

#### FACILITATION OF TRANSPORT AND TRADE IN LATIN AMERICA AND THE CARIBBEAN

## Road transport in Latin America: evolution of its infrastructure and impact between 2007 and 2015

#### Background

Investing in road transport infrastructure is essential to the development of both the sector and the economy as a whole: it connects people and provides them with access to different public services and markets, including those for goods, services and jobs. Offering more and better road connections allows more affordable and more fluid transportation of people and goods, because it promises improvements in the effectiveness and security of operations for an optimal expansion of infrastructure in accordance with needs, which leads to lower costs and increased efficiency in personal mobility and cargo logistics. All this should have a positive influence on the dynamics of the markets served by logistics chains that largely depend on ground transport.

In this way, the benefits of more and better road infrastructure are reflected in the competitiveness, efficiency and aggregate costs of the economy, provided that the negative externalities of the deployment and use of infrastructure —such as air, water and ground pollution, accidents, greenhouse gas emissions, congestion and noise pollution— are avoided or minimized. Those external costs affect people's living conditions and so have consequences for society as a whole. In addition, if those external costs are not taken on board —in other words, if they are not covered by the fees paid by users or by the private costs of the supplier company— the private cost will be lower than the social cost (or the social benefit will be lower than the private benefit), which will encourage the non-efficient use of resources and favour projects to the detriment of others with a lower social cost. In such a situation, infrastructure and its benefits are not sustainable.

ECLAC, as an organization of the United Nations, is working to fulfil the 2030 Agenda for Sustainable Development; thus, in keeping with Sustainable

This issue analyses data on investments in Latin American road infrastructure between 2007 and 2015, examines the subsector's evolution and emphasizes the negative repercussions of accident fatalities and carbon emissions. It aims to raise awareness about the importance of this mode of transport in the region and to underscore the need for socioeconomic evaluations of road projects and for additional, better and more transparent data and information on the sector, using a cross-cutting approach in pursuit of sustainable development. The bulletin's authors are Pablo Chauvet and **Baptiste Albertone of the Natural Resources and** Infrastructure Division of ECLAC. Input was also provided by Rolando Campos Canales, a consultant with that Division.

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The views expressed in this document are the sole responsibility of the authors and do not necessarily reflect the opinions of the Organization.

#### Background

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Development Goal 9, it seeks to promote the building of resilient infrastructure<sup>1</sup> and inclusive and sustainable industrialization and innovation. Transport is a component of economic infrastructure and, within it, the roads subsector plays a crucial role in moving people and goods in Latin America.<sup>2</sup>

This FAL Bulletin aims to guide the countries' agendas towards efficient, inclusive, clean, resilient and safe infrastructure: all necessary qualities that are a part of the principles that underpin comprehensive and sustainable logistics and transport policies.<sup>3</sup> It offers an overview of the recent evolution of the physical infrastructure of the road transport sector in Latin America ("the region"), taking into account the public and private investment channelled into the sector (section II). It then compares its negative environmental and social impact with economic performance, examining, first, greenhouse-gas emissions and the number of traffic accident fatalities and, second, gross domestic product. In other words, indicators of intensity and elasticities are used to determine whether economic performance and investments in the sector were coupled to those negative impacts or not (section III). Finally, section IV offers a summary of those descriptions and analyses and proposes recommendations for enhancing the sustainability of the region's road infrastructure.

#### I. Investment, stock and quality in the Latin American roads subsector

Investment in infrastructure and the provision of infrastructure services in the region's countries is inadequate, inefficient and unsustainable. That is the first assessment set out the introduction to the paper by Sánchez and others (2017), which shows that the simple average investment in infrastructure as a proportion of GDP, for a group of six selected countries, stood at 2.2% between 2000 and 2015,

with public and private investment almost balanced (51% and 49%, respectively), at a time when, according to the growth forecasts for the region's economy, the estimated levels of infrastructure investment required (including maintenance and repairs) should have ranged between 5.1% and 7.4%.<sup>4</sup> According to the data cited in that document, the investment allocated to the transport sector —specifically, roads and railways— amounted to 39.1% of the overall total for the 2000–2015 period. In terms of the six countries' GDP, that was the equivalent of a simple average annual investment in this transport subsector of 0.8% between 2000 and 2015, with public funds far outstripping private investment (70% and 30%, respectively).<sup>5</sup>

