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Correlation between Sectoral GDP and the Values of Road Freight Transportation in Colombia

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Abstract: A correlation between economic development and road freight is demonstrated in the literature review provided in this paper. This relationship was studied in relation to the global gross domestic product (GDP) of the countries under review. Therefore, this paper presents the validation of this correlation in the Colombian case, based not only on global GDP, but also on the GDP for each of the main economic sectors of the country. The correlation was analyzed using several of the following statistical methods: correlation using the non-parametric method (Spearman), the causality relationship using the Granger test, the relationship between variables using Principal Component Analysis (PCA), and multivariate correlation to establish the level of significance of each economic sector by means of the *p*-value. The study concludes that the best correlation is between the GDP of some economic sectors and the amount of freight transported one year later.

Keywords: cargo transport; correlation GDP; Colombia road cargo index

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1. Introduction

The importance of the participation of cargo transportation in any country is undoubted, with a large number of documents that support it through the analysis of various indicators, and it is a fundamental principle in transportation economics theories. Therefore, it is vitally important for each country or region to not only have statistical data on the performance of cargo and passenger transportation, but they must also be analyzed with respect to macroeconomic variables that allow for the projection of their behavior, and thus have reliable bases for decision making, both by government entities and by companies in the industrial and transportation sectors.

This study is based on Colombia as a case study, because, even if there are official databases that record macroeconomic information about the country and the road freight transport sector, there is no study that correlates them. Additionally, it is important to disaggregate the national economy into its main sectors in order to reach better defined conclusions than simply analyzing the behavior of global GDP.

Understanding the behavior of economic cycles in periods of crisis and its relationship with the amount of freight transported in a country supports planning for the construction or improvement of road infrastructure, which, in the case of a developing country like Colombia, becomes a fundamental tool for social and economic growth.

In context, in the last decade, 3,204,000,000 tons of cargo were moved in Colombia throughout all transportation modes, with the highest participation coming from road transportation, with 2,574,097,000 tons (80%) (Ministry of Transportation, Republic of Colombia 2022). Nevertheless, in recent years (2019 to 2023), cargo transportation in Colombia, whether dry products (kg) or liquid (gal), has not displayed a significant correlation

with the economic condition, measured from the national gross domestic product (GDP). The above is a result of analyzing the data presented by the National Administrative Department of Statistics (DANE) (National Department of Statistics DANE, Republic of Colombia 2023) and the Ministry of Transportation (Ministry of Transportation, Republic of Colombia 2023).

Worldwide GDP has been regarded as one of the key indicators to explain freight transport demand. GDP rules the demand for freight transport through the size of consumer demand and on the sectoral structure of the economy. In reviewing the state of the art in the relationship between cargo transportation and economic development, it is found that the former drives the markets of key sectors of the economy. Therefore, the historical behavior of load indicators should be correlated with the economic performance of a country or region, measured from the GDP (Maparu and Mazumder 2017; Mishra 2019), based on the premise that the investment in transportation and logistics has a relevant impact on better economic development indicators.

This research focused on road freight transportation because it is the mode with the greatest impact on freight transportation in Colombia, due to the orographic complexity and because the region with the highest consumption of goods and services is the capital city (Bogotá), which is located in the central area of the map, far from the coasts. Additionally, rail and river development for multimodal cargo transportation does not cover a significant area of the country. This means that the road mode of transportation presents data with higher participation than the other modes of freight transportation. Usually, the relation between economic development and freight transport is used to make forecasts of future aggregate freight flows and volumes. Generally, GDP is used as an indicator for economic activity in a region or a country (Meersman and Van de Voorde 2013).

Given the above, the principal contribution of this research is the use of the GDP time series for each of the main sectors of the economy (established by the government entity that reports official statistics in Colombia, the National Administrative Department of Statistics). With this information and the time series of road freight transport data, this paper presents a correlation analysis between the two variables, using several methods of proven statistical validity. The causality of one variable with respect to the other is also identified, and the period in years in which one affects the other with the best correlation is obtained.

Finally, in the Discussion section, aspects resulting from the main analysis are evaluated, such as the significance of the participation of the different economic sectors in correlation with freight transport, whether the correlation with the global GDP or with the sectoral GDP is better, and whether the correlation would have been very different if there had been no COVID-19 pandemic period.

In summary, this document presents the validation of the correlation and causality between the economic development of the different economic sectors and the quantity of cargo transported by road. The validation was developed through correlation using the non-parametric method (Spearman), the causality relationship using the Granger test, the relationship between variables using Principal Component Analysis, as well as the application of linear correlations to determine the level of significance of each of the independent variables by means of their respective *p*-values, and the significance of the linearity of the correlation by means of the resulting adjusted R^2 and *p*-values.

Literature Review

In Mexico's case, German-Soto et al. (2023) concluded that the urbanization process depended on the improvements in transportation, but transportation required economic development. In another document, Lopez-Rodriguez and Pardo-Rincon (2019) stated that the economic growth of a state depends largely on the exchange of products generated with countries in the rest of the world, thus highlighting the relevance of international trade; from this perspective, road cargo transportation plays a relevant role in the logistics that support the success of commercial transactions abroad. They conclude that the land

cargo transportation sector is one of the most dynamic segments in society and that the importance of transportation for the economy arises from the impact on the performance of other sectors. The majority of producers use transportation in some stage of its production and distribution processes, in such a way that the efficiency and transportation rates affect the international competitiveness of national products and the well-being of the consumer. In this way, transportation is directly related to the economy.

Alam (2014) states that investment in road logistics corridors in South Asian countries have positively impacted the region's GDP growth. In the same theoretical trend, Chen et al. (2015) developed a model based on the economy cycle theory for predicting Shanghai container shipping market crises. Choi et al. (2018) used sixty independent variables in the development of an early-warning index, some of which include shipping, shipbuilding, and finance. McKinnon (2007) exposed the behavior between GDP and the road ton km, which represents two-thirds of the UK's domestic freight market, and thereby exerts a strong influence on the relationship between economic growth and the total freight ton km. Gao et al. (2016) exposed that, "As the fundamental and leading industry for national economic and social development, the development of transportation industry determines the trend of economic development and reflects the cyclical changes of national economy. Freight, as the basis of transportation industry, is closely related to GDP development".

Xue et al. (2023) analyzed (in China's case) the correlation between the overall GDP and railway transportation growth trends, and concluded that "the growth rate of railway operating mileage in the period of rapid economic development was equal to the economic growth rate, which indicates that railway transportation is closely related to economic development". In other article about China, Yang (2021) affirmed that the relationship between freight transportation and economic development is close, and that development promotes the growth of freight transportation.

In Mexico, the Mexican Transport Institute concluded that the correlation coefficient between the gross value added (GVA) and total ton-kilometers was 0.930, while the correlation between the GVA and ton-kilometers in motor transportation was 0.913, also suggesting a coupling between their values. The Mexican Transportation Institute (2009) and Lavee et al. (2011) examined the relationship between investment in transportation infrastructure capital and the debt-to-gross domestic product (GDP) ratio.

Another document analyzed the behavior of the GDP and the number of land freight vehicles in Slovakia in the period from 1995 to 2015. The authors argued that the growth of the GDP increased the burden on the road network. Moreover, we can assume that the increase in the GDP encouraged the growth in the demand for transport (Varjan et al. 2017). Two of the previous authors explained in more detail the relationship between transport intervention and the direct and wider impacts in economic performance in Slovakia and EU countries in the period from 2009 to 2015. The correlation between the freight transport performance and GDP was significant because it had an R value equal to 0.73 (Gnap et al. 2018).

In the case of the U.S.A., road transport registered as the highest share of GDP compared to other modes of freight transport, including rail (U.S.A. Department of Transportation 2024). Meersman and Van de Voorde (2013) developed a study in which the strong correlation between the GDP and road transport (ton kms) (between 1995 and 2010) in EU27, the Russian Federation, and the U.S.A. was clear, with China being less strong in these last two territories. Similarly, Zhang and Cheng (2023) studied the proportion in which land transport infrastructure participated in the UK GDP in a way superior to that of air transport and maritime and river transport.

Based on the previous paragraphs, the high participation of road transport in a country's GDP is supported, affirming a correlation between the economy and road freight transport. Europe has developed a methodology that allows for the study of the interaction between the elasticity of road freight transport statistics and macroeconomic variables such as the GDP, including detailed information in the database that not only includes the amount of cargo transported, but also others, such as the types of trucks (Eurostat 2023).

Other articles that also study this topic in European countries highlight that, "In most industrialized countries there has been a strong positive relationship between economic and transport growth, and specifically road transport"; moreover, "It is widely accepted that transport accounts for a significant share of the GDP in industrialized countries. For this reason, the correlation between tonne-kilometres and GDP, known as "coupling", has traditionally been applied to forecast trends in freight transport demand" (Alises et al. 2014). The same criterion is expressed by Kveiborg and Fosgerau (2007): "Historically, freight transport volumes (tonne-kilometres) and economic activities have followed similar trends", in the Danish case.

In a study developed for the Netherlands, sectoral GDP variations were used as the only independent variable in a prediction model for road freight transportation. In a wide range of determinants that influence freight transport demand, including economic and logistical structures, the GDP change in different sectors and the world trade index were identified as the most influential determinants on the freight demand (Asgarpour et al. 2023). In the case of Indonesia, Reza (2013) exposed the trend of GDP and cargo transportation volume (expressed as logistics figures) from the 1990s to 2010, showing a similar behavior for the two variables. Bennathan et al. (1992) exposed that, for developed countries (high-income countries) and developing countries (low-income countries), the total ton-kilometers of freight transport by road are clearly explained by the GDP. Road freight in developed and developing market economies shows a very similar response to variations in the GDP. Grenzeback et al. (2013) demonstrated that a model can be used to perform macro-forecasting, for example, by estimating the effect of the changes in the GDP on the freight ton-kilometers by mode in the future.

In the case of Greece, Moschovou (2017) studied information since 2003 to analyze the impact that the country's economic recession had in recent decades on the GDP data, and one of the sectors most negatively affected was road freight transportation.

