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STATISTICAL ANALYSIS OF GLOBAL DEBT IN THE WORLD ECONOMY

The object of research is global debt (or world debt) in the world economy. Today, the problem of global debt (or global indebtedness) is extremely acute in the world economy. The global debt indicator is the largest in all history of the world economy and has already amounted to 315 trillion USD in 2024. The interdependence of the global debt and the main macroeconomic indicators were investigated in this paper. The main world macroeconomic indicators (GDP, inflation, imports, exports, economic growth) and world population are treated as global in this publication. The forecasting of the global debt index was also carried out until 2035 in the world economy.

Statistical analysis methods were used in this research. All research results were obtained through the Statgraphics Centurion statistical package. This package made it possible to carry out the Multiple Analysis of Variance procedure and forecasting through the ARIMA (1,0,0) model.

During applying the Multiple Analysis of Variance procedure, this publication included the results of Pearson's correlation, Spearman's rank correlation and analysis of covariance. Pearson's correlation made possible to reveal which global macroeconomic indicators the global debt has very strong and weak connections. Spearman's rank correlation also demonstrates the interdependence of global debt and global macroeconomic indicators. Covariance analysis gave results that differ from the above methods. In turn, the ARIMA model was used to forecast the global debt until 2035 in this research.

The essence of the research results is that global debt has the closest relationships with such global macroeconomic indicators as global GDP, global exports and global imports and world population. Global debt is moderately correlated with such global macroeconomic indicators as global inflation and global economic growth. The ARIMA model predicts an increase of global debt by 2035, rather than a decrease, and, accordingly, these global macroeconomic indicators as interdependent from the debt.

In practice, these results can be used to implement appropriate economic policies to balance the main macroeconomic indicators in the economy in order to reduce the indebtedness of states that, in turn, affects on the global debt.

Keywords: global debt, global macroeconomic indicators, Multiple Analysis of Variance, Pearson's correlation, Spearman's rank correlation.

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1. Introduction

The theme of this publication is relevant due to the trend of increasing global debt in the world economy remains and has recently progressed. Global debt significantly affects on the other global macroeconomic indicators. Such organizations as the IMF [1], the Institute of International Finance [2] and others pay considerable attention to the global debt condition in their reports.

A lot of attention is paid to the state's debt, the reasons of this debt etc. in previously published economic researches. The researches by scientists from different countries [3–6] are devoted to the relationship state indebtedness and their economic growth, state debt influence economic and mathematical modeling on the economic growth of countries around the world. The authors of these publications examined public debt and economic growth mostly by using regression analysis. All other macroeconomic indicators were mostly

often used for general comparative analysis with public debt. The interdependence of the major macroeconomic indicators and public debt has been studied very little.

That is why, in today's conditions of growing global debt, it is important to study the impact of the main global macroeconomic indicators and global debt using economic-mathematical modeling, statistical analysis, etc. Taking into account the current above-mentioned trend, the forecasting of global debt is also an urgent issue in the world economy.

Many works are devoted to the study of economic and mathematical modeling and statistical analysis [7, 8].

The aim of research is to determine the interdependence and reveal the patterns of global debt development and the major global macroeconomic indicators using statistical analysis and provide a global debt development forecast. Such research will make it possible to determine the appropriate economic policy in order to reduce the debt burden on national economies and, accordingly, reduce global indebtedness.

2. Materials and Methods

The materials from the Institute of International Finance and the World Bank were used for the period 2019–2023 for the global debt research in the world economy. All research results were obtained using the Statgraphics Centurion statistical package. The Multiple Analysis of Variance procedure application made it possible to obtain final results using Pearson’s correlation, Spearman’s rank correlation, covariance of these raw data. The ARIMA model application helped to obtain forecast values of the global debt.

