomes severe and critical if is taking into account the "Free Trade Agreements", forced with Panama, the European Union, those ones which are about to enter into like United Kingdom, among others.

If there is not logistic, there is not trade, contrary to it, a good logistic carry a stable economy and the possibility to link and attach easily new companies to national or international markets. From feasibility point of view, and based on Bertrand principle, if two companies has the same product quality, that one which is able to establish lower prices will be also table o get higher market share. In here is not happening anything different than this, lets take a view: Colombian manufactured products acquire higher prices in the market, than other country's products, because, operation cost (like product mobilization) is higher than competitors countries (like Brazil in coffee and nickel), this is counter producer and get under difficulty the level of competence of Colombian products on international markets. Thus, at end the most affected is the national economy.

In addition, mining and oil and agriculture, among others, are sectors that require efficient mobility in the transportation of cargo, since they are the most traded resources/products. Around 80% of companies move freight by motorways to ports and border areas. **Due to the poor road conditions in which trucks have to travel, the carriers pay 35% over counts**, according to Clarita Maria Garcia Rúa, Executive Director of Defencarga, who also said that the representative problems are in the rotation, that is to say, if the company makes 11 monthly trips, these will ensure company profitability, but today they have been reduced to 6 trips per month. This fact makes the country get lagging behind in logistics comparisons. A clear example is the Logistics Performance Index (IDL), in which Colombia ranked 94th out of 160 countries in 2016, and the last position among the eleven reference countries to optimize logistics in the region. In the 2013 report of the Private Competitiveness Council, factors such, as "poor logistics performances are not only a reflection of infrastructure failures, but also of the lack of an efficient freight transport sector." (El Pais News Paper 2013)

For Pedro Águilar, president of the Colombian Association of Truck Drivers, "it is incredible to know that today in the country the costs are increased by road condition. A vehicle can be worn 14% more just for stopping and starting, and fuel consumption can increase by 16%. " According to Álvaro Sanín, president of the Association of Freight Conveyors (ATC), the most infamous road points are the mountain roads in the coffee hub in (1) Antioquia, (2) Caldas, (3) Quindío and in the (4) departments of Santander and (5) Norte de Santander, the route Cúcuta -Bucaramanga. The problem is also in the time of travel that has increased in recent years in routes such as Cali-Buenaventura (by almost 80%) or Bucaramanga to Cucuta (50%). (El Pais News Paper 2013)

According to Garcia Rúa, the bad condition of the motorways infrastructure causes delays in the delivery times to the ports, at the same time this situation affects the fulfilment of "delivering on time" with the clients abroad, reason why, we would clearly be behind in the FTA with the different countries.

For instance, lets see a fast mathematic example regarding to costs due to lack of transport infrastructure. Most trucks work for the mining industry or oil and gas industry.
As reference an oil company such as Pacific Rubiales (now Pacific exploration and production) mobilizes between 300 and 320 trucks from its main field of production, Campo Rubiales, to the ports of the North Coast. On average, each of these trucks carry between 200 and 227 barrels of crude, which cannot be transported by national pipelines according to oil company data, the value of the cargo per barrel amounts to US$ 27, a cost that is quite broad compared to the US $ 7 that it costs to mobilize hydrocarbons by pipeline. (El Pais News Paper 2013).

Later will be demonstrated rail line is 4 time more cost efficient than truck, by now lets make a math exercise considering this assumptions. It imply, if this this barrels were transported by trains the scenarios would be as follow:

Scenario 1: Tansport by truck:
27 USD /barrel * 227 barrels /truck = 6,129 USD/truck
6129 USD/truck * 300 trucks = 1.838.700 USD

Scenario 2: If the barrels were transported by train:
In a roughly estimation could be used the same cost, 1.838.700 USD, and be divided by 4 (since train is four time more cost efficient) it means 459.675 USD.

As it was said earlier, the poor infrastructure based just in motor ways (which are also inefficient) generate the leak of competitiveness, creating an increase in products cost mobilization, and allowing to competitors countries, to arrive to end consumer in best conditions of quality, readiness, time and price. This fact makes part of the big package of reasons, why Colombia needs to invest in infrastructure with technology. It is known trains is a high cash aggressive public expenditure, but numbers show it is be sustainable, since the Colombian manufacturers are ready on station waiting for the train.

Another bottleneck, which slows mining production, is the transportation of ore from the centre of the country to the Northern ports. According to the Minister of Mines and Energy.

The freight to transport coal in trucks from the interior of the country to the North Coast is about US $ 60 per ton, while the cost of production per ton is US $ 50," said the head of the mining portfolio. It means, to transport the coal is more expensive than produce it, just an increasing of international coal price, plus a decreasing of international oil price can become financial feasible, the exportation of coal coming from the country's centre. Actually, this example shows the level of Colombia dependency coming from commodities, and how the country's economy depends from external and not controllable variables.

A report estimates that each truck can load 35 tons of ore, meaning that only one of these vehicles per year would transport 1,820 tons in a single year. To get it profitable, the goal (more /less) is to export 20 million tons of ore per year; it would require a fleet of more than 10,000 trucks. Will not be better to built a rail line system for transport that mining, giving also the opportunity for passenger transport?. Thus, built it for transport mining ore, would give the opportunity to obtain passenger train to get the rails superstructure at zero cost. It implies to avoid an opportunity cost that normally cost the half of the project. From the social point of view it means best transport infrastructure and lest externalities due to $C0_2$.

3.4 An economy highly dependant on motorway infrastructure

Within the most important Colombia roads is "La Linea" motorway, which connects the Colombian capital with most part of the country, several times has been closed or restricted because of the landslides and floods caused by rains.
The president of the National Association of Freight Forwarders (ASECARGA), Jairo Herrera, said that more than US $ 10 million/daily, estimated losses caused by the closure of "La Línea" where approximately 60% of the Colombian cargo flows transit.

In fact, according to estimates of the National Association of Entrepreneurs of Colombia, ANDI, **the poor road network increases the cost of Colombian products by <u>10 to 15%</u>. And, according to the British magazine, The Economist, that asserts, the cost of transporting a cargo container in Colombia is <u>US $ 1,770, for US $ 1,480</u> in Argentina.**

(Later in the document are shown another prices of Colombia container transport, must be remarked that the prices are different because they are coming from different fonts. However the prices are pretty close, thus, if several fonts conclude around the same value it means, the price got an approached estimation approach)

3.5 Case study 1. Coffee from Manizales (manufacturing point) TO Cartagena (port point)

Coffee that goes from Manizales to Cartagena takes a time equivalent to having travelled at 14 kilometres per hour that route.

Just 20% of the insured freight can only be transported in daylight hours, due to the motorways are already filled up, then another infrastructure is needed to complement the existing one, is needed rail lines which just not enlarge transport infrastructure, also gives more space in the motorways network. But the solution to this problem must be also the opportunity to: (1) reduce externalities: for contamination and loosing of time due to high volume of traffic and (2) increase in aspects like technology and employment.

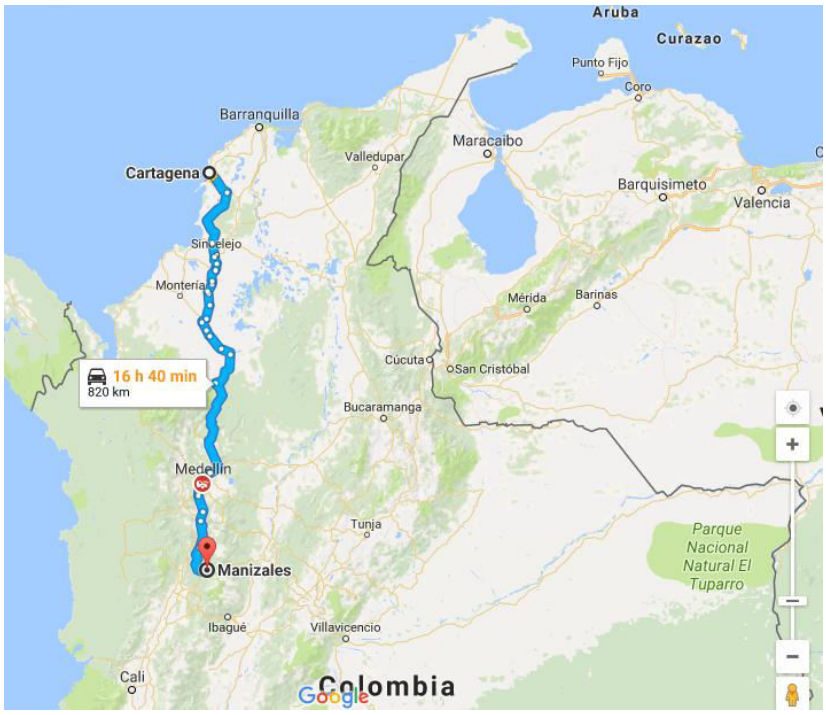
A truck in an efficient fleet, of a good company, runs between 7,000 and 8,000 kilometres a month. That's 34% of the total amount of time, or let say 8 net working days per month, 2 days a week when ideally it must be between 5 and 6 days a week.

What happens the rest of the time? A good portion is spent on loading and unloading waits. While in the United States a lorry is full in 2 hours, in Colombia it takes around 12 hours, and in some cases 24 hours. It is not that the work of loading is so slow, but it is necessary to wait while the truck is dispatched, thus, logistics delays. (Gutierrez Viana 2011)

If the coffee growers' warehouse asks for a truck at 8 am, it is confirmed at 10am and arrives at around 1pm. The loading and preparation of the documents can be done in one hour, but in that process there are delays. One of them is: for safety of this type of merchandise, generally is not sent just a single truck, but is sent a caravan of at least four trucks. This means that the filling up of trucks is finished at around 6 pm and therefore the trucks leave at 4 am in the morning the next day.

The journey of 879 kilometres takes two and a half days (from Manizales to Cartagena). In port in Cartagena are served just 50 trucks per day, so the usual thing is that if it arrives in the morning, it will be unloaded at noon.

Exhibit 3. Route Manizales to Cartagena



** Source: Google maps

To take a bag of coffee from Manizales to Cartagena it takes five days, it means 120 hours when it must take between 16 and 20 as shown in exhibit 3. Thus, It is as if the truck had travelled at 14 kilometres per hour.

For the sum of all these elements, it is not uncommon to find data from the "Doing Business" report that while in an OECD country the average cost of exporting a container is US $ 1,089 and in Latin America USD $ 1,243, in Colombia is more than USD $ 1,700 (as was already said before by another font). Nor should it be surprising the fact that (USD $ 1,000), 60% of the total cost, is attributable to transportation. (Gutierrez Viana 2011)**.**

3.6 Case 2. Taking a ton of products from Bogota to the Caribbean

Taking a ton of products from Bogota to the Caribbean costs $94 USD, while for a larger route, from Cartagena to Shanghai (China), by sea; the cost is reduced to $60 USD. (Morales Manchego, 2012)

That is just another of the bottlenecks that have Colombian cities; due to the lack of connection between one to another, which makes them lose competitiveness.

The bottleneck in the internal roads of Colombian cities is a fence. On average, an inhabitant spends 70 minutes in leaving an urban area like Bogotá to take a national road. Once there, the citizen faces another difficulty: the deficiency of roads between cities.

Thus, in Colombia, oddly, ground freight travels five times more slowly than China, which is around 8.4 times more extensive than Colombia. **To achieve a 6% growth in the economy, in a sustainable way, it would not depend on mining or agriculture, but on cities and transport infrastructure, connections and technology.** They are the real locomotives; says, Juan Mauricio Ramírez, deputy director of Fedesarrollo. (Morales Manchego, 2012)

The report points out, that in Bogotá and Medellin, the average speed of travel is 23 kilometres per hour, while in cities like Los Angeles, it is 47 kilometres per hour and in New York, 38 km/h.

Finally, the study estimates that, "if Colombia had Costa Rica's quality infrastructure, the economy could grow to 3 percent higher." For sure, supported in an efficiency transport network. (Morales Manchego, 2012).

3.7 Colombia is a country with economy and Logistics looked in oil and gas industry.

At the current juncture, the behaviour of the price of hydrocarbons represents a challenge on the external and fiscal accounts. The abrupt drop in the price of hydrocarbons since mid 2014 has affected the export value of these products, which currently contribute 53% of total exports. On the other hand, the fiscal balance could be significantly affected. The 2015 budget originally provided for an oil price of USD $ 98 per barrel. The new projection made by the Government to December 2014 lowered the price expectation to USD $ 48 per barrel, which would represent a shortfall of 49%. Under these conditions, the fiscal deficit for 2015 was revised upwards, from 2.2% to 2.6% of GDP. Given recent exploration results, it could be difficult to keep production steady at 1 million barrels per day. As a scenario, a drop in production of 10% would represent an additional 0.2% decline in GDP, which would bring the deficit to 2.8% of GDP (Interamerican Development Bank 2015). It means Colombian output matrix and exportations, basically depends on oil and gas international price and also, the transport logistics of other products whose transports depend on oil and gas, are also darned to be affected to this prices since there is not any other structure of transport as is supported in next chapter.

3.8 Analysis Colombian transport infrastructure, statistics and numbers

The following information and tables are based on the Colombian transport numbers of 2015. The info is not lagged, due to the large structure of transport plus the technology weakness to collect it, make the most actual report is always back at least one or one and half year.

The information in next tables is all taken from the notional report from transport ministry and called "Transport on numbers" (Colombian Transport in Numbers 2015).

3.8.1 Analysis of Contribution of transport infrastructure on National GDP

The next exhibit shows the contribution of the transport infrastructure on national GDP

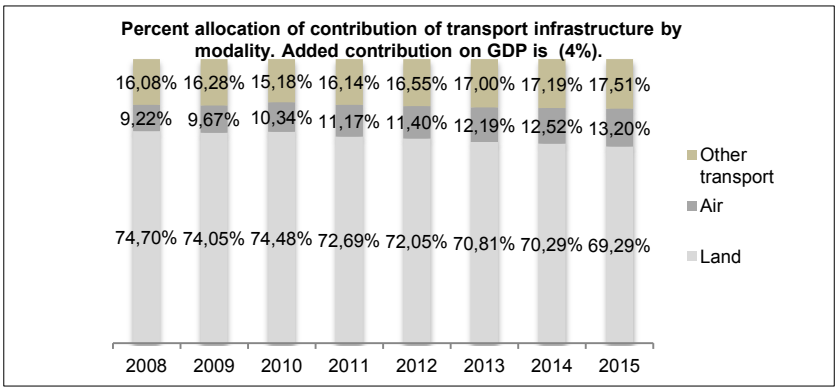
Exhibit 4. Contribution of the transport infrastructure on national GDP

Year	Total National GDP	TRANSPORT INFRASTRUCTURE ON GDP							
		TOTAL	Variation (%)	Land Transport	Participation (%)	Air Transport	Participation (%)	Other Transport	Participation (%)
2009	408.3	17.042	**	12.789	75,04	1.648	9,67	2.605	15,29
2010	424.5	17.993	5,58	13.402	74,48	1.861	10,34	2.730	15,17
2011	452.5	19.244	6,95	13.989	72,69	2.150	11,17	3.105	16,13
2012	470.8	19.923	3,53	14.355	72,05	2.271	11,40	3.297	16,55
2013	493.8	20.455	2,67	14.485	70,81	2.494	12,19	3.476	16,99
2014	515.4	21.317	4,21	14.984	70,29	2.669	12,52	3.664	17,19
2015	531.3	22.069	3,53	15.292	69,29	2.914	13,20	3.863	17,50

**Thousand Million of Colombian pesos; source: (Colombian Transport in Numbers 2015)

The Colombian transport infrastructure contribution on GDP, is on average around 4%, next exhibit shows the percentage contribution of each transport system to this 4% (average), from 2008 to 20015

Exhibit 5. Percentage allocation of contribution of transport infrastructure by modality. Total added contribution on GDP is (4%)



Source: (Colombian Transport in Numbers 2015)

In Colombia, the transport infrastructure contributes with around 4% of the GDP, but away from numbers, the importance of transport as activity is: to be the first support of entire national economy. Lets consider economy is based on a triangle composed by: (1) Human capital and its mobilization, (2) Merchandize and its mobilization, and finally (3) financial capital and its mobilization.