Lehtonen (2006) also concluded that, in some developed countries, such as the UK, the phenomenon of a 'relative decoupling' is happening, but, in many other countries, the volume of road freight transport is expected to continue following the growth of the GDP. Nonetheless, in the present study, we can say that, in the Colombian case, the decoupling situation is not expected to arise. Beyzatlar et al. (2014) studied the causality between the real GDP and inland freight transportation per capita in ton km. They concluded that the relationship is bidirectional and not homogeneous. This means that neither of the two indicators has more relevance as a causal variable between them.

In other study regarding China, Wang et al. (2021) established that the demand for freight transportation shows an inverted U-shaped trend with economic development, and that there are regional characteristics that define that relationship. Diaz et al. (2016) proposed, for Brazil, a model that relates the impact of variables, such as investment and the extension of transportation infrastructure, population growth, and travel demand, on the GDP's potential. In the case of India, Ghosh and Dinda (2022) showed a strong linear trend correlation between the GDP per capita (GDPPC) and the transportation infrastructure index (TRNINF) for the periods from 1989 to 2017.

The GDP is also significantly correlated with the rate of motorization in cities, with the number of Twenty Equivalent Units (TEUs) transported, and with the value of investments in transportation infrastructure, among other relationships with the transportation sector (Rodrigue 2024).

In the Colombian case, Caicedo (2013) and Gómez (2016) analyzed the relationship between national economic development and the amount of cargo transported by road. However, they did not perform a statistical or comparative analysis of the indicators. Gonzalez et al. (2022) exposed the difference between the growth of national GDP in Colombia (2005 to 2019) and the behavior of the total tons of cargo transported (2015 to 2020). The first indicator showed an increasing behavior with a low deviation, and the second indicator showed a seasonal cyclical behavior. The document concluded that "the COVID-19 pandemic had a negative effect on the growth of the freight forwarding sector in

Colombia. Due to the different restrictions defined by the rapid expansion of the pandemic, freight transportation stopped growing as it was doing in previous years", and that "the analysis can help planners implement policies to improve freight transport behavior and react to unusual future economic periods".

By analyzing the figures recorded by the "Anuario de transporte de carga y logística 2014" (Freight transportation and logistics yearbook 2014) by the Inter-American Development Bank (IADB 2014) concerning the GDP per capita and the domestic cargo transported by road for Argentina, Belize, Brazil, Chile, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, and Uruguay, an R^2 of only 0.25 is obtained. This means that the amount of cargo transported in the main Latin American countries has no relationship with the general economic behavior of the respective country. This is one of the few documents that does not agree with the hypothesis raised.

The Banco de Desarrollo de America Latina (CAF) (Development Bank of Latin America and the Caribbean 2014) published the "Logistics Profile of Latin America. Workshop on cargo transportation and logistics", presenting the main action strategies in the region, but the document does not analyze the economic impact of the interventions.

The Economic Commission for Latin America and the Caribbean (ECLAC) published the following: "the estimation of the potential load demand facilitates the optimization of the supply through an efficient allocation of resources and thus satisfy the demand, converging on the development of the countries at the pace established by their objectives, that is, the endowment infrastructure allows the expected GDP growth". This ratifies the relationship between economic development (measured based on the behavior of five economic sectors) and the condition of cargo transportation for four Latin American countries (ECLAC 2017).

In another document, ECLAC (2018) states the following: "the freight mobility and logistics sectors are sectors that require greater attention and vision in the future, given that they provide the services that form the "blood" that feeds the countries using infrastructure as distribution arteries. As has been shown, the future development of emerging economies, including the LAC region itself, will require freight transportation services of greater volume, quality and diversification" (ECLAC 2018).

Other authors have found that there is a spatial distribution relationship between the economic performance of a country and the amount of cargo transported. This is an important analysis for future research that analyzes the economic behavior and the cargo transported between neighboring countries, as in the case of the "Andean area" in South America (Boldizsár et al. 2023).

In the literature reviewed above, we find that there is no document that analyzes the recent historical correlation between the behavior of the economy and the amount of cargo transported by road, or if that correlation indicates which of the two variables can be considered the dependent one. This validates the contribution of this article to the state of knowledge, especially in developing regions such as Latin America, and in particular Colombia. Finally, the question to be resolved through this research is as follows: does the performance of the economic sectors allow for the establishment of a statistically strong correlation to determine the short-term behavior of cargo volumes transported by road?

2. Methods

The economic theory of transportation, set forth in the literature review, indicates that a greater amount of freight transported in a country should be correlated with a better economic condition. To study the behavior of these variables, the following from Colombia's official data were used: the global GDP and the GDP for 11 economic sectors [Construction, Commerce (wholesale and retail; repair of motor vehicles and motorcycles; transportation and storage; accommodation and food services), Real Estate Activities, Professional Activities (professional, scientific, and technical activities; administrative and support services activities), Agrobusiness (agriculture, livestock, hunting, forestry and fishing), Finance (financial and insurance activities), Mining (exploitation of mines

and quarries), Manufacturing Industries, Home Public Services (supply of electricity, gas, steam, and air conditioning; water distribution; wastewater evacuation and treatment, waste management and environmental sanitation activities), Communications (information and communications) and Public Administration (public administration and defense; mandatory social security plans; education; human health care and social services activities) between the years 2015 and 2022, using the value of current prices in billions of Colombian pesos (COP) (quarterly) data from the National Department of Statistics DANE, Republic of Colombia (2023) (Table A1).

The information used corresponding to cargo transportation includes indicators of cargo transported by land (Logistics Corridors in Colombia between 2019 and 2023) in quarterly values from the Ministry of Transportation, Republic of Colombia (2023) (Table A2).

The methodology applied was to correlate economic and road freight transportation variables, first in the same time series, and then in time series in which one variable begins one or two years before the other. In each case, two analyses were performed: a. with the time series of the economic variables starting before the time series of the cargo transportation; b. with the freight transport time series starting before the GDP time series.

The difference in the beginning of the time series intended to determine whether there was a greater correlation: if the economic variables were initially those of freight transportation, or the opposite. In the first situation, it was deduced that it was the behavior of the economy that influenced the performance of cargo transportation in a period of time equal to the overlap of the time series. In the second situation, it would be the behavior of the transported cargo that would indicate the future data of the economy (GDP).

In the case of the same time series, the data (sectoral GDP and cargo transported) correspond to a period of five consecutive years (2019 to 2023). For the time series with a difference in the beginning, it is as follows:

a. GDP data start one year earlier: GDP series (2019 to 2023) and freight series (2020 to 2024).
b. GDP data start two years earlier: GDP series (2017 to 2021) and freight series (2019 to 2023).
c. Freight data start one year earlier: Freight series (2019 to 2023) and GDP series (2020 to 2024).
d. Freight data start two years earlier: Freight series (2019 to 2023) and GDP series (2021 to 2025).

The analyses are presented with a maximum of two years of difference in the beginning of the time series because the results obtained with three and four years of difference present lower correlation values than those obtained with a difference of two years. This means that the data obtained two years apart show that, after only one year of difference between the time series, the correlation decreases. The data used in the research are only available until the year 2023, but, in order to extend the time series, the data were projected until the year 2025. For this, the following instruction was used in R Studio (2023.12.0) statistical software:

> predict (object = linearized data series, newdata = data_group, interval = "confidence", level = 0.95)

2.1. Analysis of the Normality of Variables to Establish Whether to Use a Parametric or Non-Parametric Correlation Method

The statistical behavior of the sectoral and global GDP data series was analyzed using the *p*-value of the Dickey–Fuller and Shapiro–Wilk tests to establish seasonality and normality, respectively. The data series do not move around a central value, but increase (see Section 3.1). This indicates that there is no seasonality in the series. It is also observed that there is no increasing tendency towards the mean of the data and a reduction in the value at the two extremes; that is, there is no shape similar to a Gaussian bell, which indicates that there is no normal distribution in the series.

The Shapiro–Wilk test *p*-value results were <0.05 for all of the variables. That means that the variables do not have a normalized distribution, which validates the use of the non-

parametric Spearman correlation method (Ramachandran and Tsokos 2015). The statements in R Studio software for the Dickey–Fuller and Shapiro–Wilk tests are as follows:

adf.test(data_series, alternative = "stationary"), and

shapiro.test(data_series)

2.2. Analysis of the Correlation between Variables by Non-Parametric Method (Spearman)

The rho values resulting from applying the Spearman method established which of the indicators correlated significantly with the others (economy vs. freight transportation) and with how many years of difference. Rho values close to 1.0 indicate a strong correlation between variables, while, if the value is close to 0.0, it is considered that there is no correlation (Figures 4–8) (Hauke and Kossowski 2011; Khalid et al. 2019, 2022; Rehman et al. 2018).

The Spearman's rho value of the correlation between variables was determined in R Studio software using the following statement:

Chart.correlation (data_group, method = "spearman").

2.3. Analysis of the Correlation between Variables by the Principal Components Method (PCA)

As an additional step, the correlation between variables was corroborated using the Principal Components Analysis (PCA) method using the following R Studio statements:

data.frame_name<- prcomp(data_group, scale = TRUE)

fviz_pca_var(data.frame_name, repel = TRUE)

As a result of the PCA test, the relationship between the variables can be identified graphically. If the vectors of the variables are similar in direction and magnitude, with a small angle between them, the correlation is strong and direct. If the direction between vectors tends to be 180° apart, the correlation is strong but inverse. If the direction between vectors is close to 90°, it is considered that there is not a good correlation between the variables (Figure 9). The comparison of the trends of the series of independent variables was carried out graphically (Figure 10).

2.4. Analysis of Causality between Variables Using the Granger Test

As a complementary analysis for the determination of the significance in the correlation parameters between the variables, a test was performed to determine if there was a causal relationship between them. For this purpose, the Granger test was used, which in R Studio used the following instruction:

grangertest(independent variable data~dependent variable data,order = 1,data = data base)

The causality between the variables was checked if the *p*-value (Pr(>F)) was less than 0.05.