3. Results and Discussion

In order to study the global debt impact on the world economy development based on statistical data from the official Internet resource of the World Bank and the Global Debt Monitor (May 2024) Institute of International Finance official report, the Multiple Analysis of Variance procedure was carried out using the statistical package Statgraphics Centurion. The Multiple Analysis of Variance procedure is designed to summarize two or more columns of numerical data. It calculates summary statistics for each variable, as well as correlations and covariances between variables and applies other research methods.

Global debt and major macroeconomic indicators of GDP, world exports, world imports, world inflation and world economic growth, world population were compared in this research. They will be presented as global GDP, global export, global import, global inflation, global economic growth, as well as world population (Table 1) in this research. Statistical data (Table 1) were presented for the period from 2019 to 2023.

The results of the Pearson’s correlation are presented between the global debt and the major global macroeconomic indicators in Table 2.

Table 2 shows for each pair of variables:

1. R_{ij} is the estimated Pearson product moment correlation coefficient between row variable i and column variable j .
 2. N_{ij} is the number of cases used to estimate this correlation. The correlation can be calculated using rows with complete information for all variables or using all rows with non-missing values for a variables selected pair depending on the analysis parameters.
 3. P_{ij} is a P -value that can be used to test the hypothesis that the correlation between two variables is 0.
- Thus, the correlation coefficient (R) ranges from -1 to $+1$ and in this way measures the strength of the linear relationship between variables. Also shown in parentheses is the number of data values (N) pairs used to calculate each coefficient.

Table 2

The Pearson’s correlation of global debt and major global macroeconomic indicators

Global macroeconomic indicators	Global debt (trillion USD)
GDP (trillion USD)	$R=0.9661$
	$N=(5)$
	$P=0.0074$
Economic Growth (%)	$R=0.4753$
	$N=(5)$
	$P=0.4185$
Global export (trillion USD)	$R=0.9299$
	$N=(5)$
	$P=0.0221$
Global import (trillion USD)	$R=0.9181$
	$N=(5)$
	$P=0.0278$
Global inflation (%)	$R=0.5234$
	$N=(5)$
	$P=0.3654$
World population (billion people)	$P=0.9613$
	$N=(5)$
	$R=0.0091$

The third number in each place of the table is the P -value (in bold), which tests the estimated correlations statistical significance. P -values below 0.05 indicate statistically significant non-zero correlations at the 95.0 % confidence level. Small P -values (less than 0.05 when working at the 5 % significance level) correspond to statistically significant correlations. In the table above, all pairs of variables show significant correlations.

The following four pairs of macroeconomic variables and global debt have P -values below 0.05:

1. Global debt (trillion USD) and GDP (trillion USD).
2. Global debt (trillion USD) and Global export (trillion USD).
3. Global debt (trillion USD) and Global import (trillion USD).
4. Global debt (trillion USD) and Population (billion people).

The Spearman’s rank correlation was also applied on the Multiple Analysis of Variance basis, which results are presented in Table 3.

The Spearman’s rank correlations between each pair of variables is shown in Table 3. These correlation coefficients range from -1 to $+1$ and measure the strength of the relationship between variables. Unlike the more common Pearson’s correlations, Spearman’s coefficients are calculated from the

Table 1

The indicators of global debt and the world major global macroeconomic indicators from 2019 to 2023

Year	Global debt (trillion USD)	Global export (trillion USD)	Global import (trillion USD)	World population (billion people)	Global economic growth (%)	Global inflation (%)	Global GDP (trillion USD)
2019	250	24.86	24.37	7.74	2.5	3.5	87.95
2020	260	22.53	21.89	7.82	-3.2	3.2	85.58
2021	296	28.2	27.2	7.89	6.2	4.7	97.53
2022	308	31.4	30.75	7.95	2.6	8.7	101.23
2023	313	30.86	30.23	8.02	2.4	3.5	105.44

Note: systematized by the author based on data [9, 10]

ranks of the data values, not from the values themselves. The number data values pairs are used to calculate each coefficient are also shown in parentheses. The third number in each place of the table is the P -value, which tests the statistical significance of the estimated correlations. P -values below 0.05 indicate a statistically significant non-zero correlation at 95.0 % confidence level. The following pairs of variables have P -values below 0.05 (bolded in the table).