Now days due to the technology, financial capital can be mobilized by electronics means, but human capital and merchandize are forced to be mobilized in a transport infrastructure, then; if it is inefficient, the economy will be compressed and surpassed easily by competitors.

Then, a fundamental fact is, if there is not transport (in this case transport means any way used to mobilize any of the three main pillars) there is not economy, since three mainstays cannot be connected. Thus; efficiency, quality and technology performance of the transport, is directly proportional to the economic growth and sustainability of the country.

Finally, within this 4% contributed by transport infrastructure to Colombian GDP, there are 3 infrastructures, (1) land, (2) air and (3) water (inside other way). For sure the main input is made by land. It is the easiest way to develop and use. The main portion of national territory is composed by land, then human capital is mainly forced to move merchandize by land. Rivers do not arrive to many places and airplane although is faster, is also the most expensive one, and due to the technology, cannot transport quantities in large scale as train or ship.

Lets see in next tables how is the investment strategy of the government in transport infrastructure, especially in the main one (land infrastructure)

3.8.2 Analysis of public expenditure in transport infrastructure

Exhibit 6. Public expenditures over transport infrastructure

Year	Item	Motorway	Railway	Fluvial	Air	Maritime	Others	TOTAL
2010	Appropriation	3.522.349	246.80	41.70	305.040	28.314	397.702	4.541.917
	Commitments	3.435.642	36.376	36.50	291.374	28.308	322.789	4.150.991
	Debt	2.759.288	34.925	31.663	204.390	16.453	292.319	3.339.037
	Payments	2.375.019	34.416	31.663	195.303	16.361	231.359	2.884.121
2011	Appropriation	4.840.996	67.303	91.075	259.331	105.667	379.703	5.744.076
	Commitments	4.706.693	41.131	82.072	251.733	25.527	343.152	5.450.307
	Debt	4.173.748	40.676	70.944	136.957	11.590	233.189	4.667.104
	Payments	3.582.590	40.523	63.866	102.207	6.543	110.907	3.906.636
2012	Appropriation	7.633.441	110.571	61.659	379.119	12.995	477.553	8.675.338
	Commitments	7.497.414	48.404	54.943	331.209	4.043	302.883	8.238.897
	Debt	6.852.586	46.286	43.595	272.269	1.467	204.765	7.420.968
	Payments	5.640.779	40.190	42.574	159.854	**	132.510	6.015.908
2.013	Appropriation	7.805.291	67.925	88.178	477.705	88.543	274.309	8.801.950

	Commitments	7.780.796	67.898	87.818	450.384	83.829	240.563	8.711.289
	Debt	7.253.530	38.416	84.000	436.053	81.298	216.262	8.109.559
	Payments	5.555.820	20.675	69.324	202.481	34.630	116.187	5.999.116
2.014	Appropriation	6.487.217	142.364	28.789	607.096	44.196	217.237	7.526.898
	Commitments	6.452.334	142.150	24.789	538.748	38.710	193.862	7.390.593
	Debt	5.916.313	72.196	14.497	465.676	29.739	175.048	6.673.468
	Payments	5.116.848	50.134	9.398	406.209	22.483	140.474	5.745.546
2015	Appropriation	5.389.343	94.844	33.750	746.066	66.887	297.568	6.628.458
	Commitments	5.269.981	94.836	32.224	714.788	66.727	291.077	6.469.632
	Debt	4.624.322	73.848	28.857	560.453	60.931	275.214	5.623.625
	Payments	4.054.567	62.639	21.439	299.808	29.067	213.767	4.681.287

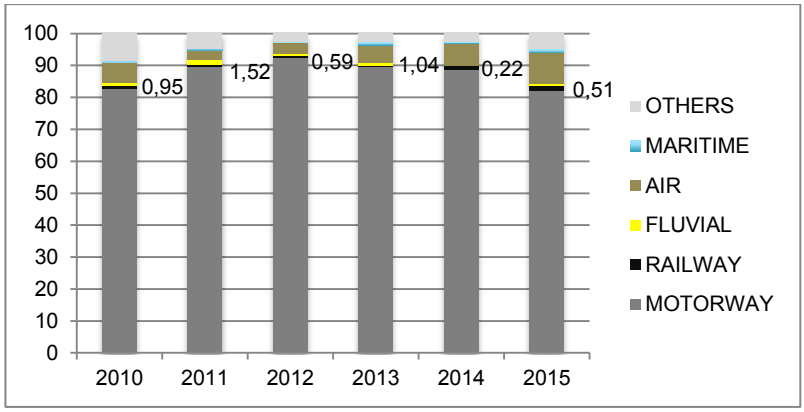
**Thousand Million of Colombian pesos. Source: (Colombian Transport in Numbers 2015)

Exhibit 7. Distribution of public investment by type of transport (Constant prices)

COMMITMENTS	2010	2011	2012	2013	2014	2015
MOTORWAY	82,64%	89,43%	92,34%	89,44%	88,65%	82,23%
RAILWAY	1,05%	0,87%	0,62%	0,47%	1,08%	1,31%
FLUVIAL	0,95%	1,52%	0,59%	1,04%	0,22%	0,51%
AIR	6,12%	2,93%	3,67%	5,38%	6,98%	9,97%
MARITIME	0,49%	0,25%	0,02%	1%	0,45%	1,08%
OTHERS	8,75%	5%	2,76%	2,67%	2,62%	4,89%
TOTAL	100%	100%	100%	100%	100%	100%

. *Source:* (Colombian Transport in Numbers 2015)

Exhibit 8. Distribution of public investment by type of transport (Constant prices)



. *source:* (Colombian Transport in Numbers 2015)

In exhibits 6 when it refers to:

Appropriation: *it means how much (in monetary value) has been acquired in assets and facilities this year*

Commitments: *it means how much (in monetary value) has been assumed as a compromise, for obtaining assets (e.g.: motorways) and facilities. Normally commitments refer to the investment made by private institutions or borrowed money from banks.*

Commitments also include values, leasing, assets rent (e.g.: land rent)

Debt: *is how much must be paid until this year. Notice that although some commitments are debts, it is not added to the current year since, normally the payment deadlines for*

commitments are made for the years in the future, e.g.: the commitment in T1 becomes a debt in T3.

Payments: *It means how much has been paid the current year*

Exhibits 6,7 and 8 show basically an unbalanced strategy on public expenditure for transport infrastructure. Around 82% of the amount of public investment is allocated in roadways infrastructure, against 18% to be divided between railroads, air and water trasnport infrastructure. This distribution looks even more unbalanced, if is known that Colombia has more than 10.000 Km navigable and it is just taking into account its 12 more important rivers (Magdalena, Putumayo, Guaviare, Cauca, Inírida, Meta, Apaporis, Vaupés, Vichada, Magdalena, Atrato, Patía) and has big extensions of valleys (Aburra, Atrato-San Juan, Cauca, Catatumbo, Cesar, Laboyos, Magdalena, Patia, Pubenza, Sibundoy, Tenza, and Llanos Orientales) to install rail ways system.

Then, would be expected for the soon future, to have at least in land infrastructure, a balanced investment, in which (1) cars/motorways and (2) Trains/ Rail Lines, are distributed in 50/50. However, although half-and-half is not a standard or a rule, but at slightest is expected to have a balanced investment, in which, one of the systems could be able to be supported by the other one in case it gets an unexpected problem.
But, it would never happen if from this 83% of expenditure in land infrastructure, 82,3% is done for motorways meanwhile the investments on train is just depressed 0,70% on average as is shown in graph 2. Mathematically (just considering land transport investment) it means a distribution of 98% for motorways and just 2% for trains.

Consequences: (1) The demand elasticity in transport between rail line and motorways is close to null (zero). Elasticity would measures how change the demand of one service (let say motorway) when increase (or decrease) the price the other one (train).

For this analysis the demand elasticity won`t suffer any change in demand or prices,(at least in short time) the reason is that trains is set just in specific zone of the country and works just for a tighten group of companies. To increase truck/bus prices will not generates any change on train services demand. Costumers just have to assume the increasing of prices; there are no more other option to choose. What about if there is not an increasing in prices but just a strong problems on the motorway due to the strong weather? Nothing changes. The result is the same; producers, costumers, merchandize and human capital must to assume the cost of he absence of alternative in transport infrastructure.

Moreover, it is known that national economy is forced and doomed to use roadways no matter the condition or the price of oil and gas, and even worst, when there are river over floods it is properly doomed to be stopped.

What is asserted above is supported on past events when national economy had to:
(1) Cushioning the changes on fuel oil prices,
(2) Cushioning the economic effects of transporters strikes since they have a big bargaining power to stop the economy thus, if they decide to not operate, like has occurred in the past and finally,
(3) Due to the poor quality of the motorways they must be closed, in rainy seasons. The principal effect is the merchandize and human capital mobilization is stopped, affecting again the economy.

Fast case study: Brazil and Colombia are coffee exporters. Both them are in the world top exporters, Brazil 2.5 M-tons year and Colombia 810 K ton year. Nevertheless, Brazilian coffee output just not overpass Colombian one in output, also in % benefit and value generated. Lets see why?

Colombian precipitations season get it's higher values between September and mid-December of each year. The Brazilian one is twice longer goes from September to mid-March.
After the high precipitations finish in Colombia, it just starts the colder season in United States and Europe (Finland, Sweden and Netherland the higher consumers).

The cold season makes increase the coffee demand, cacao and chocolate demand. An United States citizen consumes in average 13 coffee cups a week, in which June to august represent the lower consumption season in the year, and December to February the highest value of the consumption rate.
Just in United States are consumed a day 400 M cups a day, 146 Billion/year. When a journalist from Republican Herald asked to Bill Kontogiannis a coffee pub owner, about the coffee sales in a year, he answered: -"Our hot coffee sales go up in the winter by 30 percent". Another report announces marketing strategies to keep the coffee sales volume in summer as they are in winter since in summer are so low.

For sure, the winter brings also an increasing in city's energy consumption. Houses, factories, airports, stations and all city infrastructures imply an energy demand to keep them

warm. Prices of energy fonts, especially those non-renewables one (oil and gas and coal) get an increasing in world market prices.

Often, an increase in the demand of a product/service brings an increasing in their value. This value raising works in the producers, as incentive, to produce more in order to satisfice and supply the value requirement of the demand, until to obtain the equilibrium.

Meanwhile Europe and the United States ask for more coffee, Colombia and Brazil prepare themselves to support the market requirement. Unfortunately, in Colombia, after the raining season, find motorways are highly destroyed, closed due to high risk of river over flood or mountain landslide. Alternatively, the lack of maintenance and weakness in constructions structures induces shut down a part of the national motorways infrastructure.

The coffee demand increases by 30%, but in Colombia the numbers shows that in this 3 months (September, October November and first week of December) the values of coffee exportations hardly overcomes just 1% the rest of the year months. The reason is the increasing in oil and gas prices in the same season increase the logistic cost and merchandise mobilization, this fact make to avoid the capability to enjoy higher monetary benefits, thus increase the revenues but at the same time increase the costs.

Brazilian coffee industry the situation is different. The land transport infrastructure, enjoy two system, motorway and railroad networks. The problems are the same than those in Colombia, basically, problems in infrastructure. However, the risk to stop the merchandise's mobilization is lower than in Colombia. When one of both infrastructures (lest says motorways), had an inconvenience, like a river overflow or oil and gas price the coffee mobilization would be done in train, which not just give a solution for problems caused by weather, also provide a decreasing in logistic cost. At the end Brazil increase the gap between coffee price and operation cost, increasing the benefit and consequently the value generated, the opposite way of Colombia.

Brazil finds an incentive to increase their agro-industry, coming from the Colombia movement in reverse, regarding to the same opportunities.

3.8.3 Data passenger mobilization by means of transport

Exhibit 9. Mobilization of passengers by type of transports

Year	National Passengers						
	motorway transport	Air Transport			Fluvial	Railway Transport	TOTAL
		Taxi plane Regional	Companies Regulars	Sub TOTAL			
2009	177.855.357	523.877	10.156.884	10.680.761	4.095.702	165.709	192.797.529
2010	175.260.455	725.938	13.235.146	13.961.084	3.825.556	183.942	193.231.037
2011	184.958.703	821.079	13.807.682	14.628.761	4.025.265	227.075	203.839.804
2012	170.404.280	839.276	16.104.117	16.943.393	2.337.585	208.083	189.893.341
2013	179.915.072	496.956	19.257.480	19.754.436	2.476.500	274.244	202.420.252
2014	187.896.491	553.001	20.447.857	21.000.858	2.264.627	464.458	211.626.434
2015	188.836.000	407.074	22.709.266	23.116.340	2.460.460	458.619	214.871.419

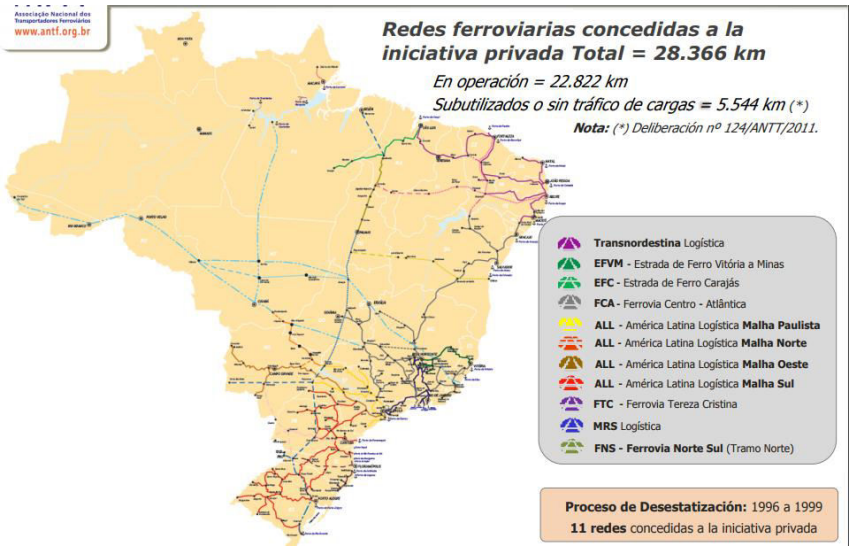
Source: (Colombian Transport in Numbers 2015)

This table refers to how is mobilized the human capital on the national territory.

