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Correlation and Regression Relationships in Analyzing the National Economy of Brazil

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Abstract: This abstract briefly outlines the socio-economic development characteristics of the Federative Republic of Brazil and its role in the global economy. Brazil is the largest country in South America and stands out due to its territory, population, and natural resource potential. The country's economy is diversified, with industry, agriculture, the service sector, and foreign trade playing significant roles. Brazil is considered one of the world's leading countries in the export of agricultural products (soybeans, coffee, sugarcane), industrial goods, and energy resources. In addition, the country has a well-developed industrial production base, including the automotive industry, mining, and processing sectors. The abstract generally characterizes Brazil's economic stability, export potential, and role in global economic integration. The growth of Brazil's gross domestic product and the factors influencing it have been sufficiently studied. Key indicators of Brazil's overall industrial sectors, agriculture, and service sector, as well as their impact on growth, have been examined and conclusions have been drawn.

Keywords: Brazil, gross domestic product (GDP), industrial sector, agriculture, service sector, foreign trade, export, import.

Introduction. In the context of the intensification of globalization processes and the expansion of international economic relations, an in-depth study of the economies of the world's major countries is gaining significant scientific and practical importance. In particular, the experience of developing and newly industrialized countries plays an important role in modernizing national economies, enhancing competitiveness, and ensuring sustainable growth. From this perspective, the economy of the Federative Republic of Brazil deserves special attention due to its distinctive development model, abundant natural resources, and large domestic market potential.

Brazil is the largest country in South America and holds a leading position in the region in terms of territory, population, and economic potential. The country's economy is based on the balanced development of industry, agriculture, and the service sector, with export-oriented production playing a crucial role. Brazil has established a strong position in the global market through the export of coffee, soybeans, iron ore, oil, and other strategic products, and has developed active trade and economic relations with many countries. In recent years, key priorities of Brazil's economic development have included industrial modernization, the introduction of innovations, the development of a "green economy," and the expansion of renewable energy sources. At the same time, global economic instability, inflation, competition in external markets, and social

challenges have had a certain impact on the country's economic development. Under these conditions, analyzing the structural composition of Brazil's economy, its development trends, and its position in the global economy is a pressing issue. Structurally, Brazil's economy is diversified, with industry, the service sector, agriculture, and foreign trade playing significant roles. The statistical data used in the study indicate a continuous increase in gross domestic product (GDP) over the years. According to the results of the analysis of pairwise correlation coefficients, there is a very strong, positive, and statistically significant relationship between GDP and export indicators. This confirms the high level of integration of Brazil's economy into external markets, especially the U.S. market. In addition, the correlation between value added in the service sector and GDP is almost complete (0.9996), indicating the economy's increasing reliance on the service sector. It was also observed that agriculture and demographic factors have had a significant impact on GDP, suggesting that population growth and rising domestic consumption are supporting economic activity in the country. In particular, the increase in import volumes accelerates the inflow of raw materials and semi-finished products for production sectors, thereby contributing to industrial expansion. The high level of accuracy of the regression model ($R^2 = 0.99993$) demonstrates the correctness of factor selection and their ability to almost fully explain changes in GDP.

Literature Review. Through correlation and regression relationships, it is possible in statistical analysis to determine the degree of interdependence between two or more variables. To understand the extent of the relationship between two variables, determining the correlation coefficient (r) is of primary importance. That is, if the correlation coefficient is close to +1, this indicates a positive relationship between the two variables, whereas if the value is close to −1, a negative relationship can be identified. If the correlation coefficient is around 0, it indicates that there is no relationship between the two variables. To determine the strength of their influence, regression analysis is used, which allows modeling or forecasting one dependent variable based on several independent variables. There are two main types of regression: linear regression and multiple regression. Through a multiple regression equation, it is possible to determine how each factor affects gross domestic product (GDP). Using the above set of statistical methods, the factors influencing the growth of Brazil's GDP can be identified, calculated, and the scope of influence of each factor can be determined. The given graph clearly reflects how the volume of gross domestic product (GDP) of the Federative Republic of Brazil was formed over the period from 1960 to 2023 and distinctly illustrates the stages of the country's economic development. As can be seen from the graph, although Brazil's economy generally exhibited a long-term growth trend, this process was not uniform and was accompanied by sharp fluctuations during certain periods. In the 1960s and 1970s, GDP levels were very low and growth rates were slow. During this period, Brazil's economy mainly relied on agriculture and the supply of raw materials, while the industrialization process was only beginning to take shape. In the 1970s and 1980s, relatively faster GDP growth was observed as a result of the expansion of industrial production, the implementation of infrastructure projects, and active government intervention in the economy. In the late 1980s and early 1990s, economic growth rates were uneven, with declines observed in some years. This situation was associated with inflation, external debt problems, and global economic instability. Nevertheless, from the second half of the 1990s, economic reforms, the strengthening of market mechanisms, and the expansion of foreign trade relations led Brazil's economy into a new phase of growth. The period after the 2000s appears in the graph as the most significant turning point. In particular, a sharp increase in GDP is observed between 2005 and 2013. During this time, Brazil significantly increased its exports of iron ore, soybeans, oil, and other strategic raw materials to the global market. At the same time, rapid development in the industrial and service sectors provided a strong impetus to economic growth. The highest peaks on the graph correspond precisely to these years, confirming that Brazil became one of the largest economies in the region. In 2014–2016, a noticeable decline in GDP was observed, which can be explained by internal economic problems, a reduction in investment, and price fluctuations in external markets. The sharp decline in 2020 was associated with the impact of the global COVID-19 pandemic, which led to a temporary contraction in the