Table 3

The Spearman's Rank Correlations of global debt and major global macroeconomic indicators

Global macroeconomic indicators	Global debt (trillion USD)
GDP (trillion USD)	$R=0.9000$
	$N=(5)$
	$P=0.0719$
Economic Growth (%)	$R=0.1000$
	$N=(5)$
	$P=0.8415$
Global export (trillion USD)	$R=0.8000$
	$N=(5)$
	$P=0.1096$
Global import (trillion USD)	$R=0.8000$
	$N=(5)$
	$P=0.1096$
Global inflation (%)	$R=0.4104$
	$N=(5)$
	$P=0.4118$
World population (billion people)	$R=1.0000$
	$N=(5)$
	$P=0.0000$

Also, the Multiple Analysis of Variance procedure includes not only correlation, but also covariance. The results of the covariation between the global debt and the major global macroeconomic indicators are shown in Table 4.

All covariance values between global debt and major global macroeconomic indicators are positive.

The numerical value of the covariance does not matter. It shows that global debt and all indicators are moving in the same direction.

The «Correlation Graph» panel was developed based on correlation and covariance analyses, which is presented in Fig. 1.

This panel displays all Pearson's correlation coefficients of global debt and major global macroeconomic indicators.

The «Correlation Graph» panel displays estimated correlations or partial correlations in the form of a matrix with colored cells. Thus, global debt has an average correlation with global economic growth ($R=0.48$) and global inflation ($R=0.52$). All other indicators have a high correlation interdependence among themselves.

Table 4

The covariation of global debt and major global macroeconomic indicators

Global macroeconomic indicators	Global debt (trillion USD)
GDP (trillion USD)	236.149
	(5)
Economic Growth (%)	45.875
	(5)
Global export (trillion USD)	101.997
	(5)
Global import (trillion USD)	99.7285
	(5)
Global inflation (%)	34.465
	(5)
Population (billion people)	3.008
	(5)

Pearson Product-Moment Correlations

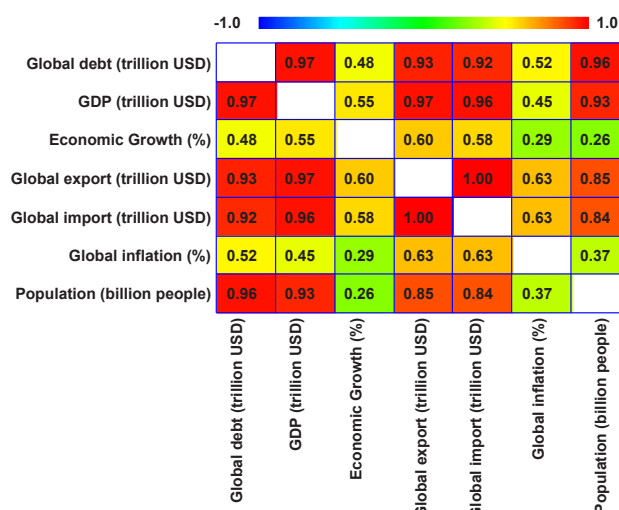


Fig. 1. The Pearson's correlation coefficients of global debt and major global macroeconomic indicators

The ARIMA (1,0,0) model was also used to forecast global debt in the world economy. Statistical data for the forecast are presented in Table 5. It is shown the current and forecasted values of global debt (trillion USD) from 2019 to 2023 in Table 5.

Table 5

Model: ARIMA (1,0,0) with constant

Period	Data	Forecast	Residual
2019	250.0	260.219	-10.2187
2020	260.0	255.135	4.86473
2021	296.0	265.034	30.9658
2022	308.0	300.671	7.32945
2023	313.0	312.549	0.450686

The results of forecasting for the following years are presented in Table 6. During the period when actual data are available, the predicted values for the fitted model and residuals (forecast data) are displayed.