Once again the relation between train and motorways is unbalanced. From total transported passengers in land infrastructure, train support just 0,24%.

The analysis is same, as it was demonstrated that merchandize is locket to be mobilized by motorway. It happens again, human capital is locked to be transported by motorway, then consequences are the similar, and the conclusion as well, the entire national economy is constrained and must assume all impacts without has any "by pass" like Brazilian or Canadian economies, (Rodrigo Vilaça 2013) which transport by train 50 Brazilian train system) and 40% respectably the entire mobilized merchandize. Exhibit 10 shows the coverage of train infrastructure in Brazil. It is Cleary higher if it is compared with Colombian train investment shown in exhibit 2.

Exhibit 10. National railroad coverage in Brazil



Source: (Rodrigo Vilaça 2013)

3.8.4 Analysis of freight mobilization by means of transport

Exhibit 11. Mobilization of national freight by types of transport

Year	Motorway	Railway			Fluvial	Air	Cabotage	TOTAL
		Concession without including coal	Coal	TOTAL				
2009	173.558	254	59.144	59.398	4.070	109	364	237.499
2010	181.021	366	66.659	67.025	3.691	119	353	252.209
2011	191.701	204	74.350	74.554	3.650	124	646	270.029
2012	199.369	20	76.780	76.800	3.474	127	388	280.158
2013	220.309	97	76.684	76.781	2.968	149	774	300.980
2014	N.D.	174	42.733	42.907	2.858	163	615	46.543
2015	N.D.	230	47.705	47.935	3.524	179	967	142.125

Thousands of tons, source: (Colombian Transport in Numbers 2015)

Source: (Colombian Transport in Numbers 2015)

In here, there are two analyses to do. That one related to (1) compare freight mobilized by motorway vs coal freight (which is transported in train), and another one regarding to (2) motorways vs trains concessions without including coal.

In the first comparison motorways has an average of 193.191,6 k tons transported a year, meanwhile coal freight has an average of 63.436,42 k tons, by adding this two averages the result is 256.626,4 k tons, from which coal freight cover 24%, like was asserted early. Just by analysing proportions, it could be a relative good balance if we analyse the distribution of freight on land infrastructure.

However as it was asserted in chapter 4,2, must be taking into account that:
(1) The asset transported on this 24% is just coal, one product, coming from primary sector. In addition, it is due to the geological randomness of the country; it is not a result of the public expenditure investment strategy. The high volumes are a result of the easy way to obtain the resource. Different from other coal exporters countries, Colombian main coal mine (Cerrejon) is uncovered, a fact which makes decrease substantially the operation cost and operations risks, thus, Colombian large scale in exportation coal is due to the luck not to the transport strategy to transport. In a nutshell, Colombia use train because has coal, but the statement must be: Colombia has train which supply a transport service between which the group of transported assets is coal.

(2) The biggest user of the rail line, to transport coal is Cerrejón (Colombian Transport in Numbers 2015), which transport around 50% of this 24%, but Cerrejón has its own rail line, which is not part from national public expenditure, then:

By considering, actual public statistics generate a noise since could be assumed that there is a balanced distribution of public expenditure in transport and big piece of the population is enjoying about this welfare.

Also, the distance from Cerrejón mine to Port Bolivar is 150km. It is a short distance, if it is compared to 1061 km ran by a truck from Bogota to Cartagena (containing elaborated products), even more is less than the half of the distance from Montelíbano to Cartagena (341 km) from which is transported the 4% of the world market share of nickel as will be shown later.

In this order of ideas, the numbers regarding to the freight transported in train and related to coal would be neglected. The math prove of the unbalances investment on the train infrastructure is that; without consider the coal values, trains cover just the 0,010%. Thus, 10k for each ton of freight.

3.8.5 Data analysis of human death allocated by means of transport.

Exhibit 12. Total of deaths by types of transports

Year	Motorway		Railway		Fluvial		Air		
	Accidents	Deads	Accidents	Deads	Accidents	Deads	Incidents	Accidents	Deads
2009	177.801	5.794	91	16	7	1	15	24	5
2010	173.171	5.696	197	2	13	3	20	15	38
2011	183.287	5.773	125	3	19	16	22	18	11
2012	194.221	6.136	22	3	14	5	17	14	12
2013	177.082	6.211	47	2	16	12	23	14	6
2014	180.519	6.352	32	5	14	20	12	16	49
2015	176.543	6.831	21	0	18	12	11	19	30

Thousands of tons, source: (Colombian Transport in Numbers 2015)

Source: (Colombian Transport in Numbers 2015)

Based on the analysis, in the tables shown earlier, is easy to establish numbers in order to decide how the train could add significance in the value chain of a exported products.

But exhibit 12 measures how much safe is the transport system for the human capital. Considering averages for each 100 accidents: (1) in motorways, there are 3 death, (2) in train, there are 5 deaths, (3) in fluvial ways, are 69 death and in (4) air 132 death. It means that transport in Colombia's is not at all safety in any of their system.

Must be emphasized in motorways, that is the most likely to arrive to 100 accidents in less time, thus, although its average of death by each 100 accidents is the lowest, is the faster transport into arrive to 100 accidents it means is also the faster into add a death; 42.793 persons died from 2009 to 2015. This is the reason why this transport presents the highest accumulation value in fatalist.

Briefly, this transport system (motorways) is the highest probability to get alive from an accident, but also is a constant risk; each time the user decides to use it, is going in the borderline to get an accident. (There was not done an economic analysis since is not

possible to value a life of people, but it is possible to say motorways is the most probable way to lose the human capital.)

3.8.6 Data analysis of number of trains services supplier companies

Exhibit 13. Number of companies covering the transport service

Year	Motor way			Railway		Fluvial		Air	
	Passengers	National Freight	Mixed	Passengers	Freight	Passenger	Freight	Passenger	Freight
2009	572	2.004	173	3	7	91	65	7	15
2010	576	2.086	173	5	5	90	73	7	11
2011	578	2.358	175	4	4	92	83	7	12
2012	551	2.528	172	3	5	94	90	7	9
2013	531	2.685	155	2	2	98	101	30*	20*
2014	531	2.854	155	3	9	117	115	36	18
2015	542	2.112	155	4	12	121	118	37	20

source: (Colombian Transport in Numbers 2015)

Finally this, statistical analysis finishes with how many companies are in charge of human and merchandize mobilization.

Often train operation industry, does not have many incumbents, and the numbers tend to be stable for years, but it does not happen in Colombia.

Exhibit 13, shows a continued enter and exit of companies on this industry. The reason is the opportunity investors see on the business, which is not longer supported by government investment expenditure, as is shown in the tables shown early. It generates a sort of crowding out, (in this case generated by the poor investment of the government strategy) it means, the exit of the companies form the business.

In infrastructure Colombia keep under the average of "Peer Group", taking into account Rail lines and infrastructure in general.

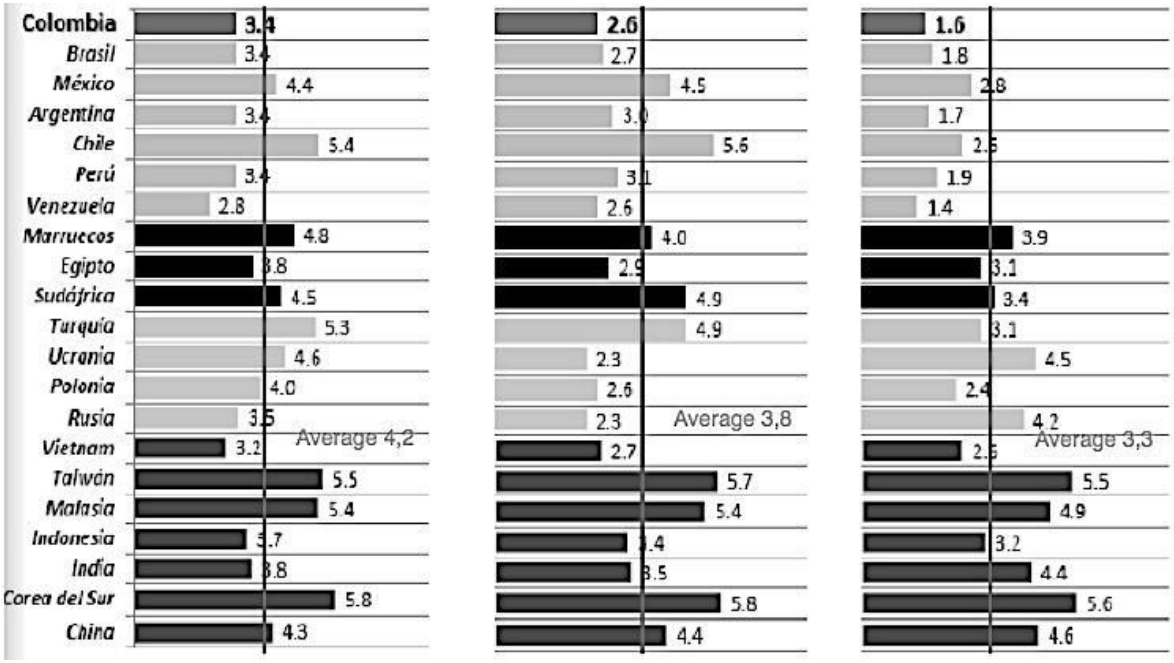
3.8.7 Rail infrastructure actual condition, comparison, between Colombia, Brazil, Mexico, Argentina, Chile and Peru

Exhibit 14. Rail line actual condition, comparison, Colombia, Brazil, Mexico, Argentina, Chile and Peru

(1) First Column measures: Rail line Infrastructure quality in general.

(2) Second Column measures: Railways quality.

(3) Third column measures: Entire network of Rail lines connection and quality. (1 the worst and 7 the best).



source: (Caicedo Arturo, 2013)

This exhibit shows the current condition of Colombian rail line, against closer and more important country competitors, and others in the rest of the world.

Mainly, it shows what has been told and demonstrated earlier in this thesis. Colombia presents a poor train's infrastructure, even more than Peru country with lower GDP (Peru 192USD billion against 300 USD billion of Colombian GDP), and actually, within Latin countries Colombia has the worst infrastructure.

With that numbers, be against closer competitors is so hard, if there is an external problem which generates secondary effect on motorway infrastructure Colombia would be the most affected economy and the last one into react in order to get away from the conjuncture.

3.9 Sight and estimations of International financial institutions (Inter-American Development Bank)

In Colombia external conditions helped to achieve good economic and social performance. The terms of trade improved by 75% between the mid 90's and 2013, driven by an increasing in value of exports, especially oil and mining. In turn, capital flows increased substantially, from US $ 3 billion in the 1990s to US $ 20 billion in average between 2009 and 2013.

However, since the middle of 2014 it has been shown that the expansion cycle based on commodity prices are ending. The terms of trade, which remained stable during 2011 and 2012, began to deteriorate in 2013 and 2014. The new stage of the world economy could limit the flow of capital to developing countries. Development and decrease the pace of private investment required by Colombia.

Colombia is a resource rich country, oil and gas, nickel, gold, and coal have put the country on feet in lasts years, since commodities have had important place in the world economy.
It lets Colombia to has a pushing up in its economy. With new technologies on market, this lucky is close to finish, the manufacturing matrix was never renewed beyond miner and oil and gas. As it is asserted by inter American bank after 2014 has been felt a reduction on flow of capital since commodities are not longer important for investors.

What Colombia must do before finish the "commodity moment", is an investment on infrastructures like transport in order to avoid bigger cost in future, when the reduction on external investment appears. This is moment to prepare for recession with an infrastructure based on technology and higher performance. Must be considered that now, with a value of transport for container close to 1700 USD, the transport is rentable due to the large quantities commodities are exploited, but is time to star getting benefit not from the lucky but the strategy. Also must be considered that for Colombian manufacturers companies, is not at all rentable to has a price of 1700 us when closer competitor are around 1000 USD.

This requires, among other actions, a significant increasing in public investment. In recent years, the Colombian State has to invest on average of 3.6% of GDP in infrastructure. It is estimated that an economic growth target of 6% would require doubling this investment effort, with rates around 7% per year. (Interamerican Development Bank 2015)

Transport costs represent a central obstacle to productivity. **The average domestic cost for a container is US $ 1,800 compared to US $ 700 in Latin America. In turn, the export cost is more than US $ 2,300, compared again with US $ 1,300 for Latin America and US $ 1,080 for the OECD.** Among the main causes of this situation are: Infrastructure provision is insufficient. The density of the paved road network in Colombia is low with 530 km per million inhabitants, less than countries like Brazil (1,066 km) and Mexico (1,188 km) and much smaller than France 15,945. The poor quality of transport infrastructure affects productivity and competitiveness. (Interamerican Development Bank 2015)

This indicator is especially important in the case of Colombia, since 72% of the cargo moves by road, compared to 50% in Brazil and slightly more than 40% in Canada. Colombia's investment in transport infrastructure has historically been low. The country invested, on average, less than 1% of GDP between 2002 and 2008, and between 1.5% 2% between 2009 and 2013, below than international competitors.
Colombia invests around 0.4% of GDP in regional and rural roads, compared to 1% in other countries in the region, such as Peru. The provision of cargo transportation services presents significant inefficiencies. In 2011 the average route per year of trucks in the United States was approximately 106,000 kilometres; in contrast to the average 56,000 kilometres in Colombia. (Interamerican Development Bank 2015, Interamerican Development Bank 2015)

4. Fuel efficiency Assessment of train and truck in transporting freight.

Considering economies is not just an accounting reckoning, is also the way to become wealth into welfare, is the way to how consume resources in order to satisfice the human needs.
The aim of this thesis is to show, if train can be a better solution than truck from the economic point of view, for a country like Colombia, with a passive logistic and output transportation, also constrained for rugged relief. (three mountain ranges of the Andes, Huila's Snowy, Ruiz Snowy, Galera's Volcano, Santa Marta Snowy, Nudo del Paramillo and others).

In order to establish what transport is better for society must be analysed together: (1) safety in transport, (2) externalities (contamination for C02), (3) and of course which is better from the financial point of view and (4) others like technology performance for social benefit.
Since it is not possible, measure all conditions together, this chapter analyses just the efficiency of fuel consumption between the two systems of transports, truck and train, since they are substitutive services, and give a soft analysis to externalities and contamination.

Since fuel efficiency is the main aspects took into account, due to enclose around 80% of the variable costs, will be the aspect used to confirm if train is or not more economic convenient for society, briefly to assert if one transport can be better than the other one.

The next analysis is based on a study made by **FEDERAL RAILROAD ADMINISTRATION**, from USA in which is made a COMPARATIVE EVALUATION OF RAIL AND TRUCK FUEL EFFICENCY ON COMPETITIVE CORRIDORS. Some of their findings are analysed in different ways in order to give support to the results of this thesis.

This research starts by its conclusion, then go ahead with proves which support the conclusion.

To analyse technological superiority of train over truck, were done 23 movements with different kind of containers and different types of train's locomotive, in order to measure the fuel efficiency in ton-miles per gallon.