2.5. Analysis of the Validation of a Multivariate Model

To establish which economic sectors have the greatest significance with the behavior of road freight transport, the *p*-value resulting from a correlation between variables was analyzed. The following commands were thus performed using R Studio:

Linear modelling name<- lm(dependent variable~independent variable 1 + independent variable 2 + . . . independent variable n, data = data_file)

> summary(Linear modelling name)

The summary results provide the adjusted R^2 value and the *p*-values of the independent variables to define whether there is a statistical validity in the relationship of the variables. If the adjusted R^2 is greater than 0.7 and the *p*-value is less than 0.05, the formulation of an explanatory model between variables is statistically valid (Sharma and Kar 2018).

3. Results

This section presents the results of the data analysis. Section 3.1 describes the behavior of the time series for each of the three variables of road freight in the country. Sections 3.2–3.4 present, for different time lags, the Spearman rho values when correlating the global GDP and that of all economic sectors with respect to the three variables of road freight transported. Section 3.5 studies the relationship analysis between variables using the Principal Component Analysis method. Section 3.6 analyzes the causality between the economy and transport using the Granger causality test. Section 3.7 uses the application of linear correlation to determine the level of significance of each of the independent variables by means of their respective *p*-values, and the significance of the linearity of the correlation by means of the adjusted R^2 and the resulting *p*-values.

3.1. Descriptive Statistical Analysis of Freight Transportation Variables

The time series of the three freight transportation variables are non-seasonal. The Dickey–Fuller test gives a *p*-value result greater than 0.05 for the three variables, as follows: 0.30 for the total trips, 0.23 for the total in kilograms, and 0.38 for the total in gallons. Furthermore, these are also not series with normal distributions. Applying the Shapiro–Wilk normality test, the *p*-values were greater than 0.05, as follows: 0.18 for the total number of trips, 0.24 for the total number in kilograms, and 0.15 for the total number of gallons. The non-normality of the series validates the use of the non-parametric Spearman correlation method and the resulting rho value to define its validity between two variables. Both non-seasonality and non-normality in the data series can be seen graphically in Figures 1–3.

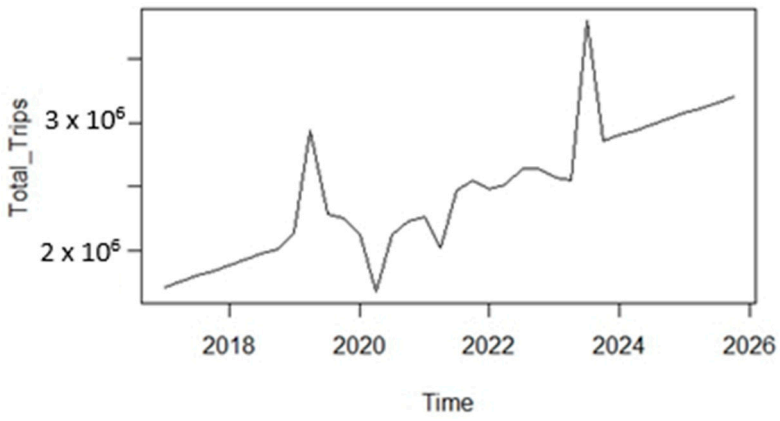

Figure 1. Total trips data series.

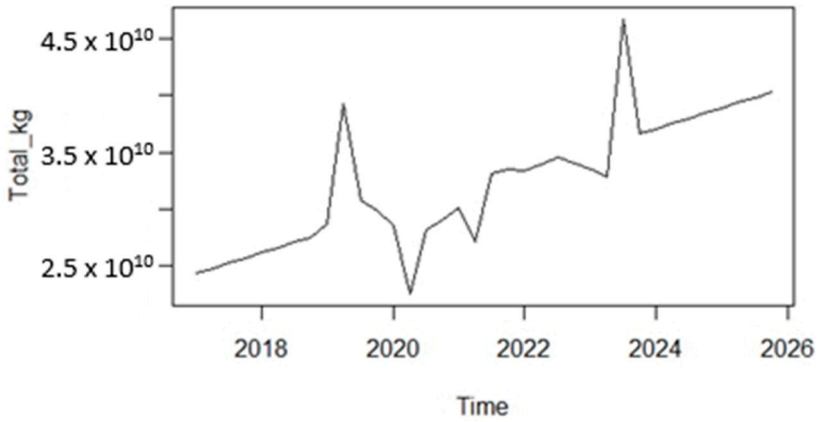

Figure 2. Total kilograms data series.

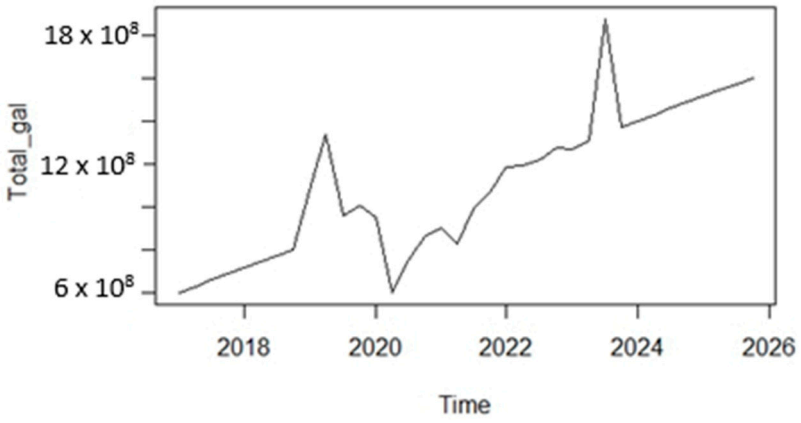

Figure 3. Total gallons data series.

3.2. Correlation Analysis in the Same Year

Correlations were carried out for the data of the dependent and independent variables in the same years. That is, the values of the dependent variable in 2019 were correlated with the values of the independent variable(s) for that same year. In the same way, the data were correlated until the year 2025, obtaining the following rho Spearman values (Figure 4).

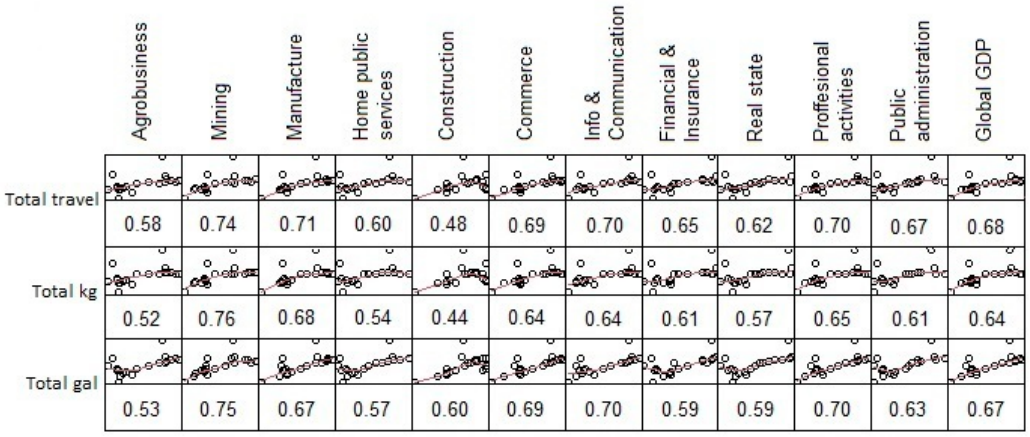

Figure 4. Rho values for the correlation between the global and sector GDP vs. three indicators of cargo transported by road. Quarterly accounts between the years 2019 and 2023 for the GDP and cargo (same year).

According to Figure 4: The highest-level correlations (rho $\geq$ 0.7) are presented for the Mining sector in the three load variables, for the Manufacturing sector related to the number of trips, for the Information and Communications sector regarding the number of trips and the number of gallons, and for the Professional Activities sector, also regarding the number of trips and the number of gallons. The correlations of the statistically acceptable levels (rho $\geq$ 0.5 < 0.7) are presented for most other economic sectors and cargo variables, except for the Construction sector, and the indicators for the number of trips and the number of kilograms transported. There were no correlations with a low significance value (rho < 0.5). There is consistency between the rho values. The standard deviation of the three freight indicators in each of the economic sectors has an average value of 0.03. This means that, in each economic sector, there is no freight indicator that is more relevant than another.

This analysis presents a good correlation between the global economy in Colombia and land cargo transportation in its three measurement indicators, both for the global GDP and for most economic sectors. The above is interpreted as the impact of a direct relationship (rho > 0) between economic development and the movement of land cargo in the country. However, it cannot be said that the correlation is highly significant (rho > 0.7).

3.3. Analysis of the Correlation between GDP and Transported Cargo, One Year Later

For this analysis, the cargo data transported between the years 2019 and 2023 were correlated with the global and sectoral GDP data from the years 2020 to 2024 (Figure 5). Later, GDP data between 2019 and 2023 were correlated with cargo values between 2020 and 2024 (Figure 6). In this analysis, the following rho values were obtained.

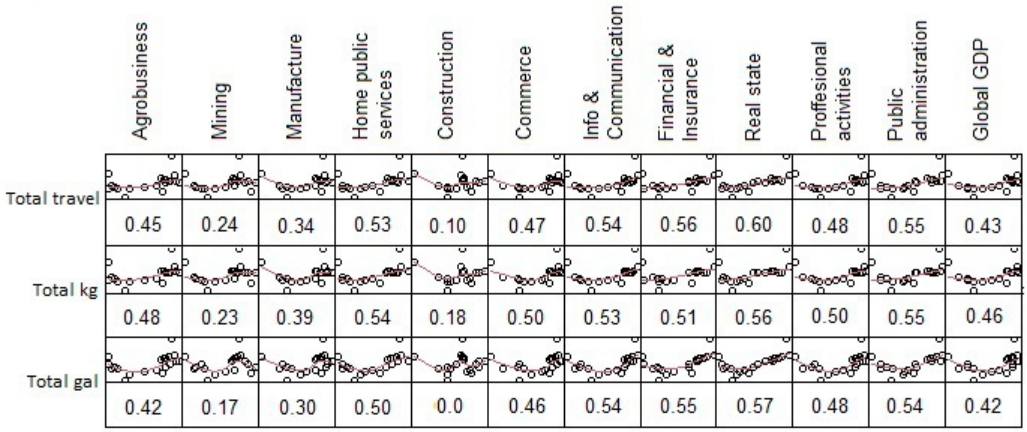

Figure 5. Rho values for the correlation between the global and sectoral GDP vs. three indicators of cargo transported by road. Quarterly accounts: years 2019 to 2023 for cargo, and 2020 to 2024 for GDP (1-year difference).