To focus on road transport, the following section analyses the evolution of investment in that subsector between 2008 and 2015 in 14 of the region's countries. Together, this group of countries accounts for 78.5% of the region's GDP and 80.1% of its population (according to ECLAC data for 2008–2015). Taking this as representative sample, and using data from Infralatam (http://www.infralatam.info/) for the period in question, it can be concluded that the region's average annual investment in the roads subsector was 0.7%, with similar levels of public and private participation as indicated above for roads and railways taken together in the six countries (72% and 28%, respectively). First, this regional percentage does not reflect the wide variation between the countries' willingness to invest in relation to their GDP, as can be seen on figure 1. Second, compared with benchmark countries from other regions, it can be concluded that the region's effort is not far below --or even surpasses— that made by such developed economies as Germany, the United States and the European Union (27 countries), but is below the figures for China, the Republic of Korea and Japan. The explanation for this, however, could be related to the stock and quality of road infrastructure already attained by those developed economies and to the pursuit of infrastructure development policies, either recently (as in the case of China) or, alternatively, that began long ago as part of comprehensive, long-term approaches (such as the experiences of Germany and the Republic of Korea, analysed by Cipoletta, Pérez and Sánchez, 2010).

<sup>&</sup>lt;sup>1</sup> Several definitions of resilience exist, including "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" (UNISDR, 2017).

<sup>&</sup>lt;sup>2</sup> According to figures from some of the region's countries, it can be estimated that road cargo haulage accounts for more than 80% of the total volume of goods carried. At the national level, roads also account for a majority of people's journeys. In Chile, for example, roads carry 92.7% of the country's total goods tonnage (Association of Engineers of Chile, 2016) and for 60.9% of intercity passengers (CONICYT (2010); in Uruguay, they account for 99% of public passenger transport and 97% of domestic haulage (Cáceres and Farinasso, 2013).

<sup>&</sup>lt;sup>3</sup> The paper by Jaimurzina, Pérez and Sánchez (2015) sets out and explores the vision proposed for logistics and mobility policies (goods haulage and passenger transport) by the ECLAC Natural Resources and Infrastructure Division. Specific issues related to energy efficiency in road haulage and at ports, security of road haulage operations, road safety and other topics have been dealt with in earlier FAL Bulletins (past issues of which are available at https://repositorio.cepal.org/handle/11362/60).

<sup>&</sup>lt;sup>4</sup> The selected group of countries comprises Argentina, Brazil, Chile, Colombia, Mexico and Peru. Data and information from those countries were used to estimate the infrastructure investment needed in Latin America to respond, over the 2016–2030 period, to "demand" caused by growth in the economy and in the economically active population and to an unmet "need" for living standards (such as universal access to basic services, including electricity, fixed broadband, and water and sanitation). For regional GDP growth forecasts of 2.5%, 3.2% and 3.9% a year, the estimated infrastructure investment needs (including maintenance and repairs) would be 5.1%, 6.2% and 7.4%. For further details on the results and an explanation of the methods used, see Sánchez and others (2017).

<sup>&</sup>lt;sup>5</sup> All the percentages for shares of investment (for the public and private sectors and for the road and rail subsectors) cited thus far are calculated in current dollars in accordance with records for the six selected countries.







Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from Infralatam [online database] http://www.infralatam. info/ [accessed on: 20 September 2018]; and International Transport Forum (ITF), "Transport infrastructure investment and maintenance", ITF Transport Statistics [online database] https://doi.org/10.1787/g2g55573-en [accessed on: 17 September 2018].

Latin America (14 countries)

Average 2008-2015

Note: Figures for the Republic of Korea and Japan do not include private investment, and those for India do not include investments by public-private partnerships; data for Germany do not include maintenance expenses; European Union (27 countries) does not include Cyprus.

Dividing annual road investments by the countries' total populations yields an average, for Latin America (14 countries), of US\$ 64 per capita (at 2010 constant prices) between 2008 and 2015. Wide variations within the region can again be seen in this indicator, and those countries that tended to invest the most in terms of GDP and population were Chile, Colombia, Costa Rica, Panama, Peru and the Plurinational State of Bolivia. Comparing the region to the selected benchmark countries, the difference between the region's average per capita investments and those of the developed economies, the European Union and even China is more pronounced, with average per capita investment amounts among the latter group of more than US\$ 150 dollars over 2008 to 2015 (see figure 2).