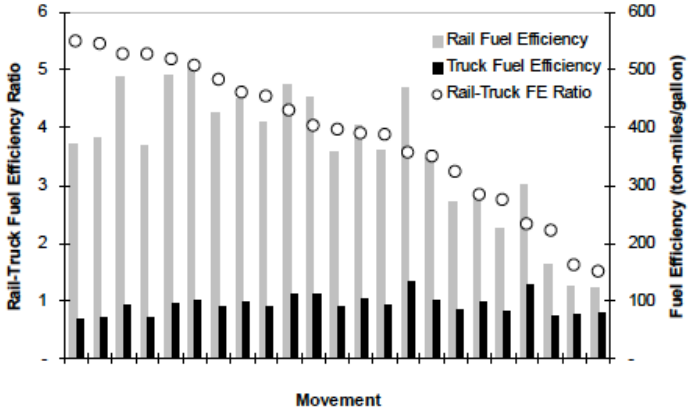
Were used different containers due to the freight is different and depends on each industry (e.g; Mining, ore, oil and gas, food, durable goods, raw goods etc), also the capacity of each kind of container is different and can generate different efficiency in fuel consumption.

Lets see findings. (The total findings are 20, but for this thesis are outstanding findings, just 7 of them: 1,2,3,4,5,8, and 11 those ones which show the fuel efficiency superiority of the train over truck)

Finding 1: Rail is more fuel-efficient than truck on all 23 movements.

For all movements, rail fuel efficiency is higher than truck fuel efficiency in terms of ton-miles per gallon. The ratio between rail and truck fuel efficiency indicates how much more fuel-efficient rail is in comparison to trucks. As illustrated in Exhibit 15, **rail fuel efficiency varies from 156 to 512 ton-miles per gallon; truck fuel efficiency ranges from 68 to 133 ton-miles per gallon, and rail-truck fuel efficiency ratios range from 1.9 to 5.5.** (Federal Railroad Administration 2009)

Exhibit 15. **Comparison of Rail and Truck fuel Efficiency**

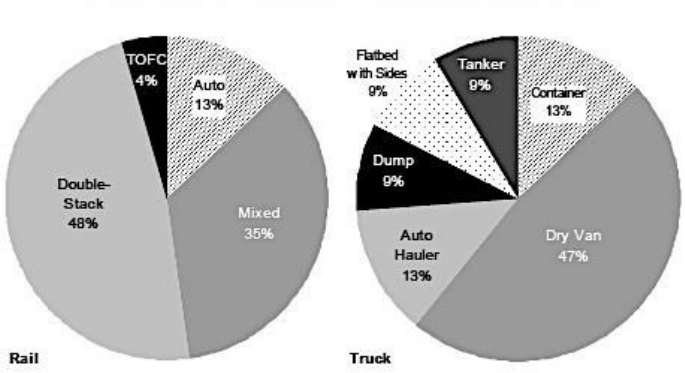


*The 23 moves were ordered by descending rail-truck fuel efficiency ratios.

Finding 2: Double-stack trains and dry van trailers are the predominant equipment types in this study.

Double-stack trains account for 11 out of 23 rail movements, while dry van trailers are the equipment of choice for 12 truck movements. Double-stack service has become more predominant in the past two decades due to their fast and reliable transit times, while 53 footdry vans provide large capacity while utilizing tractor aerodynamic aids that reduce fuel. (Federal Railroad Administration 2009)

Exhibit 16. Representation of equipment types in study movements



Finding 3: There is a strong correlation between rail-truck fuel efficiency ratio and equipment type.

Exhibit 17 provides the range of rail-truck fuel efficiency ratio by rail equipment type. The tank car movement resulted in the highest ratio, followed by Double-stack, covered hopper, and gondola movements. Auto rack movements resulted in the lowest ratios. The wide variation in rail-truck fuel efficiency ratios in Double-stack movements is a result of the higher number of Double-stack movements considered in this study. (Federal Railroad Administration 2009)

Exhibit 17. Range of Rail-truck fuel efficiency ratios by Rail Car type

Rail Equipment	Min	Max
Tank Car	5.3	5.3
Double-Stack	2.7	5.5
Covered Hopper	3.7	4.3
Gondola	2.3	4.0
Box Car	3.6	3.9
TOFC	3.2	3.2
Auto Rack	1.9	2.2

Finding 4: The range of rail fuel efficiency is wider than the range of truck fuel efficiency.

Exhibits 18 and 19 illustrate the range of rail and truck fuel efficiency across all movements included in this study. Rail fuel efficiency has a much wider range, varying from **156 to 512 ton-miles/gallon, while truck fuel efficiency ranges from 68 to 133 ton-miles/gallon**. (Federal Railroad Administration 2009)

Exhibit 18. Range of rail fuel efficiency (Ton-miles/gallon

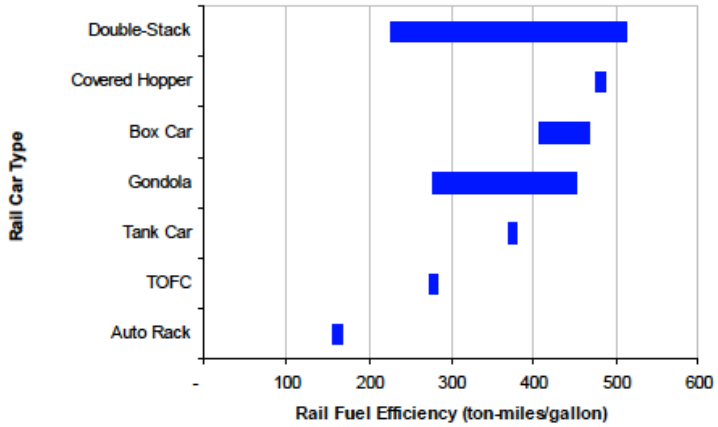
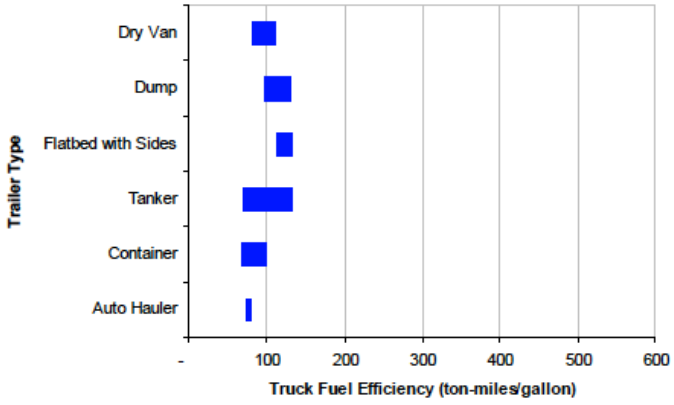


Exhibit 19. Range of truck fuel Efficiency (Ton-miles/gallon)



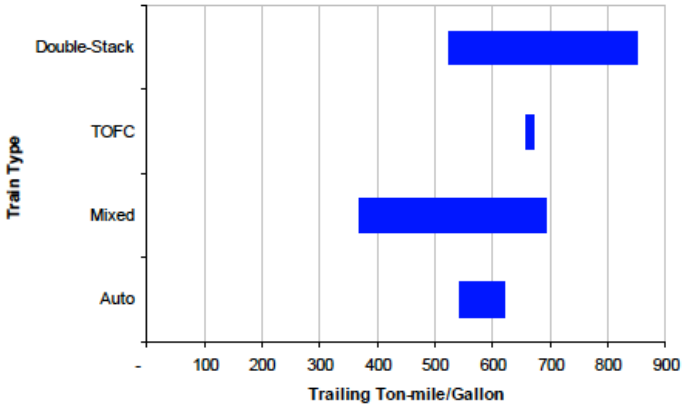
Finding 5: The variation in rail fuel efficiency is narrower if analysed in terms of trailing ton-miles per gallon. (Federal Railroad Administration 2009)

Rail fuel efficiency can be measured at the train level in trailing ton-miles per gallon. Exhibit 20 illustrates the range of trailing ton-miles per gallon for different types of trains, and the most fuel efficient train is about 2.3 times more fuel-efficient than the least fuel efficient train. In contrast, the ratio between the highest and the lowest fuel efficiencies measured in lading ton-miles per gallon at the car level is 4.2.

Double-stack trains tend to be more fuel-efficient than other types of trains, despite their higher average speeds and poorer aerodynamic performance. The fact that intermodal operations do not require subsequent switching operations to classify rail cars contributes to the better performance of Double-stack trains. The wide variation in fuel efficiency of Double-stack and mixed trains as opposed to auto and TOFC trains is justified by the

smaller number of movements analysed in the latter trains. (Federal Railroad Administration 2009)

Exhibit 20. Train fuel efficiency by train type

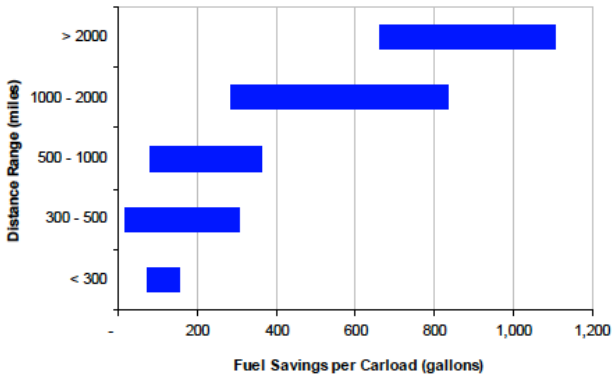


Finding 8: Fuel savings from using rail can be significant.

Rail results in fuel savings when compared to their counterpart truck movement, **ranging from 18 to 1,108 gallons per carload**. Because the range of variation in fuel savings is more dependent on route distance than equipment type, Exhibit 21 illustrates the range of savings by distance segments. (Federal Railroad Administration 2009)

Fuel savings can also be analysed at the train level. For example, if trucks were to carry the equivalent payload included in the Double-stack rail movements, fuel savings would evidently be much greater, varying from 1,549 to over 80,000 gallons per Double-stack train. (Federal Railroad Administration 2009).

Exhibit 21. Rail vs Truck fuel saving by distance segment



Finding 11: Rail Double-stack shows improved fuel efficiency while mixed freight and unit auto rail fuel efficiency diminished since the 1991 Study. Truck fuel efficiency diminished in each category.

Finally, the study compared the current results with those included in the 1991 Study. Exhibits 22 and 23 provide a comparison of the ranges of rail and truck fuel efficiency for both periods, respectively. Exhibit 18 also illustrates the rail-truck fuel efficiency ratio range for the two studies. Overall, Double-stack trains appear to have become more fuel efficient. At the same time, dry vans and container on chassis are somewhat less fuel efficient in this study, possibly because of the more realistic representation of truck movements. These two factors explain why the rail-truck fuel efficiency ratios increased for commodities moved in Double-stack trains. The most striking difference between the studies relates to mixed trains, where the current study estimates much lower rail fuel efficiencies, possibly because of the inclusion of more fuel used in short branch line movements and switching operations. (Federal Railroad Administration 2009)

Exhibit 22. Evolution of rail fuel efficiency (ton-miles/gallon)

Train Type	Rail Fuel Efficiency Range		Rail-Truck Fuel Efficiency Ratio Range	
	1991 Study	Current	1991 Study	Current
Double-Stack	243 - 350	226 - 512	2.5 – 3.4	2.7 – 5.5
TOFC	196 - 327	273	1.4 – 2.1	3.2
Mixed	414 - 843	278 - 487	2.8 – 5.5	2.3 – 5.3
Unit Auto	206	156 - 164	2.4	1.9 – 2.2

Exhibit 23. Evolution of truck fuel efficiency (Ton-miles/gallon)

Trailer Type	Truck Fuel Efficiency Range	
	1991 Study	Current
Dry Van	131 - 163	82 – 110
Container	97 - 132	68 - 100
Dump	N/A	98 - 129
Flatbed with Sides	147	112 - 133
Tank	N/A	70 - 132
Auto Hauler	86	74 - 81

4.1 Technological growth

Between 1990 and 2006, rail fuel efficiency has improved by about 20%, or 1.1% per year. These figures represent the overall industry average for U.S. Class I railroads and are the net outcome of multiple changes in railroad traffic mix, technological improvements, and operating practices. Most of this improvement took place without the strong incentive of rising diesel fuel prices after 2004. The principal factors behind rail fuel efficiency improvements were:

Changes in traffic mix, especially the steady growth of unit train traffic and in particular, coal and intermodal traffic;

Technological improvements in locomotives, freight cars, signal, train control and dispatching systems, and track systems;

Changes in operating practices that lowered fuel consumption, such as the optimization of train meets and passes at sidings, crew training in fuel saving operating techniques, and improved scheduling to avoid delays.

Overall fuel efficiency gains over the period from 1990 to 2006 were a combination of gains due to individual changes in railroad technology and operations, with the mix of factors varied by traffic type. The challenge in this task was not only to document the overall gain but to understand as far as possible how this gain was distributed among the different traffic types and individual improvement areas.

4.2 Changes in Traffic Volume and Mix

Railroad traffic has been growing rapidly over the 16year period (1990 – 2006), as shown in Exhibit 24. The overall growth in revenue ton-miles of 71% (a compound annual growth rate (CAGR) of 3.4%) was the highest rate of growth in rail traffic since World War II. ICF estimates of the distribution of this growth among key commodity and traffic types shows that coal traffic growth has been the strongest at 86% (4.0% per year), largely driven by increasing shipments of low sulphur coal from the Powder River Basin in Wyoming. The next strongest growth was in intermodal traffic (container and trailer on flat car) with 79% growth (3.7% per year) over the 16year period. Intermodal growth was also driven primarily by external factors, in this case the surge in imports of containerized manufactured goods through West Coast ports. Note that intermodal ton-miles as counted in railroad statistics include the weight of the container or trailer, its contents and the weight of any empty containers shipped. The growth in other traffic (excluding grains) reflects the ability of the railroads to retain their share of the overall U.S. freight transportation market. This is a change from previous years, where rail steadily lost market share.

Exhibit 24. Summary of Rail Traffic Growth

Year	Quantity	Coal	Intermodal	All Other	*Total*
1990	Revenue Ton-miles (billion)	385	155*	495	1034
2006	Revenue Ton-miles (billion)	718	278*	776	1772
Change	Percent	+86%	+79%	+57%[8]	+71%
1990-2006	CAGR (percent)	4.0%	3.7%	2.8%	3.4%

*ICF Estimate

The implications for fuel consumption of these changes are summarized in Exhibit 25.

Exhibit 25. Fuel Consumption Effects of Rail Traffic Changes

Commodity	Factors	Overall Effects
Coal	• Mostly unit trains (no switching) • High ratio of payload to empty car weight • Longer, heavier trains • 100% empty return • Best available technology used for coal trains • Low-moderate speeds	Best fuel efficiency of all traffic, with lowest GTM/RTM ratio (approx. 1.4).*
Intermodal	• All unit trains (no switching) • Low ratio of payload to empty car weight • Few empty miles (approx. 10%) • High speeds (up to 80 mph) • Shift from trailers on flatcars (TOFC) to double-stack containers	Relatively high fuel consumption per revenue ton-mile, due to high speeds and high GTM/RTM ratio (approx. 2.5, including weight of container or trailer).
Other	• Mostly carload service with classification yard visits and local switching • Moderate ratio of payload to empty weight • Empty miles about 80% of loaded miles, with many commodities using specialized cars with 100% empty miles (e.g. tank cars) • Moderate train speeds • Sale or closure of low-density lines	Medium to high fuel consumption due to switching and yard visits, high empty miles and medium to high GTM/RTM ratio (approx. 2.0). Loss of low-density local routes will eliminate some low-efficiency operations.

