

Păunică, Mihai; Manole, Alexandru; Motofei, Cătălina; Tănase, Gabriela-Lidia

## Article

# Resilience of the European Union economies: An analysis of the granger causality at the level of the gross domestic product

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**RESILIENCE OF THE EUROPEAN UNION ECONOMIES.  
AN ANALYSIS OF THE GRANGER CAUSALITY AT THE LEVEL  
OF THE GROSS DOMESTIC PRODUCT****Mihai Păunică<sup>1\*</sup>, Alexandru Manole<sup>2</sup>, Cătălina Motofei<sup>3</sup>  
and Gabriela-Lidia Tănase<sup>4</sup>**<sup>1)3)4)</sup> Bucharest University of Economic Studies, Romania<sup>2)</sup> "ARTIFEX" University of Bucharest, Romania**Please cite this article as:**

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**Abstract**

Gross Domestic Product (GDP) is one of the most important indicators that reflects the evolution and resilience of national economies. The importance of this macroeconomic indicator is growing in the current economic context, context in which international studies start to emphasize the importance of resilience and sustainable development and in which the GDP can be seen either as an obstacle to sustainability, or a tool to protect the environment and achieve the resilience and sustainability goals. Consequently, the authors consider that understanding the formation of the GDP and the elements that exert an influence on it, remains of vital importance for the economy of a country or group of countries.

The objective of the paper is to see if some of the indicators that are used to determine the GDP, respectively final consumption expenditure of general government, final consumption expenditure of households, gross fixed capital formation, changes in inventories, external balance – goods, external balance – services, wages and salaries and, respectively, employers' social contributions, together with two indicators of final energy consumption, are Granger causing the GDP.

The results obtained will indicate whether GDP can be predicted at a highly accurate level, by using not only the previous values of the GDP, but also the previous values of determining variables, and will also contribute to highlight those elements that have such an impact on the GDP, in order to better estimate its evolution and to have the possibility to influence its future values.

\* Corresponding author, **Mihai Păunică** – e-mail: [mihai.paunica@cig.ase.ro](mailto:mihai.paunica@cig.ase.ro)

**Authors' ORCID:**Mihai Păunică: [orcid.org/0000-0003-2851-6677](https://orcid.org/0000-0003-2851-6677)Alexandru Manole: [orcid.org/0000-0003-2813-6025](https://orcid.org/0000-0003-2813-6025)Cătălina Motofei: [orcid.org/0000-0001-6828-9144](https://orcid.org/0000-0001-6828-9144)Gabriela-Lidia Tănase: [orcid.org/0000-0002-5713-8022](https://orcid.org/0000-0002-5713-8022)

To achieve the objective of the research, an approach based on the Toda-Yamamoto method of the Granger causality has been used, for the period 1995-2019, to evaluate the causality links in European Union-28 and the 28 countries member of the EU in 2019. The results obtained show that, for the geographical and time dimensions studied in this paper, the influence of the previously mentioned causal factors (in Granger's acceptance) can be characterized as a causality in Granger sense only in a small number of cases.

Thus, the Granger causality is demonstrated for the GDP of Netherlands (factor of influence, "final consumption expenditure of general government"), of the Republic of Cyprus (causal variables, "final consumption expenditure of households" and the "changes in inventories"), and also of the Czech Republic, Estonia, Latvia and Portugal (for the factor "final consumption expenditure of households"). In Portugal, the "external balance – goods" causes, in Granger sense, the GDP, while "wages and salaries" are emphasized ad influence factors of Granger causality type for Latvia and Slovakia. It has not been observed the existence of the Granger causality for the indicators "gross fixed capital formation", "external balance – services", "employers' social contributions", "final energy consumption – total" and "final energy consumption – industry".

**Keywords:** Gross Domestic Product; Granger causality; Final Consumption; Capital Formation; Changes in Inventories; Salaries; External Balance.

**JEL Classification:** C51, C52, O11, O47

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## **Introduction**

In the current context of the global COVID-19 pandemics, the duration and effects of which cannot yet be accurately predicted, national economies have been and will be tested, with negative effects that are likely to be felt on the long run. To mitigate these unwanted effects, both the state and the private entities will be required to adopt measures and to make certain decisions in order to increase the resilience of the national economy. But, in order for those decisions to be made properly, the decision makers need information and data on the working of the economy. Here come, on the foreground, the Big Data sources, which can provide useful information, both for governing institutions and to private entrepreneurs. Among the most important data that must be analysed for increasing economic resilience, there counts the ones related to the evolution of the Gross Domestic Product (GDP) and its factors of influence.

Even if the elements that form the values of the GDP are widely known, the free circulation of goods and services, and also of the labour force, determine those factors to present a certain behaviour, depending on a certain moment and context. Starting from these considerations, this paper aims to analyse the influence of eight macroeconomic indicators (final consumption expenditure of general government, final consumption expenditure of households, gross fixed capital formation, changes in inventories, external balance – goods, external balance – services, wages and salaries and, respectively, employers' social contributions), as well as of two indicators of the final energy consumption (final energy consumption– total, considered for the entire national economy, and the final energy consumption – industry branch) on the GDP. The research is based on the consumption-driven growth theory and the theoretical approach of GDP formation. Even if the connections between these factors have made the object of numerous previous studies, the results

presented in the scientific literature are different and cannot be generalized, making their usage more difficult in order to make decisions.