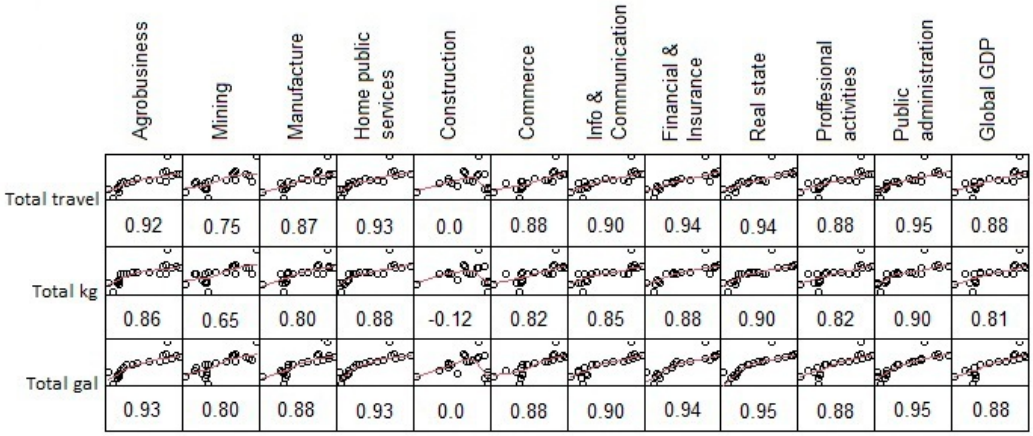

Figure 6. Rho values for the correlation between the global and sector GDP vs. three indicators of cargo transported by road. Quarterly accounts: years 2019 to 2023 for GDP, and 2020 to 2024 for cargo (1-year difference).

According to Figure 5: There are no highly significant correlations (rho $\geq$ 0.7). The correlations of a statistically acceptable level (rho $\geq$ 0.5 < 0.7) occur mainly in only the following four sectors (36%): Supply of Household Public Services, Information and Communications, Financial and Insurance, and Public Administration. The other sectors (64%) tend to have correlations with a low significance value (rho < 0.5). There is consistency between the rho values. The standard deviation of the three load indicators in each of the economic sectors has an average value of 0.03. This means that, in each economic sector, there is no freight indicator that is more relevant than another. In this case, there is no good correlation between the economy in Colombia and land cargo transportation in its three measurement indicators.

According to Figure 6: The highest-level correlations (rho $\geq$ 0.7) are presented for almost all sectors (90%), with the exception of the Construction sector, in which the correlation tends toward zero. There is consistency between the rho values. The standard deviation of the three freight indicators in each of the economic sectors has an average

value of 0.03. This means that, in each economic sector, there is no cargo indicator that is more relevant than another. This analysis presents a good correlation between the economy in Colombia and land cargo transportation in its three measurement indicators, both for the global GDP and for most economic sectors. The above is interpreted as an impact of a direct relationship (positive rho) between economic development and the movement of land cargo in the country that is generated a year later. It can be stated that the correlation is highly significant (rho > 0.7).

3.4. Analysis of the Correlation between GDP and Transported Cargo, Two Years Later

For this analysis, the cargo data transported between the years 2019 and 2023 were correlated with the global and sectoral GDP data from the years 2021 to 2025. Later, the GDP data between 2017 and 2021 were correlated with the cargo values between 2019 and 2023. In this analysis, the following rho values were obtained (Figures 7 and 8).

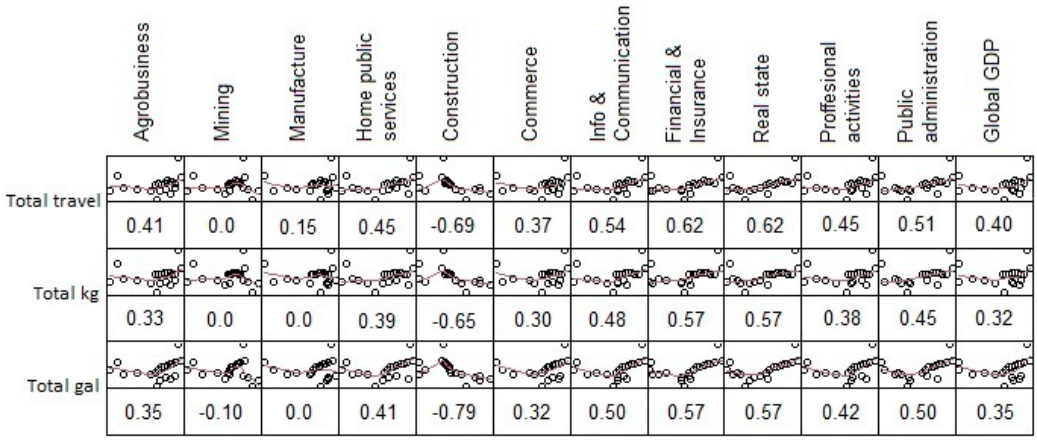

Figure 7. Rho values for the correlation between the global and sector GDP vs. three indicators of cargo transported by road. Quarterly accounts: years 2019 to 2023 for cargo, and 2021 to 2025 for GDP (2-year difference).

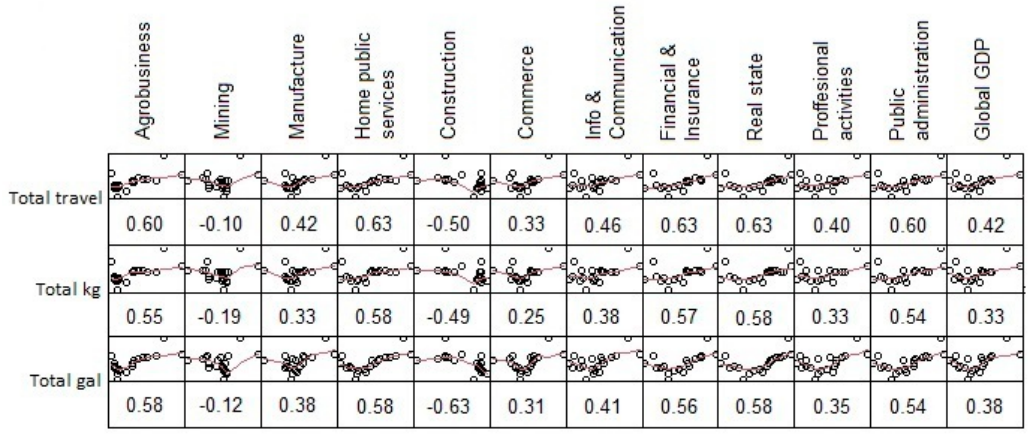

Figure 8. Rho values for the correlation between the global and sector GDP vs. three indicators of cargo transported by road. Quarterly accounts: years 2017 to 2021 for GDP, and 2019 to 2023 for cargo (2-year difference).

According to Figure 7: Only one correlation was presented with a high significance value (rho $\geq$ 0.7), but with a negative sign, which does not give validity to the analysis approach. The rho values with medium significance ($\geq$0.5, <0.7) corresponds to the Financial and Insurance, Real Estate economic, Information and Communications, and Professional Activities sectors. The Construction sector obtained the three rho values with an inverse relationship, being the only sector with this condition. The low significance rho values

(rho < 0.5) appear with a greater tendency in the following sectors: Agriculture, Supply of Household Public Services, Commerce, Professional Activities, Mining, and Manufacturing, with the last two being the only ones that present rho values with a tendency towards zero. The inverse correlations and those of low significance have influenced the correlation with the global GDP to have a low significance (0.32 < rho > 0.40) for the three freight indicators. There is consistency between the rho values. The standard deviation of the three freight indicators in each of the economic sectors has an average value of 0.04. This allows us to affirm that, in each economic sector, there is no load indicator that is more relevant than another. However, the number of trips registers higher rho values than the other two indicators. Since there is no consistency in the correlations of high significance, it cannot be stated that the amount of cargo transported by land has a similar behavior with the economic performance of the country two years later.

According to Figure 8: There were no correlations with a high significance value (rho $\geq$ 0.7). The rho values between 0.5 and 0.63 have a trend in the Agriculture, Home Public Services Supply, Financial and Insurance, Real Estate, and Public Administration sectors. The low significance rho values (rho < 0.5) are presented in the following sectors: Manufacturing, Commerce, Information and Communications, and Professional Activities. The following economic sectors presented with an inverse correlation and of low and medium significance: Mining and Construction. Inverse correlations (negative rho) detract from the validity of the general correlation being analyzed, since good economic performance is not expected to result in lower quantities of transported cargo. Inverse correlations and those of low significance have influenced the correlation with the global GDP to have a low significance for the three cargo indicators (0.33 < rho > 0.42). There is consistency between the rho values. The standard deviation of the three load indicators in each of the economic sectors has an average value of 0.04. This allows us to affirm that there is no load indicator that is more relevant than another. However, the number of trips registers higher rho values than the other two indicators. Since there is no consistency in correlations of high significance, it cannot be stated that the country's economic performance has a behavior similar to that of the amount of cargo transported by land two years later.

3.5. Relationship Analysis between Variables Using the Principal Component Analysis Method (PCA)

According to the PCA method, the relationship between variables can be identified graphically. If the vectors of the variables are similar in direction and magnitude, with a small angle between them, the correlation is strong and direct. If the direction between vectors tends to be 180° apart, the correlation is strong but inverse. If the direction between vectors is close to 90°, it is considered that there is not a good correlation between the variables.