* GTM: Gross ton-miles; RTM: Revenue ton-miles. Because GTM account for empty cars as well as the weight of the car itself, a lower GTM/RTM ratio indicates a better rail fuel efficiency.

Exhibits 26, 27 and 28 shows basically the evolution and growing of technology from the efficiency point of view (for train), how stopped and lagged has been the truck on the time and finally the growing of fuel oil on time.

For sure the growing in technology in this case Works as a shock absorb for economy. Lets consider country A and country B. Country A mobilize merchandize by train and truck, meanwhile country B made it just by truck. Both countries export merchandize to country C at the same price P which is driven basically for fuel (oil and gas prices).

At certain point of time, P increases. Hence country A and B get a shock on their economy. Due to investments on technology through years, country A, has an increase on the fuel efficiency consumption in one of their transport system, lets say trains. Then, decided to mobilize the entire merchandize by train to in until P get back to normal price. At the same time Country B locked on truck technology does not has another option than cushioning the impact. In the long run, country A will be able to maintain lower prices than B. As result Country A will take a big piece of the market share.

That's how based on technological, superiority on: systems, education, public services in this case transport infrastructure, that developed countries achieve high degree of welfare than poor countries.

Exhibit 26. Rail Fuel Efficiency Trend

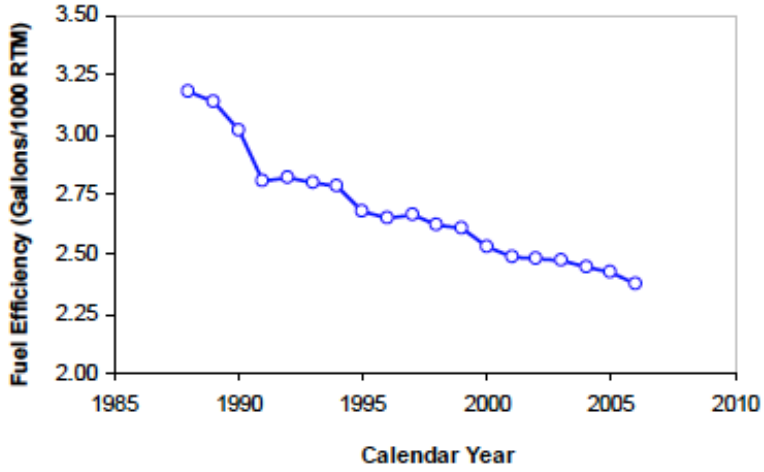


Exhibit 27. Cost of Diesel Fuel to Railroads

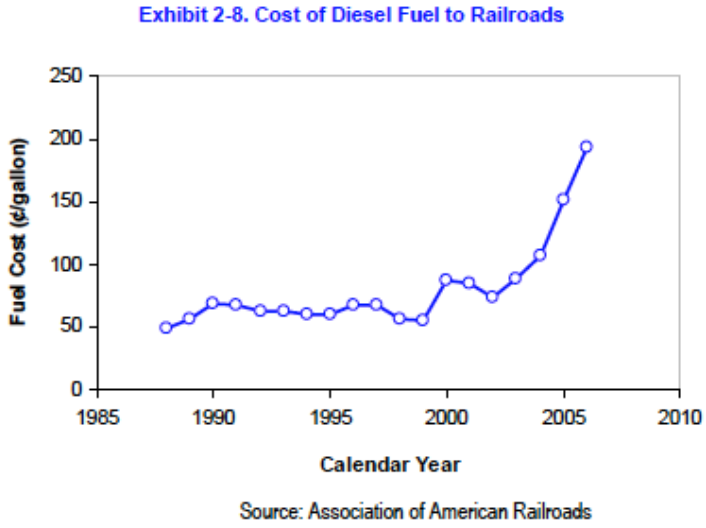
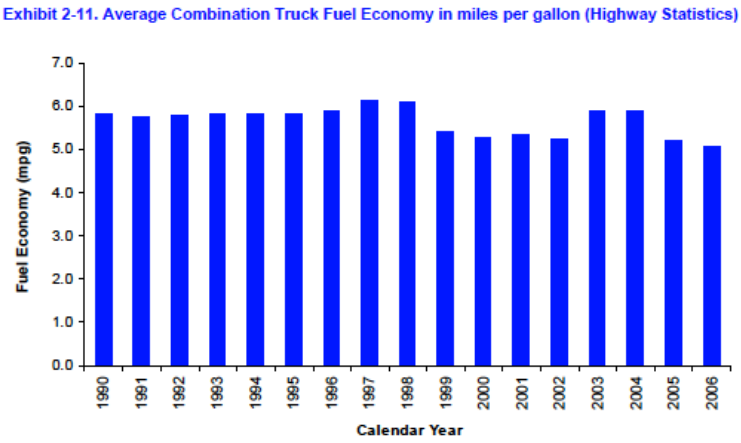


Exhibit 28. Average Combination Truck Fuel Economy in miles per gallon (Highway Statistics)



4.3 General Comparison of technologies: Rail and Truck Fuel Efficiency

Exhibits 29 summarize rail and truck movement characteristics and fuel efficiency findings. For all 23 competitive movements, rail fuel efficiency was higher than truck fuel efficiency, both measured in lading ton-miles per gallon. The rail-truck fuel efficiency ratio is a ratio between rail and truck fuel efficiency, and it is an indicator of how much more fuel-efficient rail is in comparison to truck.

Exhibit 29. Summary of Rail Movement Characteristics and Results

Movement	Equipment Type*	Distance (miles)	Grade Severity	HP per Trailing Ton	Average Speed (mph)	Payload (tons)**	Fuel Efficiency (ton-miles/ gallon)	Rail-Truck FE Ratio
1	BC	280	1.7	1.1	14	66	406	3.9
2	DS	294	1.8	1.5	31	38	384	5.5
3	G	133	1.3	1.9	31	73	301	2.3
4	BC	1,083	1.9	1.2	21	74	469	3.6
5	G	242	2.2	2.0	17	96	278	2.8
6	TOFC	790	2.0	1.6	27	15	273	3.2
7	CH	790	2.0	1.3	21	98	487	5.3
8	DS	352	1.4	1.4	31	30	373	5.5
9	CH	352	1.4	1.4	21	95	475	4.3
10	A	367	1.4	1.4	27	18	156	1.9
11	A	561	1.8	1.4	20	18	157	2.0
12	G	910	2.1	1.3	21	91	452	4.0
13	DS	450	2.2	1.9	31	30	226	2.7
14	DS	673	1.5	2.1	50	54	348	3.5
15	DS	1,415	2.0	2.7	45	69	361	3.9
16	DS	2,232	2.6	2.2	46	65	426	4.8
17	A	445	1.5	2.0	51	20	164	2.2
18	DS	1,805	2.0	1.7	39	70	449	4.6
19	DS	2,090	2.6	2.5	44	48	358	4.0
20	DS	1,034	1.5	1.6	41	50	512	5.1
21	DS	2,150	2.6	2.1	48	54	409	4.5
22	DS	1,484	1.7	1.7	37	39	490	5.2
23	TC	1,788	2.6	2.3	43	47	370	5.3

* A = Auto Rack; BC = Box Car; CH = Covered Hopper; DS = Double-stack; G = Gondola; TC = Tank Car; TOFC = Trailer on Flat Car

** Rail and truck payloads are different due to different equipment capacities. Rail payload for intermodal movements are based on two stacked containers.

Exhibit 30. Range of Rail-truck Fuel Efficiency Ratio by Rail Car Type

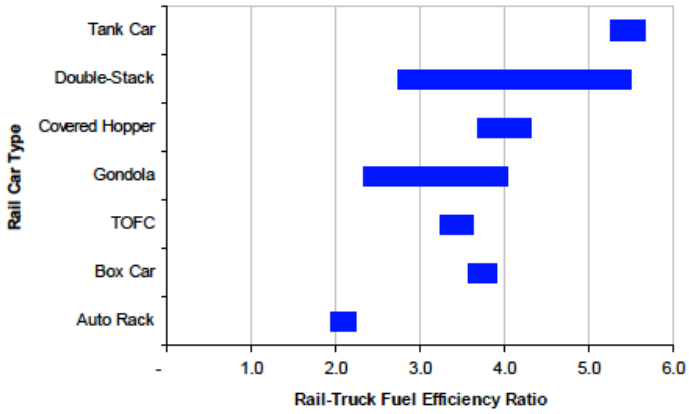


Exhibit 31. Future trends in rail and truck fuel efficiency

Future Trends in Rail and Truck Fuel Efficiency

Ongoing Improvements in Internal Combustion Engines

Strategy	Fuel Economy Gains (%)
Reduced internal friction	2%
Increased peak cylinder pressure	4%
Improved fuel injection (e.g., electronic unit injectors, electronic unit pumps, electronic distributor pump systems)	6%
Use of turbochargers and turbo-compounding	10%
Reduced waste heat and improved thermal management	10%

Exhibit 32. U.S. Heavy Duty Engine Emission Standards in g/bhphr

Model Year	CO	HC	NO_x	PM
1974-1978[a]	40.0			
1979-1983[b]	25.0	1.5		
1984-1987	15.5	1.3	10.7	
1988-1989	15.5	1.3	10.7	0.6
1990	15.5	1.3	6.0	0.6
1991-1993	15.5	1.3	5.0	0.25
1994-1997	15.5	1.3	5.0	0.1
1998-2003	15.5	1.3	4.0	0.1
2004-2006[c,d]	15.5	0.5	2.0	0.1
2007-2009[e]	15.5	0.14	1.0	0.01
2010+[e]	*15.5*	*0.14*	*0.2*	0.01
Improvement	61%	91%	98%	98%

[a] Combined HC+NOx emission standard of 16 g/bhp-hr
[b] Combined HC+NOx emission standard of 10 g/bhp-hr
[c] Under a consent decree with U.S. EPA, engine makers implemented the 2004 standards in October 2002.
[d] Standards allow option of 2.4 g/bhp-hr NMHC+NOx or 2.5 g/bhp-hr NMHC+NOx with a 0.5 g/bhp-hr NMHC cap.
[e] 2007/2010 standards start in 2007 and have a three-year phase in for the 0.2 g/bhp-hr NOx standard.

4.4 In a summary the studies says.

The train is more fuel efficiency than truck, it means considering the main cost factor, transport in train is cheaper than in trucks. It Must be remarked that it does not imply just rail lines must compose transport infrastructure, since truck is important for last mile, the system must be integration between both modalities

In the last years train has been developed since to achieve an improvement of 16% in technologic performance meanwhile the train development has been static on the same years.

If externalities are considered, train also has a superior performance giving as a result higher sustainability for ambient.

The fuel efficiency rates on exhibit 29, show in average that train is 4 times more fuel efficiency than trucks. It means it generates 4 times less cost in the main variable cost; fuel, (and also the most difficult to control because depend on the market) than truck system.

Based on this the next chapter is an analysis about cost and investment on transport infrastructure in Colombia.

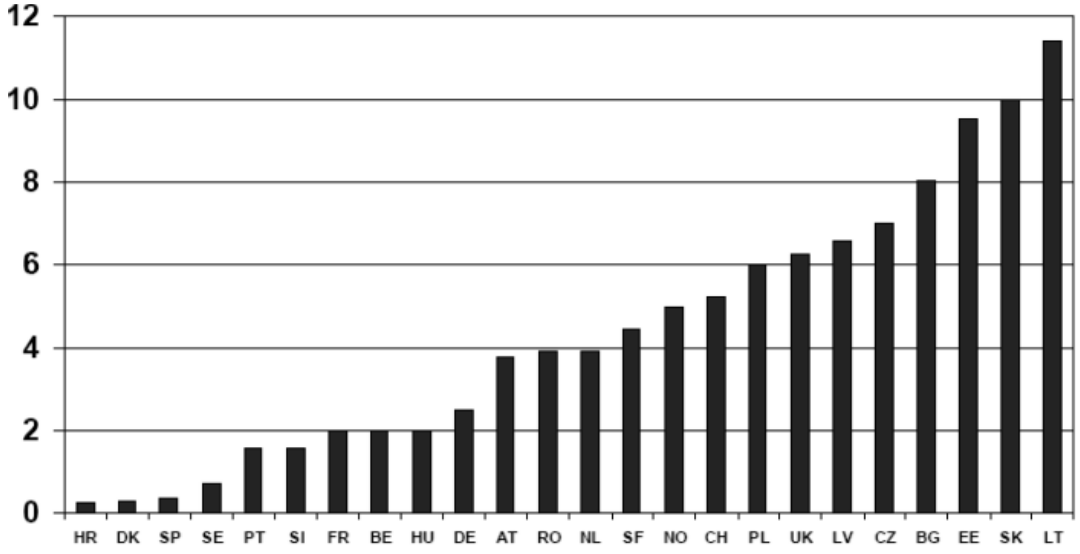
5. Train infrastructure proposal project. Nickel from Cerro Matoso, Montelíbano to Cartagena delivered by train.

5.1 Economic performance and characterization of operation strategy of railways in other countries

Assuredly, EU (Europe Union) has one of the most solid railway infrastructure system and strategy operations in the world. Train system performs its operation under a vertically disintegrated model, specifically, OA (open access). This pattern on operation is made up of an infrastructure controller, and operators.

Exhibit 33 shows the value charged to operators in different countries of EU. The value represents the opportunity cost to access to the use of the infrastructure, for freight trains until 2000 gross ton, thus 1000 net tons of freight. Basically the exhibit point over Croatia (HR) where the fee entry is about 0,20 euro gross Ton / KM. Conversely in the other side is Lithuania (LT), where the entry fee is around 11,20 euro Ton /KM[5].

Exhibit 33. Transport fee for freight train of 2000 gross Ton (Euro Ton/km).



Source: Thompson, Louis, Charges for the use of rail infrastructure 2008. International transport forum 2008.

