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„Димитър А. Ценов" - Свищов

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Международна научно-практическа конференция

90 години дарителство, знание, иновации и устойчиво развитие в СА „Д. А. Ценов" – Свищов

Том I



5-7 ноември 2026 г.

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INVESTIGATING GRANGER CAUSALITY BETWEEN GDP-RELATED INDICATORS: EVIDENCE FROM BULGARIA AND ROMANIA

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Professor, PhD, Cristian-Marian Barbu[2]

Abstract: *In this paper, the authors investigate the existence of bilateral Granger causality relationships between selected GDP-related indicators from Romania and Bulgaria. The test procedure pursues the Toda-Yamamoto approach, as the indicators are integrated of order at least one. The results indicate no causalities in Granger acceptance at the level of the indicators processed.*

Keywords: *Granger causality, macroeconomic, analysis, interdependence, indicator*

JEL: *C32, C12, F43*

1. Introduction

This paper is based on the fact that the national economies of the European Union countries are strongly interconnected, and aims to investigate whether there is cross-country Granger causalities between the selected indicators associated with the Gross Domestic Product, specific to Bulgaria and Romania. Both countries share common features: members of the European Union since 2007 (date of adhesion is the same, the first day of the said year), former communist economies, and independent countries in the Central and Eastern European communist system, opportunities for significant bilateral collaboration on the economic plan etc. However, while Romania and Bulgaria have followed broadly similar paths of European integration, their recent economic trajectories reveal important differences. The economies of both countries have experienced and benefited from sustained income convergence, increasing trade integration and substantial access to European funds, but the evolution and sources of economic growth have not been identical. The economic agents from the two countries gained access to the European Single Market, which represents a great chance, but also a challenge, alongside the better attractiveness for foreign investment and more facile participation in European production networks. According to OECD, substantial income and productivity convergence over the past two decades can be observed for Romania, while the income of Bulgaria has converged towards the advanced economies of the organization (OECD), but less rapid, when

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compared with other countries in the region, together with the presence of a significant productivity gap. From these differences, criteria such as geographical proximity, as the two countries are neighbours, and common EU membership should not necessarily be interpreted as evidence of similar economic dynamics. (OECD, 2026a, 2026b).

The integration can be supposed, and is expected to, generate or increase the economic spillovers between countries. As economic agents become part of trans-national production and trade networks, the evolutions experienced by one economy can influence the dynamics of economic indicators on aspects such as demand, production, investments and trade in the another. One additional argument for Romania and Bulgaria, in this respect, is the fact that Romania has a key position in the group of Bulgaria's most important trading partners outside the euro area, accounting for around 11% of Bulgarian goods exports and 8% of its goods imports in 2025. This makes plausible the presence of the phenomenon of changes in economic activity in one country that may precede changes in the other (OECD, 2026b).

Recent data that reflect the evolutions of each country provide significant evidence that integration does not automatically guarantee identical economic responses to common triggers. Following the COVID-19 pandemic, Bulgaria has recovered its economic growth rate, due to internal consumption favoured by rising wages and the level of real interest rates, while EU funds represent a major share in the public investment. Romania, in contrast, has been exposed to weaker external demand and stronger impact of the fiscal consolidation, with EU-funded investment providing an important source of support, as the private investments was slowing down. Therefore, when being exposed to the same shock acting at European or global level, the economies can experience different effects because of non-identical domestic demand, fiscal conditions, production structures and external exposure. (OECD, 2025; OECD, 2026a, 2026b).

2. Literature review

There are numerous studies concerning the relationships between the national economy and its main components. For the former, the Gross Domestic Product is the main indicator used as a global measure, while other indicators (final consumption, investment, exports and imports) characterize sources and uses of the resources. Fiscal variables, including taxes and subsidies, offer the measure of particular effects of governments' policies on the economies. While there is a close correlation between these indicators in the national accounts system, it cannot be stated, without solid evidence, that these correlations are present when the same indicators are compared across countries. The bilateral causality analysis between national economies is relevant if the objective of the research is to investigate if past developments in one economy include relevant information that can be used to forecast the subsequent evolution of another.