According to Figure 9, the PCA method yields admissible results because Dimensions 1 and 2 together explain at least 90% of the data. The Figure 9c shows a good correlation between all of the variables, except for the Construction sector. In the other images of Figure 9, the vectors of the three variables of the transported cargo move away from the vectors of the GDP. This allows us to confirm that the most reliable relationship is that the behavior of the GDP has an effect on the amount of cargo transported one year later.

Figure 9 also demonstrates that the GDP behavior of the construction sector differs greatly from that of the other economic sectors, regardless of its relationship with freight transportation development. Although in Figure 9 there is text that is hidden by other text and by the vector lines, we make the observation that each vector indicates an economic sector, and the relevant thing about all of the graphs in Figure 9 is to be able to observe if the angle of the road cargo vectors (travel, kg, and gal) are close to the angle of each of the GDP vectors of the economic sectors.

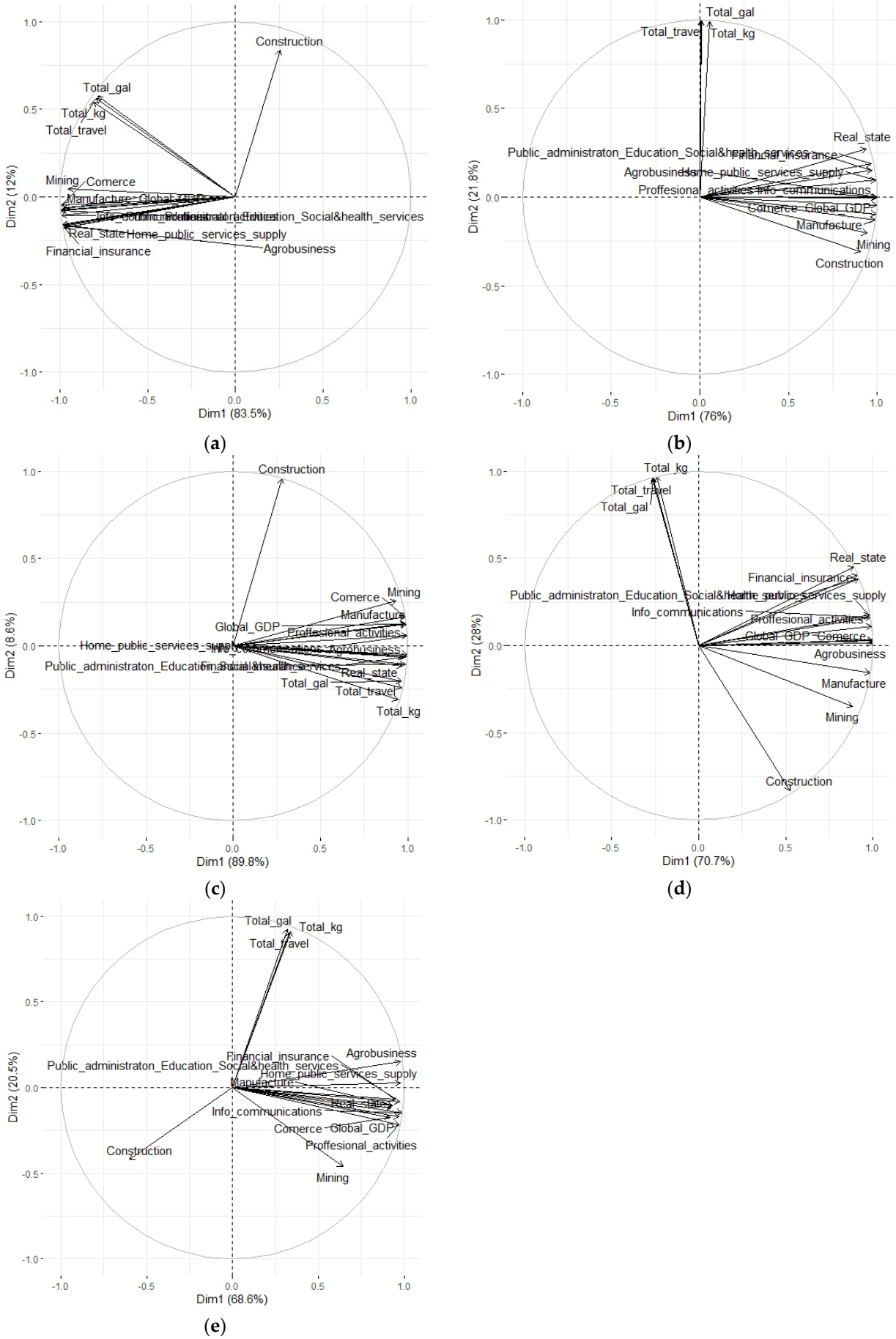

Figure 9. Graphic analysis of PCA variables for the global and sector GDP, and three indicators of cargo transported by road, accounting for the years from 2015 to 2025. (**a**) Years 2015 to 2025 for cargo

and GDP (both series start in the same year). (**b**) Years 2019 to 2023 for cargo, and years 2020 to 2024 for GDP (the first starts one year earlier). (**c**) Years 2019 to 2023 for GDP, and years 2020 to 2024 for cargo (the first starts one year earlier). (**d**) Years 2019 to 2023 for cargo, and years 2021 to 2025 for GDP (the first starts two years before). (**e**) Years 2017 to 2021 for GDP, and years 2019 to 2023 for cargo (the first starts two years before).

3.6. Granger Causality Test

To complement the Spearman correlation analysis and validate the relationship between economic performance and the amount of cargo transported one year later in Colombia, the Granger causality test was applied.

The resulting *p*-value confirms the causal relationship between the economy and the cargo transported in the cases where the value was less than 0.05. Construction is the only sector that did not meet the causality condition (Table 1).

Table 1. Granger causality test *p*-value.

	Agro.	**Mining**	**Manuf.**	**Home Public Services**	**Const.**	**Comm.**	**Info and Comm.**	**Finan. and Insur.**	**Real State**	**Prof. Activ.**	**Public Adm.**	**Global GDP**
Total travel	0.002	0.044	0.031	0.007	0.633	0.0101	0.012	0.000	0.006	0.029	0.010	0.029
Total kg	0.005	0.083	0.057	0.012	0.532	0.0152	0.025	0.0002	0.009	0.054	0.017	0.055
Total gal	0.008	0.195	0.083	0.027	0.447	0.0196	0.034	0.0007	0.020	0.093	0.024	0.092

Abbreviations: Agro.: Agrobusiness; Manuf.: Manufacture; Const.: Construction; Comm.: Commerce; Info and Comm.: Info_communications; Finan. and Insur.: Financial_insurance; Prof. Ativ.: Professional_activities; Public Adm.: Public_administraton_Education_Social_health_services.

3.7. Significance of Each of the Economic Sectors in Correlation with Economic Development

To continue with the analysis of the correlation between the country's economic development and the amount of freight transported by road one year later, the correlations were evaluated between the different economic sectors and the three freight variables. Additionally, the correlation of the freight variables was analyzed, but only with the global GDP, because the global GDP is the result of the behavior of all sectoral GDPs, and there is collinearity between them. For this reason, the following independent models were analyzed: multivariate correlation with economic sectors' GDP in Tables 2–4, and univariate correlation with the global GDP in Table 5.

Table 2. The Pr(>|t|) result of the multivariate correlation. Total travel as the dependent variable.

	Pr(>|t|)
(Intercept)	0.03336
Agrobusiness	0.0808
Mining	0.00411
Manufacture	0.22228
Home_public_services_supply	0.00999
Commerce	0.0471
Info_communications	0.19248
Financial_insurance	0.16733
Real_state	0.48152
Professional_activities	0.0055
Public_administration_Education_Social_health_services	0.03119

Table 3. The Pr(>|t|) result of the multivariate correlation. Total kilograms as the dependent variable.

	Pr(>|t|)
(Intercept)	0.03166
Agrobusiness	0.08454
Mining	0.00579
Manufacture	0.26004
Home_public_services_supply	0.01007
Commerce	0.04755
Info_communications	0.23613
Financial_insurance	0.1828
Real_state	0.50482
Professional_activities	0.00501
Public_administraton_Education_Social_health_services	0.03735

Table 4. The Pr(>|t|) result of the multivariate correlation. Total gallons as dependent variable.

	Pr(>|t|)
(Intercept)	0.016158
Agrobusiness	0.039086
Mining	0.00091
Manufacture	0.044918
Home_public_services_supply	0.002344
Commerce	0.013044
Info_communications	0.45973
Financial_insurance	0.13569
Real_state	0.942539
Professional_activities	0.000658
Public_administraton_Education_Social_health_services	0.007769

Table 5. Adjusted R^2 and Pr(>|t|) results of the correlation between the global GDP and cargo transport variables as dependent variables.

	Adjusted R^2	**Pr(>|t|)**
Total travels	0.5952	0.0000411
Total kilograms	0.5471	0.0001167
Total gallons	0.6955	0.00000298

Thus, the quantity transported (total travel) is a dependent variable for a year (n), the multivariate regression data for sectoral GDPs is found in Table 2, and the adjusted R^2 is 0.7682, with a *p*-value of 0.0003515. The results validate the multivariate correlation between the number of cargo trips and the economic sectors in Colombia. The adjusted R^2 is greater than 0.7 and the *p*-value of the correlation is less than 0.05. The most significant economic sectors are those with a *p*-value of less than 0.05, including Agrobusiness, Mining, Home Public Services Supply, Commerce, Professional Activities, and Public Administration, Education, and Social Health Services (Table 2).

For the quantity transported (total kilograms) as a dependent variable for a year (n), the multivariate regression data for the sectoral GDPs is found in Table 3, and the adjusted R^2 is 0.7611, with a *p*-value of 0.00356. Like with total travels, the results validate the multivariate correlation between the number of cargo trips and the economic sectors in Colombia. The adjusted R^2 is greater than 0.7 and the *p*-value of the correlation is less than 0.05. The most significant economic sectors are those with a *p*-value of less than 0.05, including Agrobusiness, Mining, Home Public Services Supply, Commerce, Professional Activities, and Public Administration, Education, and Social Health Services (Table 3).