As shown on figure 3, the investment trend in Latin America (14 countries) over the 2008–2015 period was slightly upwards, with two years (2009 and 2014) notably above the averages (0.7% of GDP and US\$ 64 per capita). The region reported its minimum GDP in 2009 and its maximum in 2014; thus, regardless of the heterogeneity that might be hiding behind the averages and the need for a closer study of the topic, the countries in general applied a countercyclical policy for road infrastructure spending in 2009 and a procyclical policy in 2014. Of the group of 14 countries, those reporting a clearly rising trend in road investment between 2008 and 2015 were Colombia, Nicaragua, Panama, Paraguay, Peru, the Plurinational State of Bolivia and Uruguay. Then,

comparing the regional trend with that of the selected benchmark countries reveals that only China and India reported an upward trend in road investment over the period in question (in the remaining economies, in contrast, the trend was pronouncedly downwards).



- Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from Infralatam [online database] http://www.infralatam.info/ [accessed on: 13 September 2018]; World Bank, World Bank Open Data [online database] https://data.worldbank.org/ [accessed on: 20 September 2018]; and International Transport Forum (ITF), "Transport infrastructure investment and maintenance", ITF Transport Statistics [online database] https://doi.org/10.1787/g2g55573-en [accessed on: 17 September 2018].
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Infrastructure investments in the roads subsector can be measured, albeit with some limitations, by the road stock. In Latin America (17 countries), the ratio of total road length to land area<sup>6</sup> increased by slightly over 8% between 2007 and 2015 —that is, by 1% annually— to reach 18 km of roads for each 100 km2 of territory. With the exception of Brazil, as can be seen on figure 4, all the countries increased their road densities between 2007 and 2015 and, in ten of them, the increases were greater than the regional average. Particularly notable were the improvements in Peru and Colombia, followed by those of Uruguay, the Plurinational State of Bolivia, Costa Rica, Nicaragua and Panama. As noted above, this reflects subsector investment trends in the countries in guestion (that is, rising rates of investment, on average above the regional figure; with the exception of Uruguay, where the rate has been rising, but on average more slowly than in the region as a whole). The countries with the highest road densities by land area in 2015 were Costa Rica, Uruguay, the Dominican Republic and El Salvador. These were followed, with results slightly above the average for the selected 17 Latin American countries, by Panama, Nicaragua, Mexico, Argentina, Brazil and Colombia. Nevertheless, those relative stock figures fail to take account of the quality of the infrastructure: the majority of the region's highways are not main roads, they use different designs and technologies and, because many are not surfaced, they are not fit for purpose (or for the weights they carry, in terms of either cargo or passengers). In Latin America (17 countries), in 2015 slightly below 18% of the total road network was surfaced, for a total of 3 km of roads per 100 km<sup>2</sup> of territory. Variations within the region can be seen in this indicator: nine of the countries report figures above the average percentage, notably El Salvador, the Dominican Republic, Guatemala, Panama and Mexico, where the proportion of paved roads represents more than 40% of the total. Comparing the density of paved roads to land area, a particularly good result was also reported by Costa Rica (alongside the Dominican Republic and El Salvador), with more than 20 km per 100 km2. The levels of quality in the countries' road stock can also be assessed through the evolution of investment in the subsector and,

<sup>e</sup> Land area and not total surface area is used for the indicator. Hence, areas covered by bodies of water —both inland and offshore, such as rivers and coastlines— are excluded from the calculation. as will be seen below, through analyses of opinion surveys on road quality. Thus, as can be seen below on figure 5, with the exception of Costa Rica, these five countries reported quality assessments for 2015–2016 that were above the regional average (albeit with a pronounced downward trend in El Salvador and Guatemala).

At the same time, all the selected benchmark countries —developed and developing alike— reported increases in their total road networks between 2007 and 2015. Particularly noteworthy were the relative changes in the Russian Federation, India, Germany and China. The rate of change within the European Union (27 countries) was similar to that of Latin America (17 countries), while that of the remaining developed countries was below the Latin American average. In addition, with the exception of the Russian Federation, those economies greatly outstrip the region in terms of total road network density (expressed in relation to land area).





Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from World Bank, World Bank Open Data [online database] https://data. worldbank.org/ [accessed on: 20 September 2018]; Organization for Economic Cooperation and Development (OECD), OECD.Stat [online database] https:// stats.oecd.org/; and Economic Commission for Europe (UNECE).