Dritsakis (2004) investigated Bulgaria and Romania using a multivariate autoregressive VAR model and error correction models to assess the Granger causalities, the variables considered being economic growth, exports and investment in each of the national economies. The results outline the strong causality in Granger sense between economic growth and investments, on one hand, and the exports, on the other for both countries, alongside the bilateral influence between economic development and capital accumulation and exports.

Angelov and Nikolova (2025) apply pairwise Granger Causality tests, followed by impulse responses and variance decompositions on 2013Q1–2025Q1 (quarterly) data, for Bulgaria, Estonia, Hungary and Romania. Their analysis pursues Granger causality between tax burden and economic growth and vice versa, and the results outline cointegration between the variables in Romania and Bulgaria (no similar results for the other two countries), and Granger causality from economic growth (as causal variable) to the tax burden for Bulgaria and Hungary. All analyses are focused on the same national economy.

Păunică et al. (2021) have studied Granger causality between selected indicators related to the GDP and the GDP itself for the European Union and its member countries (in 2019), based on the Toda-Yamamoto method and by capitalizing annual data between 1995–2019. It is important to outline that the findings were not totally homogenous, across countries and indicators. Some research hypotheses were not associated with any causality in Granger acceptance, while some were validated for a number of countries (each hypothesis is based on an indicator as causal variable, and the evaluation includes different indicators for the same country).

Sijabat (2022) uses the Toda-Yamamoto approach for analysing Granger causality for Indonesia. The indicators tested are Gross Domestic Product, foreign aid, foreign direct investment, and gross capital formation, and the dataset includes data between 1970-2019. Likewise, the results cannot be characterized as uniform for the entire set of indicators. Chirila and Chirila (2017) applied the Toda–Yamamoto procedure to examine Granger causality between remittances and selected macroeconomic indicators in Romania, including GDP (as measure of the economic development), investment and exports, finding no evidence that remittances Granger-caused the variables considered as dependent.

In their paper, Topcu, Altinoz, and Aslan (2020) examined the relationship between economic growth (as dependent indicator), and the natural resources, energy consumption and gross capital accumulation (as impact factors) for a significant number of countries. They have used, as research instruments, Panel VAR and Granger causality approaches. The results indicate that the relationships between capital accumulation and economic growth differ depending on the income levels of the countries, reinforcing the idea that the direction of temporal causality is not necessarily uniform across economies.

A study that is more similar in approach with the present paper is Lima Junior et al. (2014), who pursue to discover the causal relationship between corresponding external-balance indicators of China and the United States using Granger causality tests based on the Toda–Yamamoto method. Their findings support the existence of the causality.

Manole and Barbu (2026) have examined the possible bilateral causalities in Granger acceptance between the Gross Domestic Products and Gross Values Added of Romania and Bulgaria (alongside several more countries from Central and Eastern Europe, causalities were tested between Romania and each one of the other countries), the research methodology pursued the same steps, the data were the same (updated at a previous date, but no modification was found for the values of GDP), and no Granger causality was identified for the GDPs of Bulgaria and Romania. To be noted, in the study based on the datasets with definitive data only (1995-2023), it has been found that the GVA of Bulgaria does Granger cause the GVA of Romania.

The present paper extends the analysis by examining six other indicators related to the GDP, in order to assess whether the absence of bilateral Granger causality, between Romania and Bulgaria, observed for GDP also characterizes the indicators selected.

This approach leads the research beyond the aggregate GDP relationship and investigate whether bilateral predictive linkages emerge at the level of its main expenditure and fiscal dimensions and thus can provide a more granular perspective on the economic interactions between Romania and Bulgaria.

The investigation of the relevant literature identified, as far as the authors know, no studies that pursue the same type of relationship that the one envisioned by the authors (Granger causality) between indicators closely related to GDP and analysed for Bulgaria and Romania, in the same manner. Thus, to address this gap, the objective of the research is to analyse the existence and direction of causalities in Granger sense between selected macroeconomic indicators in Romania and Bulgaria. For the indicators selected, the research hypothesis is thus defined:

H1. For each GDP-related indicator considered, the corresponding indicator of Romania Granger-causes, and is Granger-caused, by the indicator of Bulgaria.

The hypothesis is tested separately for the following indicators: final consumption expenditure, gross capital formation, exports of goods and services, imports of goods and services, taxes on production and imports, and subsidies.