production and service sectors. However, as the graph shows, this decline did not last long, and the economy began to recover within a short period. In recent years, the renewed growth of GDP demonstrates the high adaptability and resilience of Brazil's economy. Industrial modernization, export diversification, the development of renewable energy sources, and the introduction of digital technologies have become key drivers of the country's economic growth. Overall, the graph analysis clearly shows that Brazil's economy has strong long-term development potential, is resilient to external shocks, and continues to occupy an important position in the global economy.

Research Methodology. The study applied the classical approach of correlation–regression analysis. Initially, pairwise correlation coefficients among the selected factors were calculated to determine the degree of linear relationships between them. A correlation matrix was constructed to assess the presence of multicollinearity among the factors. Subsequently, a multiple linear regression model was developed, with GDP selected as the dependent variable. The significance of the model parameters was evaluated using the Student's t-test, while the overall reliability of the model was assessed using the Fisher test. The coefficient of determination was used as the main indicator to determine the extent to which the regression equation explains changes in GDP. At the same time, since the selected factors demonstrated strong relationships, each factor was retained in its respective position in the model.

Analysis and Results. The main purpose of presenting the econometric model in the study is to gain a more comprehensive understanding of correlation–regression analysis and to demonstrate the extent to which the influencing factors contribute to the increase in the volume of gross domestic product (GDP).

Table 1. Outcome and influencing factors selected for correlation–regression statistical analysis[1]

Years	y	x1	x2	x3	x4	x5
2,015	1.80221E+12	2.53273E+11	2.32489E+11	1.12292E+12	77840229290	201675532
2,016	1.79569E+12	2.16686E+11	2.23863E+11	1.13494E+12	87833706982	203218114
2,017	2.06351E+12	2.43511E+11	2.58331E+11	1.307E+12	94933885403	204703445
2,018	1.91693E+12	2.72994E+11	2.80543E+11	1.20102E+12	84736124292	206107261
2,019	1.87329E+12	2.76635E+11	2.64563E+11	1.18144E+12	78772031121	207455459
2,020	1.47611E+12	2.33941E+11	2.42872E+11	9.07045E+11	84307648275	208660842
2,021	1.67065E+12	3.09853E+11	3.19251E+11	9.50822E+11	1.09574E+11	209550294
2,022	1.95192E+12	3.74482E+11	3.83178E+11	1.13382E+12	1.12577E+11	210306415
2,023	2.19113E+12	3.4394E+11	3.93732E+11	1.29669E+12	1.31973E+11	211140729
2,024	2.18582E+12	3.85709E+11	3.92105E+11	1.29337E+12	1.25735E+11	211998573

The characteristic of multiple correlation relationships is that several important and essential factors are included in its regression equation. Correctly selecting the most significant factors and incorporating them into the regression equation is of great importance. The selection of factors is based on qualitative theoretical analysis and is carried out in three stages. In the first stage (preliminary analysis), factors are selected without imposing any conditions. In the second stage, they are analyzed using pairwise correlation coefficients. For this purpose, a matrix of pairwise correlation coefficients among the variables (y) and (x_1, x_2, \ldots, x_n) is constructed. In the third stage of factor analysis, the regression equation is determined, and the statistical significance of its parameters is evaluated using special criteria. To determine which factors should be included in the regression equation, a matrix of pairwise correlation coefficients among the influencing factors is constructed (Table 2).