Table 6

Model: ARIMA (1,0,0) with constant

Period	Forecast	Lower 95.0 % Limit	Upper 95.0 % Limit
2024	317.499	252.695	382.303
2025	321.952	230.767	413.137
2026	326.361	215.243	437.478
2027	330.724	203.058	458.39
2028	335.044	193.021	477.067
2029	339.32	184.515	494.125
2030	343.553	177.173	509.933
2031	347.743	170.753	524.733
2032	351.891	165.088	538.694
2033	355.997	160.054	551.939
2034	360.061	155.559	564.564
2035	364.085	151.529	576.641

The 95.0 % forecast limits are shown for time periods after the end of the global debt series. These limits demonstrate where the true value of the data at a selected future time is likely to be with 95.0 % confidence, assuming that the fitted model fits for the data.

Current values of global debt starting from 2020 to 2023 are in blue color in Fig. 2, where the graph is presented. According to the results of the last years, the global debt began to increase significantly relative to the global GDP. In 2023, the global debt of all states amounted to 93.2 % of the world GDP and this is a negative trend [9]. Such rapid growth of global debt to global GDP is a coming global crisis sign, because it indicates the large indebtedness of states, enterprises, etc. According to the forecast of the obtained ARIMA (1,0,0) model (green line and red lines) on the graph, the global debt will have a positive forecast and a negative development forecast. Negative forecast asserts that the global debt will increase significantly relative to the global GDP and will reach 576.641 trillion USD in 2035. This is a very negative scenario and can lead to catastrophic consequences for the world economy. If the global debt reaches the mark of 364 trillion USD (by inertia) in 2035, so this is also a negative scenario. Such a trend will be a cause of the economic depression, and later will be a cause global crisis in the world economy. Global macroeconomic indicators will also change according to their interdependence to global debt. A positive forecast means that the global debt will decrease and reach the mark of 151.529 trillion USD in 2035. However, global debt is likely to increase by inertia unless there are major shocks in the global economy, for example, such as during the COVID-19 pandemic.

In previously published scientific works, much attention was paid to the public debt and its impact on macroeconomic indicators. In this work, the (world) global debt and the main world (global) macroeconomic indicators were investigated. This research confirmed that global debt is indeed closely interrelated with and influences all global macroeconomic indicators, just as these indicators affect on the global debt. But not all global macroeconomic indicators show such dependence, some have medium interdependence. This research identifies a strong correlation between global debt and world population that has previously received relatively little attention in other publications. Also, forecasting using the ARIMA model showed that the trend of global debt growth will still remain until 2035. Debt forecasting methods were not established in the other researches.

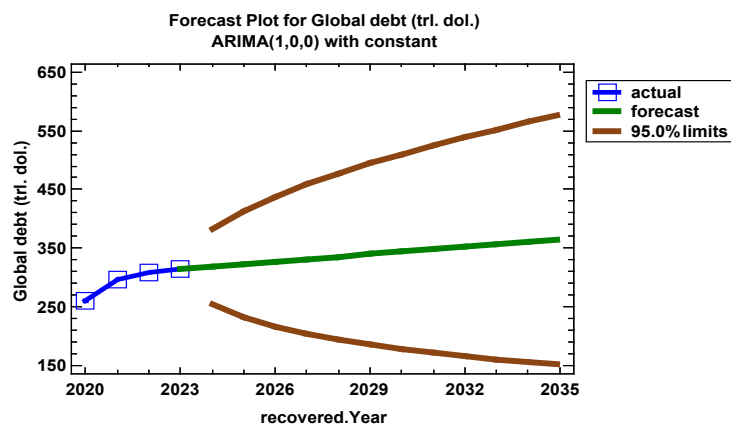


Fig. 2. The global debt (trillions USD) forecasting through the ARIMA (1,0,0) model until 2035

The research limitation consists that due to the COVID-19 pandemic, the global macroeconomic indicators of the world economy began to decrease. The global debt began to grow rapidly during this period of time and the macroeconomic situation is getting worse. Such a decline of national economies and the global debt growth, of course, affects on the obtained results. From 2022, the national (macroeconomic) indicators of Ukraine began to decrease significantly, which, of course, affects the overall the global (world) macroeconomic indicators value.