3. Data. Research methodology

3.1. Data

The data is extracted from Eurostat, from the dataset "*Gross domestic product (GDP) and main components (output, expenditure and income) - annual data [nama_10_gdp]*", data extracted on October 1st and labelled as last updated on September 30th. The data cover the period 1995-2025. All values are expressed in "*Current prices, million purchasing power standards (PPS, EU27 from 2020)*".

For all variables, the dataset includes three values flagged as provisional: the value for 2025 (Bulgarian data) and the values for 2024 and 2025 for Romanian data. The authors chose to pursue the study with the data available at the specified time, while assuming, in the future, as definitive data become available, to re-apply the test for Granger causality, on the same methodology, to observe if there are any differences in the results. For this reason, also, the outcomes of this article will be subjected to cautious interpretation.

The data were transformed by logarithm (natural). This transformation is supposed mitigate skewness and heteroskedasticity, which is particularly relevant for economic variables and, given the difference in economic size between Bulgaria and Romania, coupled with the fact that the indicators are not considered per capita, shifts the analysis from absolute to proportional changes, which is particularly relevant when comparing macroeconomic indicators across economies with this characteristic (Gujarati & Porter, 2009; Wooldridge, 2016).

The following variables have been defined:

- Final consumption expenditure (*l_fce*);
- Gross capital formation (*l_gcf*);
- Exports of goods and services (*l_egs*);
- Imports of goods and services (*l_igs*);
- Taxes on production and imports (*l_tpi*);
- Subsidies (*l_sds*).

Variables for Bulgaria carry the suffix *bg* in their name, while for Romania the label *ro* was used.

3.2. Research methodology

The research methodology is based on the Toda-Yamamoto approach for Granger causality analysis. This is justified by the orders of integration discovered for the datasets. The advantages of applying the method in such cases are outlined by Sijabat (2022). Considering the structure of the dataset and the software instrument applied (EViews® 14), the methodology takes into account and is adapted from Giles (2011), and the test procedure is configured in the following steps:

a) A pair of variables (the variables that define the same indicator) is analysed for each research hypothesis.

b) Test of unit roots, to discover the order of integration and assess the maximum order of integration between the variables. The test takes into account both the *Intercept* and *Trend and Intercept* options, and the authors have chosen to use *Augmented Dickey-Fuller* and *Kwiatkowski–Phillips–Schmidt–Shin* tests, for more solid results. The default options presented by EViews® for the other parameters of the tests (automatic lag selection etc.), are used.
   In case the results are not the same, the conciliation is based on the objective of this step, and the maximum result provided is taken into account.
c) Configuration of a VAR model including the pair of variables, with the default number of lags (2).
d) Application of the lag length criteria pursues the optimum lag for each model. The authors have chosen to offer precedence to the lag length offered by the Schwarz Info Criterion as, according to Chirila and Chirila (2017), it favours models similar to the ones used in this paper. If necessary, the number of lags (*n*) is adjusted accordingly.
e) Each VAR model is tested for proper specification, against the four tests:
   a. *Autocorrelation LM*: for the default number of lags presented by the Eviews® interface (usually, *n+1*). Each model must be free from serial correlation before being passed to the next stage of the procedure. If necessary, according to Giles (2011), the maximum lag length can be increased by 1.
   b. *AR Roots*: a good specified model must be stable, and, if necessary and possible, the same correction can be applied as in the case of the previous test (Giles, 2011).
   c. *Normality - Orthogonalization: Cholesky (Lutkepohl)*.
   d. *White Heteroskedasticity Test (No Cross Terms)*.
   If the model tested fails the last two tests, the authors choose to continue the procedure, but to interpret the results with a certain degree of caution as Hacker and Hatemi-J (2003, cited in Hatemi-J, 2004) report that inference based on the Toda–Yamamoto test statistic may be misleading in the presence of non-normality or ARCH effects.
f) Insertion of additional lags into the model, but as exogenous variables (Giles, 2011), corresponding to the maximum order of integration.
g) Application and interpretation of the modified Wald test.

The level of significance considered, for all tests, is 5%.