[1]https://data.worldbank.org/country/Brazil and https://www.statista.com/topics/3080/?srslBrazilya_tid=AfmBOoq0v-Y7E5H3B_ogAcsJiToUcKDMHQW4iaTczI-a1HlqcOa5kqd-

Table 2. Matrix of pairwise correlation coefficients among the influencing factors

	yillar	*y*	*x1*	*x2*	*x3*	*x4*	*x5*
yillar	1						
y	0.371831965	1					
x1	0.862178628	0.58683591	1				
x2	0.90327692	0.629768118	0.966832908	1			
x3	0.103467283	0.946499281	0.316860979	0.356904889	1		
x4	0.843311906	0.619244307	0.830269278	0.924053313	0.353991127	1	
x5	0.99109692	0.295136502	0.814095089	0.858601511	0.035857986	0.78568972	1

Based on the data in t**able 2**, it can be stated that the pairwise correlation coefficients indicate a strong positive relationship between gross domestic product (GDP) (Y) and the influencing factors. All indicators are highly correlated with each other. In Table 2, (r_{ij}) represents the pairwise correlation coefficient between the factors (x_i) and (x_j). As is known, in a multiple regression equation, factors that are strongly linearly correlated with each other should not be included simultaneously. However, as shown in the table, due to the strong intercorrelation among all factors, it was decided to include all four factors in the econometric model. In this case, the critical value of the correlation coefficient was taken as (r_{cr} = 0.99963). The coefficient of determination of the estimated model indicates the proportion of the variance of the dependent variable that is explained by the influence of the considered factors. This indicator takes values between 0 and 1. The closer its value is to 1, the better the factors included in the regression equation explain the variation of the dependent variable. The analysis of the significance of the identified model is carried out by testing the null hypothesis. The null hypothesis is expressed as (H_0) and reflects the overall significance of the regression coefficients. If the results of the analysis do not lead to the rejection of the null hypothesis, the following conclusion is drawn: “the influence of the factors on the dependent variable Y is insignificant, and the overall quality of the regression equation is low.” The testing of the null hypothesis is performed using analysis of variance, where the null hypothesis is formulated as (H_0: D_{fact} = D_{res}) against the alternative hypothesis (H_1: D_{fact} > D_{res}). To test these hypotheses, the F-Fisher criterion is applied. In the model developed through the analysis of factors affecting GDP growth, the actual value of the F-Fisher statistic is (F_{actual} = 891.78) (Table 3).

Table 3. Regression statistics table

Final Conclusions	
Regression Statistics	
Multiple R	0.999595423
R-squared	0.999191009
Adjusted R-squared	0.998179771
Standard Error	9530301794
Observations	10

Analysis of Variance (ANOVA)					
	df	SS	MS	F	**Significance F**
Regression	5	4.48723E+23	8.97446E+22	988.0865728	2.86097E-06
Residual	4	3.63307E+20	9.08267E+19		
Total	9	4.49086E+23			

Thus, the factors included in the regression equation can be classified as highly significant, relatively significant, and insignificant. The coefficient of determination of the estimated model shows the proportion of the variance of the dependent variable that is explained by the influence of the considered factors. This indicator takes values between 0 and 1. The closer its value is to 1, the better the factors included in the regression equation explain the variation of the dependent variable. The analysis of the significance of the identified model is carried out by testing the null hypothesis. The null hypothesis is denoted as (H_0) and reflects the overall significance of the regression coefficients. If the results of the analysis do not lead to the rejection of the null hypothesis, the following conclusion is drawn: “the influence of the factors on the dependent variable Y is insignificant, and the overall quality of the regression equation is low.” Testing of

the null hypothesis is performed using analysis of variance, where the null hypothesis is formulated as (H_0: D_{fact} = D_{res}) against the alternative hypothesis (H_1: D_{fact} > D_{res}). To test these hypotheses, the F-Fisher criterion is applied.

Conclusion. The presented statistical data clearly demonstrate that, as of November 2025, Brazil's economy follows a stable and export-oriented development model. In particular, in November 2025 Brazil recorded exports amounting to USD 28.5 billion and imports of USD 22.7 billion, achieving a positive trade balance of USD 5.84 billion. This result confirms the efficiency of the country's foreign trade and the dominance of exports over imports. The 2.42 percent increase in export volume between November 2024 and November 2025 indicates sustained demand for Brazilian products in external markets, while the 8.13 percent growth in imports reflects the expansion of industrial and consumer needs. In 2023, Brazil ranked 9th among the world's largest economies in terms of gross domestic product, highlighting its significant position in the global economy. At the same time, its 22nd place in total export volume suggests that Brazil still relies heavily on raw materials and agricultural products. Furthermore, the country's 89th position in GDP per capita indicates the presence of internal socio-economic disparities in its development.

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