The global debt theme has a significant importance for the world economy and is therefore promising for further research. Such studies can be conducted using various methods of econometric analysis and etc.

4. Conclusions

Considering that covariance measures the degree to which two variables vary together, while correlation measures not only the degree but also the direction of the relationship between two variables, Pearson correlation results suggest that global debt and global GDP, global exports, global imports and world population will change in the same direction.

Global inflation and global economic growth are less strongly correlated with global debt. These global macroeconomic indicators will also change during global debt changes, but not as much as the above global macroeconomic indicators. Based on the results of Spearman's rank correlation, it can be concluded that global debt and world population show the biggest interdependence.

According to the results of Spearman's rank correlation all other global macroeconomic indicators show not so big dependence of the global debt. The covariance, in turn, demonstrates a strong interdependence between the global debt and the world population, according to this analysis all other indicators have a weak dependence. The ARIMA model predicts an increase in global debt until 2035, which could lead to a global crisis. The results of the research are useful for forecasting the world economy development in the conditions of the global debt growth, choosing the appropriate states macroeconomic policy in order to regulate macroeconomic indicators and, accordingly, reduce the global debt. In connection with the problem of the global debt growth, it is necessary to comprehensively study this indicator, the causes and consequences of its growth. According to the forecast, the problem of global debt will not disappear in the coming years and will persist.

Conflict of interest

The author declares that she has no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has associated datum in the data repository.

Use of artificial intelligence

The author confirms that she did not use artificial intelligence technologies when creating the presented work.

References

1. Fiscal Monitor (2023). *On the Path to Policy Normalization*. Available at: <https://www.imf.org/en/Publications/FM/Issues/2023/04/03/fiscal-monitor-april-2023>
2. *Global Sovereign Debt Monitor* (2024). Available at: <https://erlassjahr.de/en/aktionsbox/global-sovereign-debt-monitor-2021/>
3. Lutsyshyn, Z., Bortnik, A. (1998). Ekonomiko-matematychna model upravlinnia derzhavnym borhom. *Visnyk NBU*, 7, 23–25.
4. Stavyskyy, A., Bilychenko, M. (2018). Modeling the impact of public debt on the economic growth worldwide. *Bulletin of Taras Shevchenko National University of Kyiv Economics*, 197, 49–59. <https://doi.org/10.17721/1728-2667.2018/197-2/8>
5. Checherita-Westphal, C., Rother, P. (2012). The impact of high government debt on economic growth and its channels: An empirical investigation for the euro area. *European Economic Review*, 56 (7), 1392–1405. <https://doi.org/10.1016/j.euroecorev.2012.06.007>
6. Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. *Journal of Econometrics*, 93 (2), 345–368. [https://doi.org/10.1016/s0304-4076\(99\)00025-1](https://doi.org/10.1016/s0304-4076(99)00025-1)
7. Golikov, A. P., Galajda, O. E., Hanova, E. V. (2011). *Reshenie zadach po ekonomiko-matematicheskomu modelirovaniuu mirokhoziaistvennykh protcessov v Microsoft Excel i Statistica*. Kharkiv: KhNU im. V. N. Karazina, 46.
8. Ponomarenko, V. S., Maliarets', L. M. (2009). *Multivariate analysis of the socio-economic systems*. Kharkiv: KhNEU, 388.
9. *Global Debt Database*. International Monetary Fund. Available at: <https://www.imf.org/external/datamapper/datasets/GDD>
10. Economy. *The World Bank*. Available at: https://datatopics.worldbank.org/world-development-indicators/themes/economy.html#featured-indicators_1

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