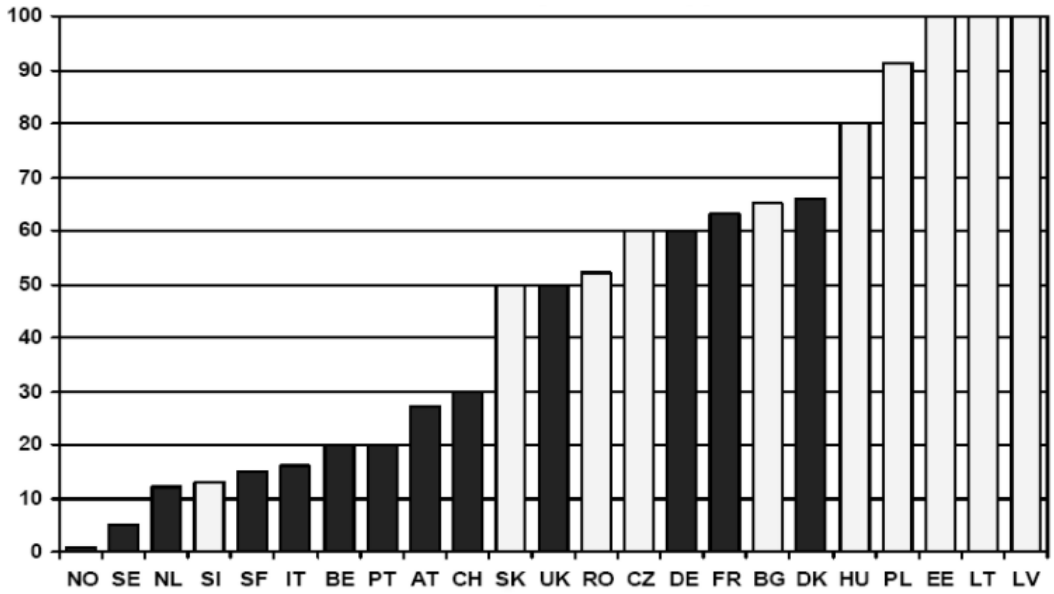
5

Exhibit 33. Transport fee for freight train of 2000 gross Ton (Euro Ton/km). Acronyms: Belgium (BE); Bulgaria (BG); Czech Republic (CZ); Denmark (DK); Germany (DE); Estonia (EE); Ireland (IE); Greece (EL); Spain (ES); France (FR); Croatia (HR); Italy (IT); Cyprus (CY); Latvia (LV); Lithuania (LV); Luxemburg (LU); Hungary (HU); Netherland (NL); Norway (NO); Austria (AT); Portugal (PT) Romania (RO); Slovenia (SI); Republic Slovakia (SK); Finland (FI); Sweden (SE); United Kingdom (UK).

Admittedly, in most of the cases the charged fee is not sufficient to cover TC (Total cost) of the infrastructure (Thompson 2008). As it follows, Exhibit 34 shows financial results obtained for administrative agencies of the railway infrastructure in 23 countries, in which where taken into account services of transport for freight and passengers.

From this 23 countries, eight of them cover at least 20% or less of their TC. Just five cover more than 60%.

Exhibit 34. Share (in %) of total infrastructure cost covered by access charges / revenues



Source: Thompson, Louis, Target Percent of Total Cost Covered by Infrastructure revenues. International transport forum 2008.

Hence, from a financial point of view, cost of operation must be shared between operators and governments. Consequently an APP (Association private-public) grant first requirement to overpass the financial unfeasibility. Next chapter shows how work APP's in Colombia.

5.2 Association private public, more convenient to the project train: Montelibano – Cartagena.

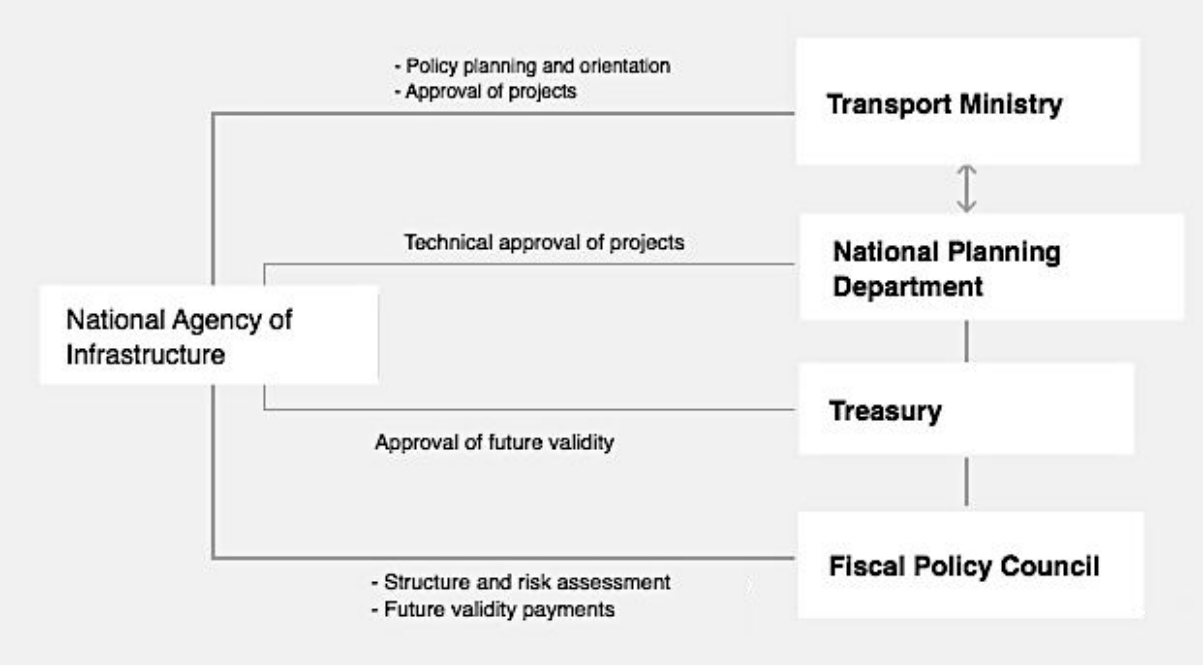
Ordinarily PPP or APP's have a source in projects proposed by governments and bedded by governments through competitive schemes in which are presented different companies from private sector, which contributes totally o partially the required to execute the project. Afterwards the private company manage the project for a period of time called "Project Horizon" in which obtain compensation coming from the service revenue[6].

[6] For Instance: A private company, which builds a motorway. Subsequently charge to the through the tolls, an amount of money, from which obtain its service revenue to compensate the initial investment.

In a framework PPP`s basically from private initiative USP (Unsolicited proposal), often this sort of PPP offers innovative solutions, which basically gives differentiation aspects or gives additional values which were not considered before. Alternatively PPP's with public initiative look for cover project within the national development plan.

Chiefly the different between the two types of PPP's previously mentioned lies at the end of project horizon. Basically, if a private company don't find feasible anymore a project could just abandon it, even if it is necessary from the public point of view. Hence the PPP adequate for the Railway Montelibano – Cartagena is an PPP with public initiative. In exhibit 35 could be appreciated the institutional framework used for the APP.

Exhibit 35. Colombian Institutional framework for PPP`s



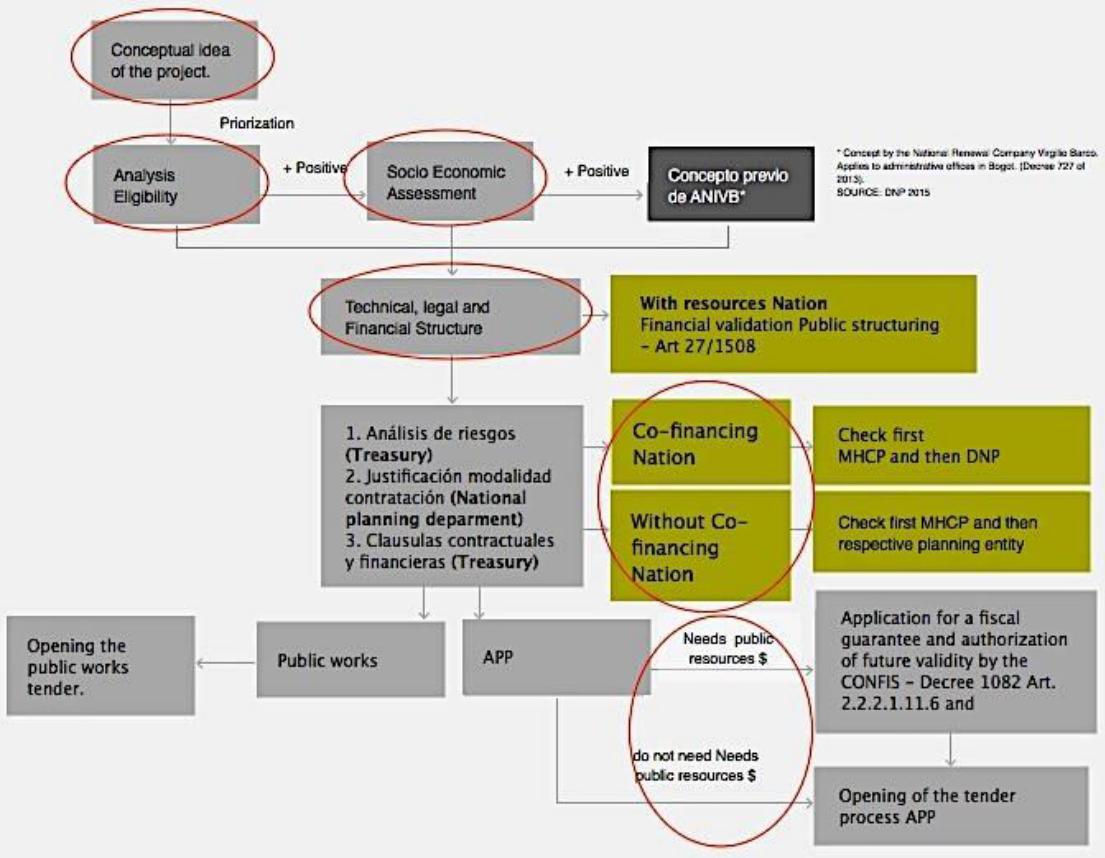
Source: Colombia ANI 2015.

Exhibit 35 provides the general road that any PPP follows before to be approved. Transport ministry and National Planning department are in charge to decide under a technical analysis how much useful could be for the country the execution of this project, meanwhile Treasury (Ministerio de Hacienda) and Fiscal Policy council, analyse from the financial point of view how much feasible is it. By mixturing the two analysis technical and financial, the result let we to elicit to the best answer for (EAPI) efficient allocation of public investment.[7].

[7] (EAPI) efficient allocation of public investment: Is called in this thesis to the capacity of a government to allocate public investment, considering: (firstly) the social benefit, (secondly) the urgent of this social benefit and finally the financial feasibility. For Instance: A town with 100,000 people need two projects: For an hospital and for a road. The hospital would be recovered from the financial point of view in 50 years, meanwhile the road would do it in 30. The hospital is to make the habitant life prevail. Hence the hospital implies a higher social urgent. Thus, would be more efficient to execute the project for the hospital than that one for the road.

In exhibit 36 it is possible to analyse how the internal process of an PPP with public initiative.

Exhibit 36. Process and structure of a Public Initiative APP



Correspondingly to the steps within red circles, there is information required by the national Intuitions in order to motivate the project until arrive the APP. In next paragraphs will be brake down the information required specially for this project that would be executed in a region, which in each national economic analysis shows highest levels of corruption and differences between social classes due to a wrong distribution of wealth.[8]

5.2.1 Conceptual idea of the project

In Montelibano Colombia is processed around 4% of the market share of global nickel market.

Since 1982 this commodity has being obtained from the mine Cerro Matoso.

8 Cerro matoso's output represents the 4% of world nickel output. However in Cordoba, department where is set Cerro Matoso, from 2014 to 2015 34 children younger than 5 year old died due to malnutrition and poor sanitary conditions (34 children have died of malnutrition in Córdoba, El Universa news paper). The average income of a poor family in Cordoba is around 200 USD monthly, meanwhile there are families in houses valued in 1 USD million and yachts and big extension of lands (called Haciendas) in the list of properties. Thus, There is a group of people living together in the same piece of land, made up by people poorer that poorer of Africa living with riches richer as a rich in Europe.

This thesis look for a project proposal through an (1) economic evaluation and (2) a feasibility analysis, to calculate if there is economic and social benefit by building an train line from Montelibano to Cartagena at North of Colombia around 350KM, to transport passengers and nickel until Cartagena where is set the port used to export the commodity to the world. (Basically: China, Spain, Italy and USA)

The analysis look for demonstrate that building a rail line is more socially efficient, since the large structure could benefit around 14 towns or cities like: Montelibano (65,000 habitants), La Apartada (15,000 habitants), Planeta Rica (68,000 habitants), Cienega de oro (64,000 habitants), Monteria (460,000 habitants), Sahagún(137,000 habitants), Chinú (48,000 habitants), Sincelejo (279,000 habitants), Tolú (33,000 habitants), San Onofre (50,000 habitants), San Antonio (not any info), Leticia (not any info), Turbana (15,000 habitants) Cartagena (980,000 habitants).

The rail line will offer:
Passenger service that will be useful to mobilize human resources from little towns to strategic points where are set more quantities of workplaces (it means cities like Cartagena, Monteria, Sincelejo, Sahagun, y Montelibano) and to mobilize people to the most touristic places like Cartagena, Coveñas y Tolu.
Merchandize service will transport Nickel from Montelibano to Cartagena, Cement from Tolu to Cartagena, and others like meat coming from local farmers and distributed in the 3 counties (Cordoba Sucre, and Bolivar)
Also the project works as a strategic connection line to link Caribe coast to centre and Pacific coast. As is shown in Exhibit 37.

Exhibit 37. The actual layout of rail line in Colombia and the proposed line by this thesis Montelibano - Cartagena

Source : Desafios del transporte ferroviario de carga en Colombia

In orange colour is represented the line proposed by this thesis, in red arrow is the line must be in the future, (it is expected orange line plus red one, would supply both services freight and passenger transport and will connect the most strategic commercial point of the country which are not exploited today). The rest lines the current operatives rail line in Colombia.

5.2.2 Analysis of eligibility, socioeconomic assessment and financial Structure

This analysis is based on the aspects that affect either positive and negatively in: society, infrastructure and country's economy. Let see how this project impact over this 3 aspects.

Eligibility Analysis.

a. The project will benefit directly around 2,214,000 habitants coming from the 14 stakeholder-towns called above, plus the habitants coming from towns benefited in an indirect way.

b. The project will influence next companies: Cerro Matoso (in Montelibano) main producer of nickel in the country. It contributes with around 0,5% of national PIB[9]. Argos (In Tolu) represents one of the strategic point of cement output of the country which has as exporting terminals Cartagena, Barranquilla and La Ceiba Venezuela additionally Tolú is central point for truism of Cordoba and Sucre counties. Furthermore Monteria is the 3th national beef producer[10].

Socio Economic assessment

a. The main Idea of this thesis is to prove that under social-economic investment coming mainly from, pubic subsidies, plus miner royalties the region composed by the three counties Cordoba, Sucre and Bolivar can improve the standard of life of their habitants. It seems to be something simple and brainless, until following lines show how is the life the habitants of Montelibano in comparison with the statistics of Cordoba. The statistics of Montelibano Are used as a sample since of the 14 towns.

*Total annual income per capita: Montelibano +/- 267 USD ; Cordoba 241 USD
*Population without water supply and sewage: Montelibano 47% Cordoba 48%.
*House quality shortage: Montelibano (69%), Cordoba (59%)
*Population with severity poverty: Montelibano (18%), Cordoba 29%, Colombia 8,5%.
*Number of violent death "each 100K habitants: Montelibano (79), Cordoba (35 without Montelibano`s)
*Child Mortality "each 100k children: Montelibano 41, Cordoba 38 (without Montelibanos rate)[11]

This information is coming from a study made by Guillermo Rudas, who concluded that miner royalties DO NOT generate substantial upgrades in the standard life over the habitants of Montelibano. Rudas is right, not because the royalties are useless, but because any royalty could build an improvement by their self when there is not capability to convert wealth in welfare. This social progress could be obtained by investing in dynamic projects, which concern to knowledge and economy, like transport.