Note: Figures for Ecuador are from 2008 and 2014; data for Germany are from 2007 and 2012.

As already stated, the quality of road transport infrastructure can also be assessed through perception surveys, such as those sent out by the World Economic Forum (WEF) to company executives for calculating the Global Competitiveness Index (GCI). The GCI is based on three subindices that involve 12 pillars covering 114 indicators.<sup>7</sup> The basic requirements subindex contains the infrastructure pillar and several

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<sup>&</sup>lt;sup>7</sup> For additional details and explanations about the methods used to construct the GCI, see WEF (2017).

related indicators, one of which is road quality. Specifically, the indicator is based on the following question: "In your country, how is the quality (extensiveness and condition) of road infrastructure?" Replies cover a range of seven answers, from 1 (extremely poor; among the worst in the world) to 7 (extremely good; among the best in the world).

As can be seen on figure 5 below, the score for Latin America (19 countries) in the most recent 2017/2018 survey was 3.6, which represents a slight improvement over the results in 2007/2008 (3.2) and 2015/2016 (3.5). Although this indicator is a regional average, which conceals the variations that exist among the region's countries, with some scoring much higher than others, the gap between the countries fell slightly during the period under study (measured both by range and by the ratio of change). This was the result of improved appraisals of road quality in 15 of the 19 countries (in contrast, the score fell for Chile —which nevertheless remains the region's leader— and for El Salvador, Guatemala and Uruguay). At the same time, eight countries reported scores above the regional average, a result that has not changed since the 2007/2008 survey. Comparing the region to the selected benchmark economies, the improvement in Latin America (19 countries) is dwarfed by the progress made in India, China and the Russian Federation, as well as by that of Japan and the European Union (27 countries). In addition, the region remains below those economies and betters only the Russian Federation (when in the 2007/2008 survey it also was ahead of India).8

In the region's countries, the number of vehicles-which traverse those countries' roads and, in some cases, those of their neighbours, making use of their capacity and generating direct and indirect effects, both positive and negative— is a catalyst for demand for the subsector's infrastructure. In Latin America (17 countries), the total vehicle fleet by population rose by more than 59% between 2007 and 2015 —that is, by around 6% a year— to reach a total of 322 vehicles per 1,000 inhabitants. As shown on figure 6, all the countries increased their fleets during this period. Particularly notable were Paraguay, which more than doubled its vehicles-to-population ratio, and Colombia and the Plurinational State of Bolivia, which were very close to matching Paraguay's performance. Another seven countries — Ecuador, Uruguay, Brazil, Honduras, Argentina, Guatemala and Panama— reported results higher than the regional percentage change. El Salvador was the country with the slowest fleet growth (close to 3% a year), but that figure was still higher than the rate of expansion in subsector investments and in the physical road stock. That situation was repeated in almost all the region's countries: greater relative growth in their vehicle fleets compared to the expansion in infrastructure investments and in the road stock.<sup>9</sup> As an additional data point, passenger cars, sports cars and SUVs (including taxis) for passenger transport make up approximately 56% of the region's fleet (this percentage is an estimate since vehicle classification methods vary from one country to the next or, in some countries, breakdowns do not exist at all).



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Economic Forum (WEF), "The Global Competitiveness Index dataset 2007–2017", Geneva, 2017 [online] http://www3.weforum.org/docs/GCR2017-2018/GCI\_Dataset\_2007-2017.xlsx.

Note: The road quality index for each country is calculated from the average ratings reported; for further details on those calculations, see WEF (2017).

<sup>&</sup>lt;sup>a</sup> As an additional data point, the three countries of the world with the best score on the road quality indicator in the 2017/2018 survey (WEF, 2017) were the United Arab Emirates (6.37), Singapore (6.35) and Switzerland (6.35). Those with the worst results were Mauritania (2.01), the Democratic Republic of the Congo (2.05) and Hait (2.06).

The exception was Peru, where the relative growth rate in the vehicle fleet was lower than the rate of growth in the total road stock but higher than that of subsector infrastructure investments. Nevertheless, road stock quality —expressed as the proportion of paved roads— is low.