4. Results and discussions

The first step of the test procedure involves the evaluation of the order of integration for each pair of variables that are related to a research hypothesis. The results achieved following the application of the unit root tests are presented in

Table 1. Order of integration for the variables included in the study

Variable name	Code	BG	RO
Final consumption expenditure	l_fce	1	1
Gross capital formation	l_gcf	2	1
Exports of goods and services	l_egs	1	4
Imports of goods and services	l_igs	1	1
Taxes on production and imports	l_tpi	1	1
Subsidies	l_sds	>6	1

Source: Authors' representation, on the basis of the unit root test results

The unit root tests indicate non-homogenous orders of integration across the variables and countries. While most of the analysed series are integrated of order one, there are some exceptions. *Gross capital formation* for Bulgaria is classified as I (2), while *Exports of goods and services* for Romania exhibit an integration order of I (4). The *Subsidies* series for Bulgaria displays a particularly high estimated order of integration, exceeding I (6). Almost all results are acceptable, and the maximum order of integration is subsequently incorporated into the augmented VAR specification in the final steps. A notable exception is the case of the *Subsidies*, for which the application of the final step of the methodology is rendered impossible and has been not further processed.

The definition of the vector autoregressive models that are to support the test procedure, the optimum number of lags, the number of lags set after adjustments (as described in the research methodology section) and the behaviour of the models against the normality and heteroskedasticity tests) led to the results presented in Table 2.

Table 2. Configuration of VAR models used during testing

Variable name	Optimum	After autocorrelation and stability tests	Compliance with Normality and heteroskedasticity tests
Final consumption expenditure	1	3	No / Yes
Gross capital formation	2	2	No / Yes
Exports of goods and services	1	2	Yes / Yes
Imports of goods and services	1	1	No / Yes
Taxes on production and imports	1	1	Yes / No

Source: Authors' representation, on the basis of the VAR models' characteristics

The model for *Final consumption expenditure* has an optimum lag length that is 1…1, and the model set as VAR (3) is well specified against the first two tests. However, the normality test is not passed, while the heteroskedasticity test produces proper results.

The VAR model defined for *Gross capital formation* did not require any additional configuration, the mandatory specification tests are compliant for the initial setting, as VAR (2). The satisfactory result for the heteroskedasticity test is to be noted but, as the model has problems with the normality test, the final results of the procedure will be treated with caution. A similar issue is encountered for the model associated with *Imports of goods and services*, redesigned and tested with one lag. The last model, configured for *Taxes on production and imports*, includes only one lag (optimum), and the only specification test not passed in this setting is the final one (heteroskedasticity, by a very narrow margin).

For the variable *Exports of goods and services*, the model is optimally configured as VAR (1). The issue with autocorrelation encountered at this stage is solved by including the second lag, which displays a good specification when the results of the other three tests are interpreted.

Most of the models respond to the tests in a manner that associates caution with the final results of the test procedure. While the model for the export-related variable is with all specification tests completed, the first two specification tests have been passed by the other four models and therefore all five of them can be subjected to the final parts of the procedure.

The configurations and the results of the Granger causality tests are presented in Table 3.

Table 3. Granger test results

Variable name / model name	**Degrees of freedom**	***Chi-sq* and *Prob.*, dependent variable for Bulgaria**	***Chi-sq* and *Prob.*, dependent variable for Romania**
Final consumption expenditure	3	0.262233 (0.9670)	2.148794 (0.5421)
Gross capital formation	2	0.423805 (0.8090)	2.983996 (0.2249)
Exports of goods and services	2	1.807843 (0.4050)	1.213185 (0.5452)
Imports of goods and services	1	1.56E-05 (0.9969)	0.098897 (0.7532)
Taxes on production and imports	1	1.745217 (0.1865)	0.235257 (0.6277)

Source: Authors' representation, on the basis of the VAR Granger Causality/Block Exogeneity Wald Tests' results

The test results provide no evidence of statistically significant predictive relationships between the corresponding macroeconomic indicators of Romania and Bulgaria analysed in this study, and therefore the research hypothesis is not validated. For all five cases (and ten potential causalities) the null hypothesis of no Granger causality cannot be rejected in either direction, as all reported *Chi-square* statistics are lower than the critical values. When causalities are analysed from Romania (as causal variable) to Bulgaria, the test parameter has (approximate) values from 0.2622 for *Final consumption expenditure* to 1.8078 for *Exports of goods and services*. When Bulgaria is considered as the potential causal variable for Romania, the *Chi-square* statistics include values (approximate) from 0.0989 for *Imports of goods and services* to 2.9840 for *Gross capital formation*. Also, for all tests, it can be observed that the *p-value* is higher than the 5% significance level.