9 Information coming from In a study about how nickel contribute to the Cordoba county is set "Economía del níquel. Impuestos, regalías y condiciones de vida de la población en Montelíbano (Córdoba) Guillermo Rudas. Bogotá, 14 de julio de 2010"
10 A report coming from Colombians Ranchers federation "FEDEGAN (Federacion Nacional de Ganaderos)" set that Cordoba is the 3th department with most participation in the national output of beef . http://www.fedegan.org.co/noticias/los-5-departamentos-de-colombia-con-mayor-numero-de-vacas

11 Information coming from In a study about how nickel contribute to the Cordoba county is set "Economía del níquel. Impuestos, regalías y condiciones de vida de la población en Montelíbano (Córdoba) Guillermo Rudas. Bogotá, 14 de julio de 2010"

b. Social problems normally are solved with pertinent investment, which look to cover, unemployment, health, education, transport, etc.

Growth in economic output is composed of two drivers: labour, capital and technology development. Thus, countries' economy will get better by investing in capital goods and production factors, technological progress and more capable persons in making goods or outstanding a service.[12]

Indeed, the turnkey railway Montelibano-Cartagena project is an investment that will generate work places at least in 4 years of the project execution, plus the vacancies during the project operation (60 years). The train would entail a decreasing of transport cost for freight and passenger, also embodies kind technology and innovation. Finally it represents a strategy of diversification of transport in the country. Likewise as it is set on the theory: production factors+ labour + capital+ technology. The result would be that the national economy would growth by transferring wealth to social welfare (it is possible to get impoverishing country growth).

c. Real salary is a factor that determines the qualitative life of the society, it also affect the level of employment and tax collection income. For instance: In Italy a minimum salary is around 600 and 700 euro per month. A worker, who found a job vacant 150 km away from his/her residential point, could use the train, at a cost of about 5 or 6 euro/journey. If this employee works 4 days a week, would have a monthly expenditure close to 160 euro. Thus, it represents 24% of his/her salary, in a trade-off between: the remaining wage and to wait at home without work until find a work vacant in a local place, this individual would accept the job with a remaining payoff equals 511 euro/month. In Colombia, the minimum monthly wage Is about 781,000 COP. A shared-taxi ticket from Montelibano to Monteria (150 KM) cost around 20,000 COP, go and return each day means 40,000 COP. If the employee works 4 days a week per month it imply 640.000 COP thus, 89% of the salary, this person will just refuse the job and keep in unemployment. This analysis applies also for farmers who must transport his/her small and medium-sized output. In the long run a higher quantity of people with stable working condition means a rising on country's rent since there is higher willingness to pay tax contribution.

The following paragraphs describe what happened in United States when was built Amarak train line, to connect New York with northeast cities Pensilvania, New York, New Jersey,

12 MACROECONO My, Rudiger Dornbusch, Stanley Fischer, Richard Startz

Manhatan and other. This train connects closed cities and make get better the employment rate of this region.

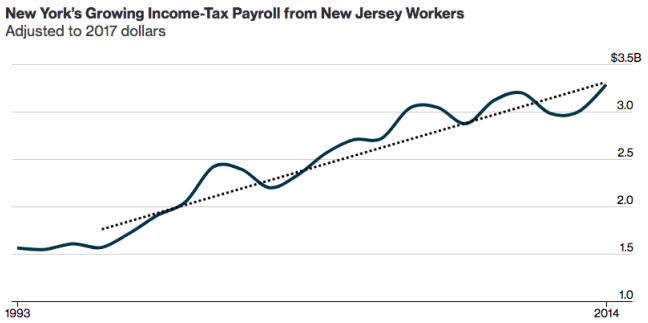
Amtrak, which calls Gateway "the most urgent infrastructure program in the country," knows that $30 billion is a big ask. The railroad's selling point: Even under the most conservative assumptions, Gateway benefits would amount to $2.16 for every dollar spent, or a ratio of 2.16.
It's easy to think of this as a New Jersey problem: It's their trains, their commuters. But Gateway may be a boon more to New York City than its neighbour. Almost 13 percent of Manhattan's workforce consists of New Jersey residents. For New York State, that represents more than $3 billion in payroll-tax revenue.
From 1950 to 2004, New Jersey gained 2.3 million jobs and New York City gained 82,000, according to Amtrak analysis of Bureau of Labor Statistics data. Then, the city began adding jobs in larger numbers than New Jersey. From 2004 to 2014, New York City added 550,000 jobs while New Jersey lost 27,000.
Wages for Manhattan workers on average are 92 percent higher, elsewhere in the region. In 2014, 14 percent of Manhattan's workforce consisted of New Jersey residents, and 8 percent of all New Jersey workers commute to Manhattan. The total income earned in Manhattan by New Jersey commuters is at least $33 billion annually.[13]

This is a reference on how train can help to build a virtuous circle where the main beneficiary is the society. Train is an instrument to make work the money at service of human being and not the contrary, how a normal business works: humans at service of money.

Exhibits 38 shows an increasing in income tax onNew Jesey, which is not generated by a reduction on tax income but generated by the capability to cover workplaces by decreasing logistics cost

13 https://www.bloomberg.com/graphics/2018-hudson-river-amtrak-tunnel-american-economy/

Exhibit 38. New Yorks growing income tax 1993-2014



Source : Bloomber news

Financial Structure

a. Savings due to technology change:

Before in chapter 7 was asserted the idea, train is around 4 times more efficient than truck. Then:

Lets take, as assumption 42.362 ton is the average as it is shown in exhibit 39.

According to UPME[14] Cerro Matoso pays around 0.36 USD/Ton*KM.

A ton from Montelibano to Cartagena (350 Km) = 0.36 USD/Ton*KM *350 Km = 126 USD/Ton. Then, to transport the entire nickel output in truck cost 5,337,612 USD Millions. If trucks companies ensure in their service a mark-up close to 1,25. Inconsequence the real cost is 4,270,089 USD Millions and revenues are 1.067.522.4

Exhibit 39. Cerro Matoso's Annual Nickel output from 2010 to 2017

Year	Output
2010	49.443
2011	37.817
2012	51.595
2013	49.320
2014	41.221
2015	37.000
2016p	36.500
2017p	36.000
Average	**42.362**

Source: MME. Sistema de Información Minero Colombiano, SIMCO. https://www.minminas.gov.co/anuario-estadistico-minero

Nonetheless the proposal to this thesis is to extend and scale up the country transport matrix (50/50 train-truck), thus half of the nickel output will be mobilized in trains. It would grant as train service revenue of 2,668,806 USD (5.337.612/2). Applying same value for mark-up operation cost would be 2,135,044 USD. Afterwards, by applying what was proved by

[14] Unidad de planeacion Minero Energetica , In English Mining and Energy Planning Unit Resolution 576 2017

FEDERAL RAILROAD ADMINISTRATION "Train is around four time less costly thanks truck". Thus the train real cost is 533.762 USD (2,135,044/4) and actual revenues are 2.350844 USD.

b. To invest miner royalties in a dynamic projects, those ones which grant a virtual circle in which the invested money would serve as a booster for the economy looking to benefit everyone. Exhibit 40, shows the total amounts (current values in Colombian pesos) paid by Cerro Matoso to Colombia. As well is appreciated that all assignee towns for royalties, will be also benefited by the train. The proposal is to allocate 20% the royalties in the train construction by during next 60 years. If it is esteemed that royalties would get in average an amount of 141.000 Millions COP [(Σ of miner royalties form year 2004 to year 20011)/ 8]. Then, 20% of the average turns on 28,250 Millions COP (141,000 COP *0,20). Finally under a currency conversion to dollars it entails to 9,4 million dollars (28,250 Million COP /3.000)[15]

Exhibit 40. Nickel`s mining royalty allocation by town and Entities

Nickel Mining royalties allocation by town.	Years					Millones de pesos corrientes		
	2004	2005	2006	2007	2008	2009	2010	2011
Ayapel	2.788	3.874	4.928	10.292	5.322	3.305	5.305	5.618
Buena Vista	1.743	2.421	3.080	6.432	3.326	2.065	3.316	3.415
La Apartada	1.743	2.421	3.080	6.432	3.326	2.065	3.316	3.415
Montelíbano	13.593	18.886	24.023	50.172	35.525	22.223	35.677	36.026
Planeta Rica	2.788	3.874	4.928	10.292	5.322	3.305	5.305	5.463
Pueblo Nuevo	2.440	3.390	4.312	9.005	4.656	2.891	4.642	4.780
Puerto Libertador	3.137	4.358	5.544	11.578	5.987	3.718	5.968	6.146
CVS	20.950	29.108	36.954	77.181	39.908	24.782	39.785	40.971
Gobernación de Córdoba	19.170	26.634	33.878	70.755	50.830	31.806	51.062	50.106
Total Córdoba	*68.351*	*94.967*	*120.725*	*252.139*	*154.200*	*96.160*	*154.376*	*155.941*
Cartagena	697	969	1.232	2.573	1.589	991	1.592	1.594
Fonpet	3.962	5.504	6.988	14.594	9.849	6.155	9.881	8.628
Fondo Nacional de Regalías	1.333	1.852	2.352	4.911	3.528	2.208	3.544	3.478
DNP - Interventorías	526	730	881	1.840	1.201	750	1.204	1.208
Ingeominas - Autoridad minera	1.314	1.826	2.202	4.599	3.002	1.875	3.010	3.020
4 x 1000	305	423	538	1.123	693	433	694	695
Total Others	*8.136*	*11.305*	*14.192*	*29.640*	*19.863*	*12.412*	*19.926*	*18.623*
TOTAL	**76.488**	**106.271**	**134.917**	**281.779**	**174.063**	**108.572**	**174.302**	**174.564**

Source : Economía del níquel. Impuestos, regalías y condiciones de vida de la población en Montelíbano (Córdoba)

c. The National government of Colombia assigns national income in 3 levels. Deposit to towns, to counties and Central Government. Thereupon, by a financial cooperation between the 14 towns (between which there are 3 capital county cities), plus a counties' financial aid (Cordoba, Sucre and Bolivar), together a subsidy from central government, could be achieved an amount of 33 Million USD. As follow: the group of 14 towns will contribute 22

[15] To consider :1USD costs 3,000 COP

USD million, the group of Counties 7 Million and Central Government Subsidiary based in 4 millions USD, with 4 extra for contingency.

Exhibit 41 shows the investment of each town to achieve the 22 USD million between the group of 14 towns. It must to be emphasized that 2,2 million of persons could be beneficed just by investing 9.5 USD/year, it means and investment of 570 USD dollars in the next 60 years.

Exhibit 41. Allocation of contribute group of 14 towns

#	Town	Habitants x 1000	% Contribute to provide	Financial Contribute (USD)
1	Montelibano	65	3%	646,766.17 $
2	La Apartada	15	1%	149,253.73 $
3	Planeta Rica	68	3%	676,616.92 $
4	Cienaga de Oro	64	3%	636,815.92 $
5	Monteria	460	21%	4,577,114.43 $
6	Shagaun	137	6%	1,363,184.08 $
7	Chinu	48	2%	4,77,611.94 $
8	Sincelejo	279	13%	2,776,119.40 $
9	Tolú	33	1%	328,358.21 $
10	San Onofre	50	2%	497,512.44 $
11	San Antonio	Not contribute	Not contribute	Not contribute
12	Laticia	Not contribute	Not contribute	Not contribute
13	Turbana	12	1%	119,402.99 $
14	Cartagena	980	44%	9,751,243.78 $
		2211	**100%**	**22,000,000.00 $**

d. Finally, under an assumption in which each habitant made 1 travel (go and return) each 2 months (thus six travels a year) in which each single journey is valued at 3,5 USD, thus the entire travel go and return valued at 7 USD. Not revenues made by other companies and by tourist are taken into account. Thus, 92.862.000 USD.

Exhibit 42 shows contribution the source where is coming the financial contribution to built this turnkey project.

Exhibit 42. Source of financial contribution to execute the turnkey railway project Montelibano-Cartagena

Source	Amount(USD Million)
Royalties	9,4
Towns	22
Counties	7
Central Goverments	4
Revenues	~93
Total	***128,4***

Exhibits 43, 44, 45 and 46 display the result of the financial analysis. Basically:

Exhibit 43 shows the general condition used for the financial feasibility. A study of the Rail Infrastructure in Africa shows a benchmark of project in which Railwais :

China: Yichang-Wenzhou, length 377 KM were invested 9,1 USD M/km

UK: Glasgow to Edinburgh, Lengh 75 KM were invested 6,6 USD M/km

Zambia-Angola: Chingola- Benguela railway line, length 554 KM were invested 1,98 USD M/KM

Ethiopia: Mieso-Djibouti border railway line, length 339 KM were invested 3,53 USD M/KM

For this the Rail Line Montelibano-Cartagena will be considered 4 USD M /KM (all inclusive) for a total of 1,4 billion to be executed in for years

Exhibit 43. General condition under which is made the financial analysis of feasibility

General Condition	
Total USD / KM	USD 4,000.000,00
Turnkey Construction	USD 1,400.000.000,00
Gross Government Contribution Year	USD 50,420.000,00
Costs	USD 17.500.000,00
Inflation rate	2,50%
Cost of equity	13,00%
ST debt nom rate	6,70%
LT debt nom rate	8,20%
Initial fee	**1,00%**
Interest rate (positive balance)	1,00%
Interest rate (negative balance)	10,00%
Tax rate	20%

Train and operation cost in an European system expend between 30.000 and 50.000 USD/KM in this case were used 50.000USD /KM turning in a yearly amount of 17,500.000 USD

Cost of equity at 13% was considered in a first instance under which the project was financed by private projects

Inflation rate, cost of equity ST/LT debt nom rates, Interest rates (positive/negative) balance were considered like if it were a PPP with private .