Comparing with the selected benchmark countries, vehicle fleet growth in China and India was higher than that of Latin America (17 countries); China's expansion, in particular, was explosive, with the number of vehicles per 1,000 inhabitants tripling between 2007 and 2015. In the Russian Federation, the growth of the fleet-to-population was not marginal; in contrast, for the developed countries and the European Union (27 countries), the growth rate in this indicator was lower than that of the Latin American country with the least change (El Salvador). In Germany, the indicator even fell slightly over the study period. Again it can be seen that the developed countries, and also China, report more similar figures for growth in investment and road stock and for the expansion of their vehicle fleets.



- Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from World Bank, World Bank Open Data [online database] https://data. worldbank.org/ [accessed on: 20 September 2018]; Organization for Economic Cooperation and Development (OECD), OECD.Stat [online database] https:// stats.oecd.org/; and Economic Commission for Europe (UNECE).
   Note: "Automobiles" covers four-wheeled passenger cars, SUVs and sports cars
- Note: "Automobiles" covers four-wheeled passenger cars, SUVs and sports cars intended for the conveyance of passengers, including taxis (collective vehicles, such as buses, and lorries, pick-up trucks and others, such as tractors, are not included); disaggregations performed according to information from national sources, when possible; the number of automobiles in Uruguay includes trucks, buses and ambulances; figures for India are for 2007 and 2013.

# II. Damaging effects of road infrastructure and its use in Latin America

Along with the positive effects of road infrastructure on the economy, its agents and society as a whole, it also has negative repercussions. These are more cross-cutting in nature and persist over time: in other words, they have an intergenerational impact. The most notable and worrying examples are the deaths and injuries caused by accidents, and the pollution created by both vehicles and the infrastructure itself. In the region, taken as meaning the 20 countries of Latin America, the negative externalities in 2015 —measured not in monetary terms, but in the number of traffic accident fatalities and the volume of carbon dioxide (CO<sub>2</sub>) emissions were estimated at 93,500 people and 548.6 million tons, respectively. The death figure is equal to 15.4 people per 100,000 inhabitants in the region, and the emissions represent 34.3% of the total CO<sub>2</sub> emissions generated by total fuel consumption, making road transport the sector that contributes the largest share of emissions.<sup>10</sup> It should also be noted that traffic accidents were the ninth most common cause of death in the region in 2015 (the same position as in 2007).<sup>11</sup>

There are other forms of negative externalities that must be measured and assessed, in monetary terms as far as is possible. For instance, the private transport costs paid by households and companies do not correspond to the social costs borne by society, which leads to the inefficient use of the economy's resources. Thus, for example, if using a mode of transport creates costs that are not charged for, demand for that mode of transport could be encouraged while at the same time undermining another form of transport with lower costs to the community. Moreover, it generally holds true that transport is the sector that receives the largest share of public infrastructure investment. According to Infralatam data for Latin America (14 countries), between 2008 and 2015 this sector accounted for 47.7% of public infrastructure investment (followed by energy with 35.1%, water with 14.9% and telecommunications with 2.6%).<sup>12</sup> Within that total, the road transport subsector accounted for the largest portion, receiving 78.2% of all public investment in the sector (followed by the river and maritime-port subsectors with 8.6%, railways with 7.8% and air transport with 5.3%).

Thus, given the significant impact of the roads subsector and its substantial participation in the policies and budgets of the region's governments, the search for a better rationale for public spending —and the imposition of levies on taxpayers and/or the charging of user fees, particularly at times of account deficits and economic and financial instability— requires the use of socioeconomic evaluation or calculation tools that take due account of externalities in choosing between infrastructure projects, in decision-making regarding rules and regulations and in the decisions of private economic agents, such as individuals, households and companies.

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<sup>&</sup>lt;sup>10</sup> The figure for traffic accident fatalities was estimated by the ECLAC Natural Resources and Infrastructure Division using national sources from 19 of the 20 countries (Haiti was excluded because information was not available) and so the calculation method may vary from one country to the next. The figure for road transport fuel CO<sub>2</sub> emissions was calculated for the 20 countries on the basis of IEA (2018).

<sup>&</sup>lt;sup>11</sup> This estimate was calculated for the 20 countries from the data catalogue of the Global Health Data Exchange (GHDx) of the Institute for Health Metrics and Evaluation (IHME) (see [online] http://ghdx.healthdata.org/). In 2017, this cause of death was the tenth most common in the 20 countries; traffic accidents rank outside the top ten causes of death in only four countries, and in two of them it is in the top five.
<sup>12</sup> For the same sample of countries and year range, 57.5% of the region's total investment

<sup>&</sup>lt;sup>12</sup> For the same sample of countries and year range, 57.5% of the region's total investment in infrastructure came from public funds and 42.5% was private. The sector breakdown of private infrastructure investment was as follows: energy, 47.9%; transport, 36.3%; telecommunications, 11%; and water, 4.8%.