These results need to be interpreted with caution, as there are two issues affecting the variables and the models: the presence of provisional data, and the behaviour of the models against the specification test. From this point of view, the most solid model characterizes the variables for *Exports of goods and services.*

These results are convergent with the findings of Manole and Barbu (2026), which have analysed the behaviour of the GDP and found no bilateral causality, for the same underlying dataset and methodological framework. Taken together, these findings suggest that the absence of bilateral predictive transmission is not confined to aggregate economic output but extends to several major indicators related to the Gross Domestic Product.

The results are consistent with the heterogeneous evidence reported in other studies based on the Granger-causality framework. Păunică et al. (2021) found various shapes of causalities in Granger sense (the quoted study also applies the Toda-Yamamoto procedure by pursuing Giles, 2011) between some causal variables and the GDP, analysed across the European Union and its member countries, alongside causal relationships that were not statistically supported at all (no causality). In the same line of results, Sijabat (2022) reported heterogeneous causal patterns between economic growth, foreign direct investment, foreign aid and gross capital formation, analysed for Indonesia. These findings corroborate the conclusion that Granger causality is a phenomenon specific to certain countries and variables, and can be demonstrated (or not) empirically, not assumed *a priori* from the economic relevance or significance of certain variables.

Dritsakis (2004) has identified significant causal relationships involving economic growth, exports and investment in Bulgaria and Romania, but these indicators were studied within the framework of each national economy, without causalities between countries. Corroborated with the results of the present paper, it means that results outlined by national-focused studies do not imply similar or identical results in cross-country evaluations. The same idea applies to the study of Sijabat (2022), who found non-uniform causal relationships. While Angelov

and Nikolova (2025) discovered relationship between taxation and economic activity that can be different in nature and specific to the national economy, the present paper found no evidence of Granger causality between *Taxes on production and imports* of Romania and the same indicator in Bulgaria. Lima Junior et al. (2014) have found causality in Granger sense between the external balances of the US and China, demonstrating that there is possible to encounter such causalities in cross-border studies.

5. Conclusions

This study investigated the existence of bilateral Granger-causality relationships between a set of GDP-related macroeconomic indicators, namely final consumption expenditure, gross capital formation, exports and imports of goods and services (exports and imports were treated as separate cases), taxes on production and imports, and subsidies (for this final indicator, the analysis was not completed because of the high order of integration) for Bulgaria (on one hand) and Romania, on the other. The analysis extends the perspective of the authors' previous research of the bilateral relationship between Romanian and Bulgarian GDP and GVA, from the aggregate level to a broader set of macroeconomic indicators. The absence of Granger causality between the GDPs is substantiated by the absence of the same type of relationship when the selected GDP-related indicators have been put to the test.

The results obtained from the application of the test procedure do not provide evidence of statistically significant Granger-causality relationships between Romania and Bulgaria, for any of the indicators included in the present paper. This involves that, considering the test procedure and the data available at this moment, the evolutions of the national indicators of either country do not contain statistically significant additional predictive information for the indicators that characterize the other national economy.

The limitations of the study arise from the datasets and choices made to design the test procedure, as the groups of values can influence in a critical manner many of its parameters (the order of integration, the configuration and possible adjustments to the VAR models, the degrees of freedom etc.). The results must be interpreted with caution, as the authors have chosen to use the data as they are available (that is, including provisional data for both countries). The authors hope to re-assert the study on the same dataset, when the data that are now provisional will be replaced with definitive data and, if more data become available, this will grant a higher level of freedom for performing the tests.

As the two countries share the status of EU members and there is substantial integration, the absence of bilateral causalities in Granger sense for the indicators selected for this study does not suggest the independence between the two national

economies. The findings are consistent (even if the research has been designed in a different manner) with the results of other studies.

Certainly, there are other forms of manifestation of economic interactions between the national economies of Romania and Bulgaria, even captured by statistical data. The authors of the present paper also hope to extend the study with more variables, and that future results will contribute to a better shape for the image of the complex system of relationships that characterize the two neighbouring countries.

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ФИНАНСИ, ИКОНОМИКС, ЗАСТРАХОВАНЕ И ОСИГУРЯВАНЕ