Exhibit 44. Financial analysis of feasibility (unleveraged scenario)

	4 constuction years				start-up year	56 operating years										
Item/ Years	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Turnkey Construction	$-350.000.000,00	$-350.000.000,00	$-350.000.000,00	$-350.000.000,00												
Revenues					$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00
Public subsidie					$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00
(O&M) Costs					$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00
Dep. and Amr					$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33
Financial Charges		$-100.000,00	$-100.000,00	$-27.417.965,38	$-26.156.958,22	$540.832,34	$601.781,86	$532.799,16	$471.254,45	$416.842,55	$368.733,25	$326.192,15	$288.571,35	$255.299,10	$225.870,67	$199.840,35
EBIT	$-350.000.000,00	$-350.100.000,00	$-350.100.000,00	$-377.417.965,38	$76.291.708,45	$102.989.499,01	$103.050.448,53	$102.981.465,83	$102.919.921,11	$102.865.509,22	$102.817.399,92	$102.774.858,82	$102.737.238,02	$102.703.965,77	$102.674.537,34	$102.648.507,02
Taxes					$-11.443.756,27	$-15.448.424,85	$-15.457.567,28	$-15.447.219,87	$-15.437.988,17	$-15.429.826,38	$-15.422.609,99	$-15.416.228,82	$-15.410.585,70	$-15.405.594,87	$-15.401.180,60	$-15.397.276,05
EBIAT	$-350.000.000,00	$-350.100.000,00	$-350.100.000,00	$-377.417.965,38	$64.847.952,18	$87.541.074,15	$87.592.881,25	$87.534.245,95	$87.481.932,95	$87.435.682,84	$87.394.789,93	$87.358.629,99	$87.326.652,31	$87.298.370,90	$87.273.356,73	$87.251.230,97
Unlevered CF	$-350.000.000,00	$-350.100.000,00	$-350.100.000,00	$-377.417.965,38	$88.181.285,52	$110.874.407,49	$110.926.214,58	$110.867.579,29	$110.815.266,28	$110.769.016,17	$110.728.123,27	$110.691.963,33	$110.659.985,65	$110.631.704,24	$110.606.690,07	$110.584.564,30
UCF under inflation	$-350.000.000,00	$-309.823.008,85	$-274.179.653,85	$-261.569.582,16	$54.083.233,84	$60.178.186,31	$53.279.916,04	$47.125.444,62	$41.684.255,24	$36.873.325,49	$32.619.214,92	$28.857.135,07	$25.529.910,23	$22.587.066,85	$19.984.035,26	$17.681.449,25
NPV	$-619.743.932,44															

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00
$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00
$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00
$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33
$176.814,49	$156.445,31	$138.425,50	$122.483,47	$108.379,16	$95.900,36	$84.859,43	$75.090,46	$66.446,74	$58.798,51	$52.031,02	$46.042,75	$40.743,92	$36.055,10	$31.906,01	$28.234,51
$102.625.481,16	**$102.605.111,98**	**$102.587.092,16**	**$102.571.150,13**	**$102.557.045,83**	**$102.544.567,02**	**$102.533.526,09**	**$102.523.757,13**	**$102.515.113,41**	**$102.507.465,18**	**$102.500.697,69**	**$102.494.709,42**	**$102.489.410,59**	**$102.484.721,76**	**$102.480.572,68**	**$102.476.901,18**
$-15.393.822,17	$-15.390.766,80	$-15.388.063,82	$-15.385.672,52	$-15.383.556,87	$-15.381.685,05	$-15.380.028,91	$-15.378.563,57	$-15.377.267,01	$-15.376.119,78	$-15.375.104,65	$-15.374.206,41	$-15.373.411,59	$-15.372.708,26	$-15.372.085,90	$-15.371.535,18
$87.231.658,99	**$87.214.345,18**	**$87.199.028,34**	**$87.185.477,61**	**$87.173.488,95**	**$87.162.881,97**	**$87.153.497,18**	**$87.145.193,56**	**$87.137.846,40**	**$87.131.345,40**	**$87.125.593,03**	**$87.120.503,01**	**$87.115.999,00**	**$87.112.013,50**	**$87.108.486,78**	**$87.105.366,00**
$110.564.992,32	**$110.547.678,51**	**$110.532.361,67**	**$110.518.810,95**	**$110.506.822,29**	**$110.496.215,30**	**$110.486.830,51**	**$110.478.526,89**	**$110.471.179,73**	**$110.464.678,74**	**$110.458.926,37**	**$110.453.836,34**	**$110.449.332,33**	**$110.445.346,83**	**$110.441.820,11**	**$110.438.699,33**
$15.644.530,86	**$13.842.549,58**	**$12.248.346,58**	**$10.837.915,92**	**$9.590.035,63**	**$8.485.942,60**	**$7.509.045,89**	**$6.644.673,94**	**$5.879.851,37**	**$5.203.102,08**	**$4.604.275,34**	**$4.074.392,19**	**$3.605.509,78**	**$3.190.601,48**	**$2.823.450,97**	**$2.498.558,57**

32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00
$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00
$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00
$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33
$24.985,59	$22.110,58	$19.566,46	$17.315,11	$15.322,84	$13.559,83	$11.999,68	$10.619,06	$9.397,30	$8.316,12	$7.359,33	$6.512,64	$5.763,36	$5.100,29	$4.513,51	$3.994,23
$102.473.652,25	**$102.470.777,25**	**$102.468.233,12**	**$102.465.981,78**	**$102.463.989,51**	**$102.462.226,49**	**$102.460.666,35**	**$102.459.285,73**	**$102.458.063,97**	**$102.456.982,78**	**$102.456.026,00**	**$102.455.179,30**	**$102.454.430,02**	**$102.453.766,95**	**$102.453.180,17**	**$102.452.660,90**
$-15.371.047,84	$-15.370.616,59	$-15.370.234,97	$-15.369.897,27	$-15.369.598,43	$-15.369.333,97	$-15.369.099,95	$-15.368.892,86	$-15.368.709,60	$-15.368.547,42	$-15.368.403,90	$-15.368.276,90	$-15.368.164,50	$-15.368.065,04	$-15.367.977,03	$-15.367.899,14
$87.102.604,41	**$87.100.160,66**	**$87.097.998,15**	**$87.096.084,51**	**$87.094.391,08**	**$87.092.892,52**	**$87.091.566,40**	**$87.090.392,87**	**$87.089.354,37**	**$87.088.435,37**	**$87.087.622,10**	**$87.086.902,41**	**$87.086.265,52**	**$87.085.701,91**	**$87.085.203,15**	**$87.084.761,77**
$110.435.937,75	**$110.433.494,00**	**$110.431.331,49**	**$110.429.417,84**	**$110.427.724,41**	**$110.426.225,85**	**$110.424.899,73**	**$110.423.726,20**	**$110.422.687,71**	**$110.421.768,70**	**$110.420.955,43**	**$110.420.235,74**	**$110.419.598,85**	**$110.419.035,24**	**$110.418.536,48**	**$110.418.095,10**
$2.211.058,49	**$1.956.645,63**	**$1.731.510,90**	**$1.532.283,98**	**$1.355.982,73**	**$1.199.968,43**	**$1.061.906,21**	**$939.730,02**	**$831.611,67**	**$735.933,40**	**$651.263,70**	**$576.335,80**	**$510.028,74**	**$451.350,57**	**$399.423,48**	**$353.470,69**

48	49	50	51	52	53	54	55	56	57	58	59	60
$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00	$92.862.000,00
$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00	$50.420.000,00
$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00	$-17.500.000,00
$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33	$-23.333.333,33
$3.534,71	$3.128,05	$2.768,18	$2.449,71	$2.167,88	$1.918,47	$1.697,76	$1.502,44	$1.329,59	$1.176,63	$1.041,26	$921,47	$815,46
$102.452.201,37	**$102.451.794,71**	**$102.451.434,84**	**$102.451.116,37**	**$102.450.834,54**	**$102.450.585,14**	**$102.450.364,42**	**$102.450.169,10**	**$102.449.996,26**	**$102.449.843,29**	**$102.449.707,93**	**$102.449.588,14**	**$102.449.482,13**
$-15.367.830,21	$-15.367.769,21	$-15.367.715,23	$-15.367.667,46	$-15.367.625,18	$-15.367.587,77	$-15.367.554,66	$-15.367.525,37	$-15.367.499,44	$-15.367.476,49	$-15.367.456,19	$-15.367.438,22	$-15.367.422,32
$87.084.371,17	**$87.084.025,51**	**$87.083.719,62**	**$87.083.448,92**	**$87.083.209,36**	**$87.082.997,37**	**$87.082.809,76**	**$87.082.643,74**	**$87.082.496,82**	**$87.082.366,80**	**$87.082.251,74**	**$87.082.149,92**	**$87.082.059,81**
$110.417.704,50	**$110.417.358,84**	**$110.417.052,95**	**$110.416.782,25**	**$110.416.542,69**	**$110.416.330,70**	**$110.416.143,09**	**$110.415.977,07**	**$110.415.830,15**	**$110.415.700,13**	**$110.415.585,07**	**$110.415.483,25**	**$110.415.393,14**
$312.804,81	**$276.817,55**	**$244.970,61**	**$216.787,62**	**$191.847,03**	**$169.775,81**	**$150.243,82**	**$132.958,94**	**$117.662,62**	**$104.126,09**	**$92.146,88**	**$81.545,84**	**$72.164,40**

Exhibit 45. General conditions to executethe financial analysis of feasibility taking into account a LCF.

Debt-Equity scenario	
DSCR	1
Total CAPEX'	$1.400.000.000
Debt	$897.367.220
Equity	$502.632.780
Rd	7,83%
Re	5,15%
R_{wacc}	6,11%

Exhibit 46. Financial analysis of feasibility considering a LCF

Item/ Years	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
UCF Initial fee	$-350.000.000,00	$-350.100.000,00	$-350.100.000,00	$-377.417.965,38	$88.181.285,52	$110.874.407,49	$110.926.214,58	$110.867.579,29	$110.815.266,28	$110.769.016,17	$110.728.123,27	$110.691.963,33	$110.659.985,65	$110.631.704,24	$110.606.690,07	$110.584.564,30
LCF Initial fee under Rwac	$-350.000.000,00	$-329.931.547,64	$-310.924.953,23	$-315.876.828,88	$69.550.996,94	$82.411.909,94	$77.700.639,54	$73.185.778,90	$68.937.171,77	$64.938.746,23	$61.175.182,50	$57.632.194,73	$54.296.446,93	$51.155.476,87	$48.197.627,90	$45.411.987,85
NPV' (Rwacc)	**$138.588.317,12**															
IRR	**0,65%**															

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
110.564.992,32 €	110.547.678,51 €	110.532.361,67 €	110.518.810,95 €	110.506.822,29 €	110.496.215,30 €	110.486.830,51 €	110.478.526,89 €	110.471.179,73 €	110.464.678,74 €	110.458.926,37 €	110.453.836,34 €	110.449.332,33 €	110.445.346,83 €	110.441.820,11 €	110.438.699,33 €
42.788.333,82 €	40.317.082,34 €	37.989.244,05 €	35.796.382,45 €	33.730.576,17 €	31.784.384,47 €	29.950.815,46 €	28.223.296,89 €	26.595.649,13 €	25.062.060,28 €	23.617.062,97 €	22.255.512,92 €	20.972.568,99 €	19.763.674,54 €	18.624.540,17 €	17.551.127,46 €

32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
110.435.937,75 €	110.433.494,00 €	110.431.331,49 €	110.429.417,84 €	110.427.724,41 €	110.426.225,85 €	110.424.899,73 €	110.423.726,20 €	110.422.687,71 €	110.421.768,70 €	110.420.955,43 €	110.420.235,74 €	110.419.598,85 €	110.419.035,24 €	110.418.536,48 €	110.418.095,10 €
16.539.633,96 €	15.586.478,94 €	14.688.290,25 €	13.841.891,91 €	13.044.292,45 €	12.292.674,07 €	11.584.382,39 €	10.916.916,86 €	10.287.921,74 €	9.695.177,64 €	9.136.593,56 €	8.610.199,39 €	8.114.138,89 €	7.646.663,06 €	7.206.123,91 €	6.790.968,61 €

48	49	50	51	52	53	54	55	56	57	58	59	60
110.417.704,50 €	110.417.358,84 €	110.417.052,95 €	110.416.782,25 €	110.416.542,69 €	110.416.330,70 €	110.416.143,09 €	110.415.977,07 €	110.415.830,15 €	110.415.700,13 €	110.415.585,07 €	110.415.483,25 €	110.415.393,14 €
6.399.733,95 €	6.031.041,18 €	5.683.591,08 €	5.356.159,40 €	5.047.592,48 €	4.756.803,20 €	4.482.767,14 €	4.224.518,92 €	3.981.148,85 €	3.751.799,64 €	3.535.663,44 €	3.331.978,97 €	3.140.028,79 €

6. Results

Exhibit 44 shows that it is not possible to execute a train project under private conditions. A NPV of -619,743,932.44 USD M.

Exhibit 45 is a support for the analysis that table 46 presents.

A DSCR (Debt-Service Coverage Ratio) is based in 1, included Revenues and Governments' subsidies. A debt valued in 897 USD million used to leverage the project under which the project becomes feasible. Supported in a Re and Rd, 7,83% and 5,15% respectively emerges and Rwacc based in 6,11% to leverage the project. It turns in a positive NPV of around 138 USD million with a positive IRR valued in 0,68 indicating is possible to execute the Railway Line Montelibano Cartagena by beneficing companies, job opportunities, entrepreneurs projects, company operations and improving social conditions.

7. Conclusions

1. Train is more profitable than truck when must be transported high quantities of a product (commodity) but truck will be always needed for last mile
2. Unreceptive from which transport system is better between train and trucks, "the land transport infrastructure" cannot be composed by only one of them. From the strategic point of view diversification on investment gives less faculty to external issues to impact on countries' economy. Thus, investment in land transport system must be balanced.
3. Train is an infrastructure essential to get higher rates of growth on economy, its efficiency on logistic cost generates higher saving values with which could be generate value in other socio-economy sectors.
4. Alike most of the cases in Unites States of America and Europe, a railroad from Montelibano to Cartagena is not feasible from the self-support financial point of view. It must be supported by the states. This investment involve in an investment of 10 dollars by year (600 USD per habitant in next 60 years) over the 2,2 million of habitants of 14 towns.
5. The railway Montelibano-Cartagena will activate the economy of Cordoba, Sucre and Bolivar. A cut down on the logistic cost of small and medium enterprisers will rise the capability to open job vacancies, which are going to be cover by a labour force, who shall find favourable to cover vacancies jobs even away from home.
6. A virtual circle would be generated: Less cost in transport of merchandize, increase capacity to contract labour hand, it will increase the production, hence train will acquire economies scale to reduce more prices and so on until arrive to a convergence
7. To get more active labour hand under worthy work condition is the way to get out from poverty is the real meaning of social-economic investment.
8 The Colombia output matrix must be moved away from commodity rent. The primary sector cannot be the Colombian economy saver; production and service must be the main contributors of national GDP.

8. Next Steps

1. To measure the financial saving in transport of human resources and merchandize that would be generated if the rail line Montelibano- Cartagena is buit.
2. To measure the actual contribution of the small and medium enterprises to the train, it would generate higher revenues on the train and it would be more feasible than the proposal raised in this thesis.
3. To measure the revenues if is considered this rail line such as the backbone of North Coast and Pacific Coast, it would provide more revenues even than point 2.
4. To measure Gini Index in Cordoba, Sucre and Bolivar, which now a day are in the group of higher index, due to weak capability to distribution wealth. And to measure it each ten year after executes the project.

Under real study, to analyse real feasibility of a train corridor from Montelibano to a Cartagena, and to star it until be impacted by external.

This profitable Colombian corridor must be analysed and complemented by a train system, which can generate more social efficiency by giving better transport service at lower price, thus more value creator system.

9. Some fundamentals of rail to take into account

• Freight transport train is typically competitive over mid to long distances but it usually loses its attractiveness in shorter journeys because short journeys is the same last mile where car/truck must execute its contribution.

• Rail requires high volumes to be feasible, and it is a business of high volumes.

• Road and railway transport are both competitive and complementary. They compete over long distance but road transport is required for the "last mile."

• Railway infrastructure is rigid, expensive and requires an operating and maintaining.

• The performance of the operator is highly dependent on the conditions of the infrastructure and rolling stock.

• Rail freight and rail passenger transportation are very different businesses.

• Most rail projects around the world require high levels of subsidy for the construction and/or operations to be sustainable. Train often brings economic, social and environmental benefits compared with other transport modes.

• including appropriate stakeholders in the concessionaire's shareholding improves Project performance in the case of PPPs.

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