The Government of France provides an example of efforts to measure transport both from the sectoral point of view, with annual transport statistics (e.g. *Les comptes des transports*)<sup>13</sup> and in monetary terms (in other words, its socioeconomic impact). The Boiteux II Report covers the latter aspect, and it also includes the methodologies used to estimate the monetary cost of externalities.<sup>14</sup> More recently, the paper by Auverlot and others (2016), which summarizes a series of discussions on the socioeconomic evaluation of public investment projects, offers an overview of methods and progress with the topic of appraising different aspects of externalities: value of human life, biodiversity, carbon (on account of greenhouse gases), agglomeration effects and natural disasters (on account of climate change).

Road transport externalities can be classified into three groups according to the dimensions of sustainability: economic (such as benefits related to accessibility, benefits related to economies of agglomeration, costs related to the depreciation of infrastructure through use, costs related to congestion and costs related to accidents); environmental (such as costs related to greenhouse gases, costs related to air pollution, costs related to noise and visual pollution, costs related to the occupation of spaces and soil artificialization and costs related to the destruction of ecosystems and damage to biodiversity); and social (such as benefits related to accessibility, benefits related to collective and human-powered modes of transport, costs related to low levels of safety, costs related to morbidity and mortality and costs related to the occupation of urban spaces) (CGDD, 2013).

Data and information are needed for socioeconomic evaluations and for the creation of indicators to measure the performance of infrastructure and its related services; however, in the region's countries, there is a dearth of such resources. In the roads subsector, for example, only some countries have up-to-date statistics on their road stock by surface type, or on their vehicles by type and age. Neither do they have data series covering operations, such as cargo or passenger movements. The absence of data, information and, consequently, indicators is not limited to the roads subsector; it also affects the other transport subsectors. This hinders any attempt to analyse and assess the sector's situation and evolution.

Given that limitation, and in light of the importance of roads over other modes of transport and the role that they play in different processes —not only logistical, productive and commercial, but also cultural, political, social and other ways in which people interact— an analysis of the subsector illustrating the harmful effect that development processes can entail as a result of the relationship between economic growth, transportation and its externalities is proposed. Transport activities tend to increase as a result of economic growth, and that relationship feeds back into itself, depending on its behaviour and the incentives created, and on the performance and location of economic activity, through productivity, investment and employment (Venables, Laird and Overman, 2014). This can lead to an expansion in the vehicle fleet, vehicle flows and distances travelled, but also to a rise in traffic accidents. In turn, this is related to increases in energy consumption,  $CO_2$  emissions and other negative externalities that can lead to environment deterioration and a lower quality of life (Loo and Banister, 2016).

This discussion therefore accepts that economic growth is desirable (and necessary for developing countries), but not at the cost of the environment and the quality of life. This leads to the concept of decoupling and, in the context of this document, of decoupling the negative externalities of road transport from economic growth. The proposal for this analysis, therefore, involves repeating a part of the exercise set out in the paper by Loo and Banister (2016).<sup>15</sup> This work expands the theoretical debate and the methodology for decoupling transport to cover the three dimensions of sustainability. To that end, the authors focused on a group of 15 countries over a period of 22 years to examine the evolution of the relationship between economic expansion (growth in incomes and in transport activities) and transport's environmental and social externalities (CO<sub>2</sub> emissions and fatalities). These two negative externalities of transport were chosen because they "represent examples of environmental and social costs associated with rising levels of mobility". The work seeks to identify situations where good practices were employed to reach the goal of sustainable economic growth with a minimal negative impact on the environment and society.

In keeping with Loo and Banister (2016), to measure the decoupling of the negative externalities of transport from economic growth, two indicators are used that, taken together, allow the construction of a general frame of reference. The first indicator is the elasticity of the negative externality i of transport with respect to income:<sup>16</sup>

<sup>&</sup>lt;sup>13</sup> See [online] http://www.statistiques.developpement-durable.gouv.fr/donneesdensemble/1924/874/ensemble-comptes-transports.html.