For the quantity transported (total gallons) as a dependent variable for a year (n), the multivariate regression data for the sectoral GDPs is found in Table 4, and the adjusted R^2 is 0.8921, with a *p*-value of 0.0001238. Like with previous cases, the results validate

the multivariate correlation between the number of cargo trips and the economic sectors in Colombia. The adjusted R^2 is greater than 0.7 and the *p*-value of the correlation is less than 0.05. The most significant economic sectors are those with a *p*-value of less than 0.05, including Agrobusiness, Mining, Home Public Services Supply, Commerce, Professional Activities, and Public Administration, Education, and Social Health Services (Table 4).

Finally, we present the univariate correlation data between the global GDP as an independent variable and the quantity of cargo transported one year later. They were analyzed for each of the three cargo variables (Table 5).

The results in Table 5 validate the correlations between the global GDP and road freight variables. However, the linearity of the correlations is less reliable because the adjusted R^2 values are lower than in the multivariate correlations (<0.7). This demonstrates the importance of carrying out an analysis of the performance of the transport sector, not only in terms of overall GDP, but also in terms of a multivariate relationship with different economic sectors.

This information is essential in the infrastructural planning process by the state and private industries, and is a tool for the projections of the freight transport business sector.

4. Discussion

The main objective of this study was to determine the performance of the GDP for the economic sectors so to predict the amount of cargo transported by road in Colombia.

The trend of the rho value was compared for the cases studied. The analysis of variables whose figures corresponded to the data series for the same years (both series started in the same year) (Figure 4) presented rho values <0.7 for 73% of the economic sectors, and <0.68 for the global GDP. Therefore, there is non-highly significant correlation between the two data sets.

For the correlations that estimated that the amount of cargo transported marked the behavior of the GDP (one and two years starting before the cargo data), the results trended towards rho values of medium and low significance (rho < 0.5). The tendency towards these low values means that there is no significant correlation between the variables. For the correlations in which the behavior of the GDP was correlated with the behavior of the amount of cargo transported many years later (one and two years starting before the GDP data), the rho values improved the correlations significantly. In the analysis with a one-year difference (Figure 6), the best correlations are presented, since 82% of the economic sectors presented rho values >0.8, and the global GDP too. However, the construction sector registered rho values tending toward zero, which rules it out of the mathematical prediction model.

4.1. The Different Behavior of the Construction Sector

Concerning the last issue, the difference in the performance of the construction sector is not only observed in Figure 9. Figure 10 shows that the cycle of the construction sector is different from that of the other sectors analyzed. The trend in the construction sector (the red points in Figure 10) is clearly different from that of other economic sectors. The construction sector shows a horizontal trend, while that of the other sectors shows an increasing trend. They only have similar behavior in the period between 2020 and 2021 (the COVID-19 pandemic), in which a decreasing peak is recorded. That is why the construction sector does not show a correlation with the other economic sectors in the indicator of its participation in the national GDP. The increasing behavior of the sectoral GDP coincides with the also increasing behavior of the freight transport variables observed in Figures 1–3.

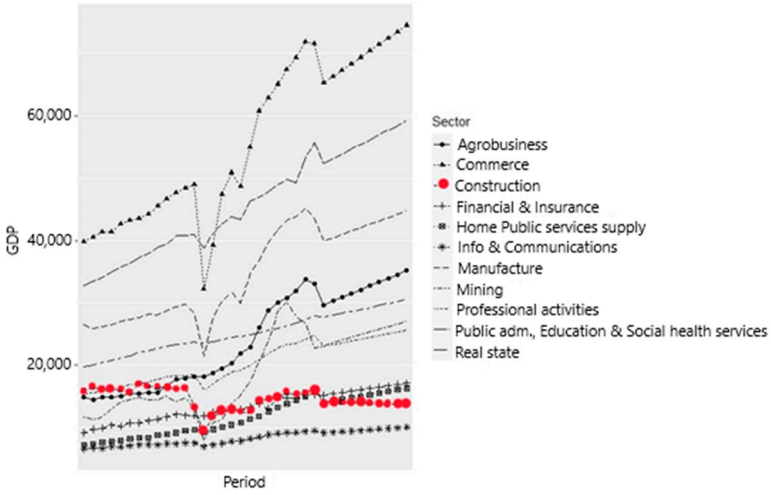

Figure 10. Colombia economic sectors GDP (billions COP). Quarterly accounts for the years 2019 to 2023.

Figure 11 shows the non-increasing trend of the Construction sector. Figure 10 clearly shows that, on the contrary, the trend of the other economic sectors is increasing. This gives greater clarity to the different behavior of the Construction sector. Figure 9 also demonstrates that the GDP behavior of the Construction sector differs greatly from that of the other economic sectors, regardless of its relationship with freight transportation development.

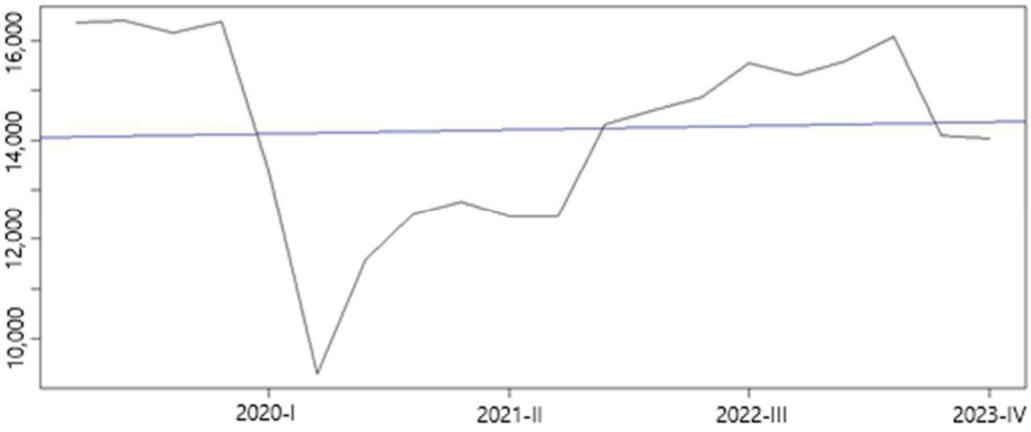

Figure 11. Colombia Construction economic sector GDP trend (billions COP). Quarterly accounts for the years 2017 to 2025.

In all of the correlation analyses performed (Figures 4–8), the rho values are in some cases inverse, in others close to zero, and when they are positive, they are not greater than 0.6. Therefore, the Construction sector differs from the others when being considered as an explanatory variable for the behavior of road freight transport in Colombia.

It is true that the Construction sector presents better correlation values in Figure 7, but they are inverse. Even so, correlation analyses were performed for those time series periods (according to Figure 7). The results of the adjusted R^2 for the three load variables were not greater than 0.26. These results do not validate an independent correlation for the GDP of the Construction sector and road freight transport in Colombia.

As a similar situation, a study developed in Brazil analyzed the relationship between investment in infrastructure and economic sectors, it turned out that the Construction sector was the only one with a back linkage. The Agricultural, Communications, and Industrial sectors turned out to be the key sectors. This is a situation like the one resulting from this study (Centurião et al. 2024).

4.2. Historical Trend Change Due to the COVID-19 Pandemic

The COVID-19 pandemic resulted in a decline in the dynamics of the economy, and it could be presumed that this also affected the transport sector. Figure 10 clearly shows the decline in economic development of each of the sectors in 2020.

At first glance, one might think that the COVID-19 pandemic period marked a difference in the trend in the behavior of transported cargo. However, we have found that the data analyzed, including the economic statistical data during the pandemic, do not affect the historical trend prior to the pandemic. This can be said because the historical behavior of transported cargo, in the three indicators analyzed, did not register atypical behavior between the years 2020 and 2021 because its trend was increasing (Figure 12).