<sup>&</sup>lt;sup>14</sup> The Boiteux II Report is the name given to the General Planning Commission's document Transports: choix des investissements et coût des nuisances (CGP, 2001).

<sup>&</sup>lt;sup>15</sup> Loo and Banister (2016) explain that the concept of decoupling transport from economic growth has become popular, as growth in the economy is seen as desirable but it should not be contingent on similar growth in the use of carbon-based transport. They add that decoupling entails both immaterialization (decoupling production and material consumption from economic production; e.g. indicators of energy intensity or transport intensity) and dematerialization (decoupling environmental damage from production or material consumption; e.g. indicators of carbon intensity in energy or of carbon intensity in transport). Decarbonization, measured as carbon intensity within the economy, is an example of dematerialization.

<sup>&</sup>lt;sup>16</sup> In their paper the authors do not specify how they calculated elasticity, for which reason this document uses the midpoint method.

$$E_i = \frac{\Delta x_i}{\Delta Y} \frac{\overline{Y}}{\overline{x_i}}$$
(1)

Where  $\Delta xi$  is the quantity change in the negative externality i of transport,  $\overline{x_i}$  is the average quantity of the negative externality i of transport,  $\Delta y$  is the change in income or GDP and  $\overline{Y}$  is average income or GDP. The second indicator is the intensity of the negative externality i of transport with respect to income:

$$I_i = \frac{X_i}{Y}$$
 (2)

Where  $x_i$  is the amount of the negative externality *i* of transport and *Y* is income or GDP.

In the case at hand, *i* can be either tons of  $CO_2$  equivalent generated by the roads subsector through the burning of fuel in all its activities or the number of traffic accident fatalities. Income or GDP has been calculated as dollars at constant 2010 values.

The indicators for intensity  $(I_i)$  and elasticity  $(E_i)$  define four decoupling and coupling relationships (out of a possible total of eight) between income and negative externalities at the national or regional level:

- Relative decoupling: when income (Y) and the negative externality i (x) change in the same direction, but intensity (I) decreases.
- Absolute decoupling: when income (Y) rises or holds steady and the negative externality i (x<sub>i</sub>) decreases and, consequently, intensity (I<sub>i</sub>) decreases.
- Relative coupling: when income (Y) and the negative externality  $i(x_i)$  change in the same direction but intensity (I) rises.
- Absolute coupling: when income (Y) decreases or holds steady and the negative externality i (x) rises and, consequently, intensity (I) rises.

relationship can be and of decoupling if the

Table 1 Frame of reference for changes in the relationship between income and the negative externalities of transport

	Decoupling ( <i>l<sub>i</sub></i> decreases)		Coupling (l <sub>i</sub> rises)	
	Strong	Weak	Strong	Weak
Absolute ( <i>Ei</i> negative)	$\bigvee I_i; E_i \leq -1$	$\psi I_i$ ; -1 < $E_i$ < 0	$\uparrow I_i; E_i \leq -1$	$\uparrow I_i$ ; -1 < $E_i$ < 0
Relative ( <i>Ei</i> positive)		$ eq I_i; 0 < E_i < 1 eq$	$\uparrow I_i; E_i \ge 1$	$\uparrow I_i$ ; <b>0</b> < $E_i$ < 1

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of B. Loo and D. Banister, "Decoupling transport from economic growth: extending the debate to include environmental and social externalities", *Journal* of Transport Geography, vol. 57, December 2016.

The green cells indicate the four possible decoupling relationships: the darkest green indicates the optimal situation —the most desirable from the perspective of sustainability— with strong absolute decoupling, where income growth is accompanied by a reduction in the negative externality associated with transport, and, in addition, in absolute values, the relative change in income is lower than the relative change in the externality. The red cells do the same for the possible coupling relationships: the darkest red indicates the worst situation, the least desirable for transport sustainability, in that it entails strong absolute coupling, where income falls at the same time that the negative externality of transport rises, and, in addition, in absolute values, the relative change in income is lower than the relative change in the externality.

If the indicators and this frame of reference are used to conduct the exercise for the region's countries —in this case, Latin America (19 countries)— with respect to traffic accident fatalities, a negative externality of road transport with immediate social and economic repercussions, the results reveal an improvement during the 2007 to 2015 study period. This was on account of a weak relative decoupling (lower intensity due to change in the same direction, but with the externality changing to a lesser extent) during the

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