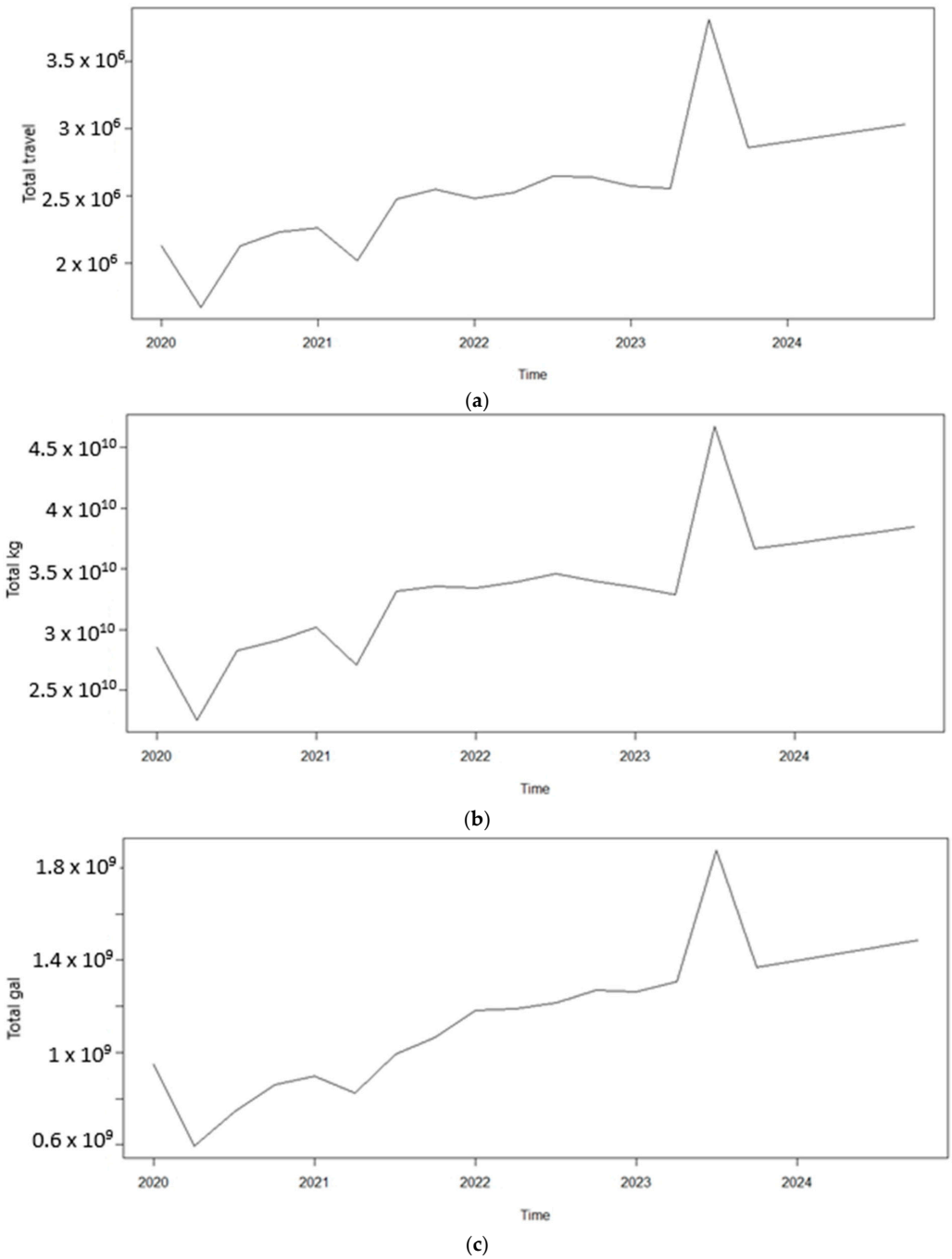

Figure 12. Colombia Construction economic sector GDP trend (billions of COP). Quarterly accounts for the years 2019 to 2024. (**a**) Total travels; (**b**) Total kilograms; (**c**) Total gallons.

However, to continue the analysis of how much the results and conclusions of this research would have changed if there had been no pandemic, another data table was generated in which the sectoral GDP values were replaced between the periods 2020-I and 2021-III (Table A3).

With the changes in the database, assuming that there was no pandemic, the Spearman rho values were close to the original ones (Figure 6). There were only better values for the Mining and the Construction sectors, although this last one still shows an inverse trend (Table 6).

Table 6. Spearman rho values. Data between 2020-I and 2021-III (COVID-19 pandemic) replaced by linear trend.

	Agro.	Mining	Manuf.	Home Public Services	Const.	Comm.	Info and Comm.	Finan. and Insur.	Real State	Prof. Active.	Public Adm.	Global GDP
Total travel	0.91	0.85	0.90	0.92	−0.72	0.92	0.92	0.92	0.94	0.92	0.94	0.92
Total kg	0.86	0.77	0.84	0.87	−0.68	0.88	0.88	0.88	0.89	0.88	0.89	0.87
Total gal	0.92	0.89	0.91	0.92	−0.74	0.93	0.93	0.93	0.94	0.93	0.94	0.93

Abbreviations: Agro.: Agrobusiness; Manuf.: Manufacture; Const.: Construction; *Comm.*: Commerce; Info and Comm.: Info_communications; Finan. and Insur.: Financial_insurance; Prof. Ativ.: Professional_activities; Public Adm.: Public_administraton_Education_Social_health_services.

It is logical to think that, without the economic changes caused by the pandemic between 2020 and 2021, the correlation between the economy and transport would have more significant coefficients. However, this research shows that the correlation remains valid despite the change in trend in the statistics of all the indicators studied.

5. Conclusions

The results obtained coincide with the premise that the economic behavior of the main country's economic sectors significantly correlates with the amount of cargo transported by road, but one year later. This is stated based on Spearman's rho values, since, for all sectors except the Construction sector, they are greater than 0.7 (comparing Figures 4, 5, 7 and 8 with Figure 6).

The different behavior of the Construction sector is confirmed in the Principal Component Analysis (PCA) (Figure 9), in which the vector of this economic sector deviates from that of the other sectors. In addition, when performing the Granger test, the Construction sector is the only one that does not meet the causality condition, because it has a *p*-value greater than 0.05. The other sectors achieve the causality condition between the sectoral GDP and the road freight transport indicators (Table 1).

Another aspect analyzed was the significance of each of the economic sectors in the correlation with the economic development according to the *p*-values obtained from the linearized multivariate correlations for each of the three indicators of transported cargo (number of trips, kilograms, and gallons). As a result, it is concluded that the multivariate correlation between the GDP of the economic sectors and the cargo transported one year later has greater statistical validity than the correlation between the overall GDP of the country and the cargo indicators. This is because, for the first case, the three adjusted R^2 values (for total travels, total kilograms, and total gallons) are greater than 0.7 and the *p*-value of the correlation is less than 0.05. In the second case, the three adjusted R^2 values are lower (<0.7) (Tables 2–5).

It is valid to assume that a time series analysis to predict indicator data should not include the negative and atypical changes generated by the COVID-19 pandemic in the economy. By analyzing the correlations and causalities between variables (Spearman's

rho and the Granger test *p*-value), assuming the above premise, the results are more reliable because the down peak of the data between 2020 and 2021 is eliminated. However, this research verified the validity of the correlation between the economy and freight transport by working with real historical numbers, that is, including the consequences of the pandemic in the data.

According to what is written in this section, it is concluded that, in the Colombian case, the phenomenon of coupling occurs, and it is a unidirectional relationship. This information is essential in the infrastructural planning process by the state and is a tool for the projections of the freight transport business sector.

As for recommendations, it is important to increase the number of studies that analyze the impact between economic development and infrastructure in Latin America to unify the criteria and behaviors of the data series. In the region, there are a significant number of sources that provide official data. However, it is not common to find documents in specialized journals that work with statistical analyses such as the one presented herein.

A major limitation in conducting this research was the lack of similar studies in major countries in the Latin American region that have economic and infrastructural conditions like Colombia. If these studies had been found, a comparative analysis of the relationship between economic sectors and the amount of road freight transportation would have been possible.

Thus, in the future, we will also study the cases of countries in the Andean region in road freight transportation, due to the similarity of infrastructural development with Colombia. The next step in our investigations is to study the figures of other means of cargo transportation, such as air or sea, but as an independent analysis. In this case, we only analyzed Colombia and road freight transportation due to the importance it has in the development of the country's infrastructure.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

Agro.	Agrobusiness
CAF	Development Bank of Latin America and the Caribbean
Comm.	Commerce
Const.	Construction
COP	Colombian pesos
COVID	coronavirus disease
DANE	National Administrative Department of Statistics

ECLAC	Economic Commission for Latin America and the Caribbean
Finan. & Insur.	Financial_insurance
GDP	gross domestic product
GDPPC	GDP per capita
GVA	gross value added
IADB	Inter-American Development Bank
Info & Comm.	Info_communications
Manuf.	Manufacture
PCA	Principal Component Analysis
Prof. Ativ.	Professional_activities
Public Adm.	Public_administraton_Education_Social_health_services
UK	United Kingdom
U.S.A.	United States of America
TEU	Twenty Equivalent Unit
TRNINF	Transportation Infrastructure Index

Appendix A

Table A1. Sectoral and global GDP. Colombia's data in billions of Colombian pesos (COP).

Quaterly Period	Agrobusiness	Mining	Manufacture	Home Public Services Supply	Construction	Comerce	Information and Communications	Financial and Insurance	Real State	Professional Activities	Public Administraton, Education, Social Health Services	Global_GDP
2017_I	14.784	11.674	26.464	7.159	15.847	39.781	6.551	9.117	19.736	15.428	32.745	225.178
2017_II	14.363	11.257	25.931	7.293	16.390	40.560	6.690	9.697	20.044	15.612	33.495	227.859
2017_III	14.780	11.697	26.168	7.557	16.139	41.326	6.649	9.880	20.411	15.800	34.111	232.030
2017_IV	14.887	12.910	26.458	7.780	16.098	41.385	6.931	10.366	20.785	16.058	34.884	235.404
2018_I	15.048	14.058	27.048	7.835	15.995	42.710	6.872	10.168	21.100	16.451	35.728	240.549
2018_II	15.415	14.443	27.279	8.126	15.611	43.182	7.034	10.698	21.466	16.832	36.356	245.009
2018_III	15.432	14.896	27.640	8.282	16.992	43.545	7.199	10.704	21.947	17.031	37.255	250.176
2018_IV	15.602	14.391	28.191	8.373	16.512	44.271	7.243	11.057	22.312	17.283	37.877	252.057
2019_I	15.624	14.434	27.980	8.730	16.358	45.539	7.174	11.311	22.690	17.665	38.900	256.822
2019_II	16.773	14.945	28.768	8.856	16.391	46.668	7.381	11.686	22.997	18.169	39.334	263.438
2019_III	17.747	14.192	29.260	9.093	16.160	47.715	7.321	12.047	23.266	18.273	40.728	268.314
2019_IV	17.814	14.747	29.823	9.445	16.368	48.344	7.505	11.940	23.435	18.351	40.800	271.494
2020_I	18.155	13.152	28.388	9.655	13.360	48.923	7.470	11.859	23.686	18.425	40.985	267.840
2020_II	18.144	7.867	21.450	9.192	9.309	32.238	6.898	11.818	23.510	16.048	38.841	218.762
2020_III	18.768	10.626	27.699	9.695	11.582	39.171	7.190	12.427	23.795	16.978	41.015	245.173
2020_IV	19.426	11.202	30.202	10.094	12.493	47.448	7.403	12.705	24.052	17.941	42.642	265.966
2021_I	20.241	13.818	31.821	10.390	12.764	50.899	7.709	12.790	24.409	18.873	43.859	280.596
2021_II	21.865	15.091	29.855	10.799	12.448	48.690	7.829	12.824	24.607	19.088	43.395	281.605
2021_III	22.911	17.445	34.774	11.302	12.458	54.985	8.154	13.263	24.894	19.966	46.356	304.916
2021_IV	26.042	20.628	36.789	11.754	14.311	60.787	8.454	13.776	25.227	20.853	46.959	325.468
2022_I	28.783	23.740	39.599	12.487	14.599	62.858	8.809	12.970	25.565	21.797	47.762	344.676
2022_II	30.104	28.687	41.865	13.182	14.853	65.093	9.009	14.880	25.870	22.779	48.998	363.415
2022_III	30.725	30.223	43.258	13.806	15.549	67.410	9.129	14.645	26.315	23.244	49.831	377.709
2022_IV	31.846	27.824	43.747	14.342	15.302	69.297	9.172	14.630	26.685	23.412	49.268	376.722
2023_I	33.806	26.621	45.274	14.925	15.581	71.907	9.325	15.135	27.256	24.155	53.396	392.277
2023_II	33.000	22.675	43.565	15.858	16.074	71.604	9.465	15.251	27.872	24.663	55.677	388.904
2023_III	29.669	23.082	39.889	13.923	14.087	65.260	9.105	15.143	27.713	22.952	52.364	360.685
2023_IV	30.276	23.524	40.429	14.183	14.039	66.293	9.206	15.359	28.020	23.241	53.126	366.050
2024_I	30.884	23.966	40.968	14.444	13.990	67.325	9.306	15.574	28.327	23.531	53.889	371.416
2024_II	31.491	24.408	41.508	14.705	13.941	68.358	9.407	15.790	28.635	23.820	54.651	376.781
2024_III	32.099	24.850	42.047	14.965	13.893	69.390	9.508	16.005	28.942	24.109	55.413	382.147
2024_IV	32.706	25.292	42.586	15.226	13.844	70.423	9.608	16.221	29.249	24.399	56.176	387.512

Table A1. *Cont.*

Quaterly Period	Agrobusiness	Mining	Manufacture	Home Public Services Supply	Construction	Comerce	Information and Communications	Financial and Insurance	Real State	Professional Activities	Public Administraton, Education, Social Health Services	Global_GDP
2025_I	33.314	25.733	43.126	15.487	13.795	71.456	9.709	16.436	29.557	24.688	56.938	392.878
2025_II	33.921	26.175	43.665	15.748	13.747	72.488	9.810	16.652	29.864	24.977	57.700	398.243
2025_III	34.529	26.617	44.205	16.008	13.698	73.521	9.910	16.867	30.171	25.267	58.463	403.609
2025_IV	35.136	27.059	44.744	16.269	13.649	74.553	10.011	17.083	30.478	25.556	59.225	408.974

Table A2. Indicators of cargo transported by land through logistics corridors. Colombia's data.

Quaterly Period	Total Trips	Total Kilograms	Total Gallons
2017_I	1,712,139	24,403,893,109	598,805,107
2017_II	1,754,630	24,856,611,315	627,361,966
2017_III	1,797,121	25,309,329,520	655,918,824
2017_IV	1,839,612	25,762,047,726	684,475,682
2018_I	1,882,102	26,214,765,931	713,032,541
2018_II	1,924,593	26,667,484,136	741,589,399
2018_III	1,967,084	27,120,202,342	770,146,258
2018_IV	2,009,575	27,572,920,547	798,703,116
2019_I	2,128,272	28,715,234,440	1,071,545,808
2019_II	2,937,974	39,224,867,127	1,335,159,450
2019_III	2,284,749	30,752,663,253	957,446,070
2019_IV	2,253,100	29,840,117,733	1,002,501,912
2020_I	2,123,129	28,552,312,234	950,074,318
2020_II	1,671,380	22,563,113,345	595,634,532
2020_III	2,124,219	28,234,632,136	745,152,235
2020_IV	2,228,770	29,108,835,203	859,227,950
2021_I	2,261,989	30,174,420,639	898,275,486
2021_II	2,015,411	27,107,307,599	825,454,243
2021_III	2,470,906	33,120,531,267	993,196,511
2021_IV	2,548,051	33,563,269,564	1,064,696,558
2022_I	2,480,903	33,392,600,617	1,180,961,171
2022_II	2,518,905	33,914,633,099	1,189,402,223
2022_III	2,640,869	34,575,554,921	1,216,439,646
2022_IV	2,635,817	33,990,783,320	1,270,543,551
2023_I	2,573,636	33,476,995,991	1,262,474,131
2023_II	2,550,652	32,886,768,444	1,307,820,168
2023_III	3,806,436	46,707,308,514	1,875,156,347
2023_IV	2,859,390	36,627,284,657	1,369,840,285
2024_I	2,901,881	37,080,002,863	1,398,397,143
2024_II	2,944,372	37,532,721,068	1,426,954,002
2024_III	2,986,863	37,985,439,274	1,455,510,860
2024_IV	3,029,353	38,438,157,479	1,484,067,719
2025_I	3,071,844	38,890,875,685	1,512,624,577
2025_II	3,114,335	39,343,593,890	1,541,181,436
2025_III	3,156,826	39,796,312,096	1,569,738,294
2025_IV	3,199,316	40,249,030,301	1,598,295,152

Table A3. Sectoral and global GDP. Colombia's data in billions of Colombian pesos (COP). Data between 2020-I and 2021-III replaced by the linear trend of the other values.

Quaterly Period	Agrobusiness	Mining	Manufacture	Home Public Services Supply	Construction	Comerce	Information and Communications	Financial and Insurance	Real State	Professional Activities	Public Administraton, Education, Social Health Services	Global_GDP
2017_I	14,784	11,674	26,464	7159	15,847	39,781	6551	9117	19,736	15,428	32,745	225,178
2017_II	14,363	11,257	25,931	7293	16,390	40,560	6690	9697	20,044	15,612	33,495	227,859
2017_III	14,780	11,697	26,168	7557	16,139	41,326	6649	9880	20,411	15,800	34,111	232,030
2017_IV	14,887	12,910	26,458	7780	16,098	41,385	6931	10,366	20,785	16,058	34,884	235,404
2018_I	15,048	14,058	27,048	7835	15,995	42,710	6872	10,168	21,100	16,451	35,728	240,549
2018_II	15,415	14,443	27,279	8126	15,611	43,182	7034	10,698	21,466	16,832	36,356	245,009
2018_III	15,432	14,896	27,640	8282	16,992	43,545	7199	10,704	21,947	17,031	37,255	250,176
2018_IV	15,602	14,391	28,191	8373	16,512	44,271	7243	11,057	22,312	17,283	37,877	252,057
2019_I	15,624	14,434	27,980	8730	16,358	45,539	7174	11,311	22,690	17,665	38,900	256,822
2019_II	16,773	14,945	28,768	8856	16,391	46,668	7381	11,686	22,997	18,169	39,334	263,438
2019_III	17,747	14,192	29,260	9093	16,160	47,715	7321	12,047	23,266	18,273	40,728	268,314
2019_IV	17,814	14,747	29,823	9445	16,368	48,344	7505	11,940	23,435	18,351	40,800	271,494
2020_I	19,879	17,237	31,744	9936	15,985	51,225	7669	12,267	23,692	19,078	41,867	286,002
2020_II	20,820	17,925	32,615	10,289	15,893	52,605	7822	12,484	23,972	19,433	42,693	293,170
2020_III	21,761	18,613	33,487	10,642	15,802	53,985	7946	12,701	24,252	19,787	43,511	300,338
2020_IV	22,703	19,301	34,358	10,995	15,711	55,366	8069	12,917	24,532	20,141	44,328	307,506
2021_I	23,644	19,989	35,230	11,348	15,619	56,746	8192	13,134	24,812	20,495	45,146	314,674
2021_II	24,585	20,677	36,102	11,701	15,528	58,126	8315	13,351	25,091	20,850	45,963	321,842
2021_III	25,527	21,365	36,973	12,053	15,436	59,507	8438	13,568	25,371	21,204	46,780	329,009
2021_IV	26,042	20,628	36,789	11,754	14,311	60,787	8454	13,776	25,227	20,853	46,959	325,468
2022_I	28,783	23,740	39,599	12,487	14,599	62,858	8809	12,970	25,565	21,797	47,762	344,676
2022_II	30,104	28,687	41,865	13,182	14,853	65,093	9009	14,880	25,870	22,779	48,998	363,415
2022_III	30,725	30,223	43,258	13,806	15,549	67,410	9129	14,645	26,315	23,244	49,831	377,709
2022_IV	31,846	27,824	43,747	14,342	15,302	69,297	9172	14,630	26,685	23,412	49,268	376,722
2023_I	33,806	26,621	45,274	14,925	15,581	71,907	9325	15,135	27,256	24,155	53,396	392,277
2023_II	33,000	22,675	43,565	15,858	16,074	71,604	9465	15,251	27,872	24,663	55,677	388,904
2023_III	29,669	23,082	39,889	13,923	14,087	65,260	9105	15,143	27,713	22,952	52,364	360,685
2023_IV	30,276	23,524	40,429	14,183	14,039	66,293	9206	15,359	28,020	23,241	53,126	366,050
2024_I	30,884	23,966	40,968	14,444	13,990	67,325	9306	15,574	28,327	23,531	53,889	371,416
2024_II	31,491	24,408	41,508	14,705	13,941	68,358	9407	15,790	28,635	23,820	54,651	376,781
2024_III	32,099	24,850	42,047	14,965	13,893	69,390	9508	16,005	28,942	24,109	55,413	382,147
2024_IV	32,706	25,292	42,586	15,226	13,844	70,423	9608	16,221	29,249	24,399	56,176	387,512

Table A3. *Cont.*

Quaterly Period	Agrobusiness	Mining	Manufacture	Home Public Services Supply	Construction	Comerce	Information and Communications	Financial and Insurance	Real State	Professional Activities	Public Administraton, Education, Social Health Services	Global_GDP
2025_I	33,314	25,733	43,126	15,487	13,795	71,456	9709	16,436	29,557	24,688	56,938	392,878
2025_II	33,921	26,175	43,665	15,748	13,747	72,488	9810	16,652	29,864	24,977	57,700	398,243
2025_III	34,529	26,617	44,205	16,008	13,698	73,521	9910	16,867	30,171	25,267	58,463	403,609
2025_IV	35,136	27,059	44,744	16,269	13,649	74,553	10,011	17,083	30,478	25,556	59,225	408,974

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