The objective of this study is to analyse (in view of possible generalization of causality relationships, at least for the countries included in the study) whether the selected elements, that participate in the formation of the GDP, along with the proposed indicators of energy consumption, have the capacity to determine, in the sense of Granger-type causality, the economic evolution of a country, measured through the GDP, and which of them have the capacity to forecast this evolution and at the same time, the resilience of the national economy. Also, another objective of this study is to ensure a better understanding of the economic development of a country and to contribute to the improvement of the literature in this area. The authors consider that the analysis of the Granger causality-type connection between the indicators analysed in this article, or similar indicators, referring to the same phenomena / branches and GDP, was not sufficiently taken into account in previous studies and research.

By evaluating the connection between the GDP and the chosen determinant indicators at the level of the Member states of the European Union (EU-28, that is, including the United Kingdom of Great Britain and Northern Ireland, part of the UE in 2019, the last year included in the dataset) and by including the EU as a whole in the study, a comparative analysis regarding the behaviour of analysed factors was carried out, in order to achieve some in-depth knowledge on their importance in the economic evolution. The European Union, as a whole, has been analysed due to the similarities that can be found at the level of economic policies in the member countries. The analysis per country was performed in order to determine whether the results achieve can be generalized for each hypothesis, or whether a major influence of national specific characteristics is highlighted. In the literature review section, were evaluated a series of relevant approaches on some connections with significance more or less similar with the type of causality pursued in this paper, the results of the researches were analysed, and there have been formulated, according to the objective of the study, the research hypotheses. In the methodology section, there have been described the essential theoretical landmarks of the method on which the research methodology is based and the modality of implementation of the method, in the context of the present research, has been presented (for example, the use of a certain software application, the dimension of the dataset make necessary some clarifications, useful for potential readers). There have been considered the statistical tests used, their significance and the hypotheses associated to them, and the mode of interpretation as well. In the results and discussions section, some aspects related to the behaviour of the tested models have been described, the results have been presented and analysed, starting from the elements extracted from the literature review and from the expectations of the authors. The next sections of the paper present the literature review, the research methodology, followed by results and discussions. In the end, the conclusions of the research are presented, together with its limitations and the future study directions.

## **1. Review of the scientific literature**

In the current context, the resilience of any national economy is put to the test by the unwanted “inputs” of the COVID-19 pandemic. More than a year and half after the occurrence of this (now) global medical emergency, the economy is experiencing the effects of the measures taken in order to fight the spread of the infection, mainly lockdown measures that have affected the private businesses, the public sector and the population. Bratianu

(2020) makes a detailed description of the crisis and of its economic facets, outlining the fact that it generates, in turn, new crises, unexpected, in the economic systems, whose evolution is predominantly influenced by the public policies adopted by each country, and as well by the behaviour of the population. Păunescu and Mátyus (2020) have analysed 17 measures adopted by enterprises during the pandemic and consider that efforts should be made in order to ensure the efficiency of the internal operational management.

The economic resilience in the current context can be characterized as the capacity of the economy to face and recover following the occurrence of a disaster, namely an unforeseen event capable to provoke unfavourable consequences (Hallegate, 2014), category in which the spreading of SARS-CoV-2 virus is included. The COVID-19 pandemic and its effects on the economy have already created visible challenges. Resilience involves, first, public/political measures and then decisions of the private entrepreneurs, which are taken depending on the restrictions imposed by the public policies. Proper decisions involve precise information on the working of the economy. The existence of Big Data sources represents an advantage that can be capitalized to offer such information to decision makers. The public policies can use the results of analyses made on macroeconomic data to achieve better results. The private entrepreneurs can also pursue the study of macroeconomic data, to analyse, for example, past and future trends in the evolution of their sector (and in related fields) and even the evolution of the national economy, in order to extract and evaluate correlations and causalities between the indicators that are relevant to their businesses. In the opinion of the authors, the efforts of the public and private actors cannot ignore the proofs obtained from the analysis and interpretation of data (including Big Data sources).

As GDP is the main indicator of the economic evolution, which contributes to the measurement of economic growth and resilience, information on the factors that influence its value and can be capitalized in forecasting its evolution represent a main subject in correspondence with the context described above: the need to act (the existence of the crisis) – data (big data sources) – proper instruments for data analysis – information – actions (response to the necessity to act). Grigorescu, Zamfir and Mocanu (2020) outline the role of knowledge in the economy in the current context and emphasize a package of key benefits of knowledge's capitalization. Therefore, this paper analyses the influence of Granger causality-type of ten factors (final consumption expenditure of general government, final consumption expenditure of households, gross fixed capital formation, changes in inventories, external balance – goods, external balance – services, wages and salaries and, respectively, employers' social contributions, as well as final energy consumption– total, and the final energy consumption – industry branch), considered individually, on the GDP. These factors have been selected on the basis of theoretical and practical aspects presented in the scientific literature. Eight of the considered factors have a direct impact on the Gross Domestic Product, given the mathematical relationship between them: they are included in the synthesis formula that leads to the formation of the GDP. Furthermore, the final consumption is considered, by most economists, as an important factor of influence for the GDP, being the main actor of the consumption-driven growth theory. The value of this indicator reveals the intensity of consumption-based growth in the national economy of a country. Moreover, because the government can decide on the size of public expenses, the government's expenses for final consumption are, also, especially important in implementing policies aimed towards stability and, at the actual moment, the economic resilience. The authors consider that such analysis is necessary, in the context in which the results presented by the scientific literature are not uniform.

Regarding the connection between the GDP and the *final consumption*, the analysis of scientific literature indicates the possibility of existence of a bi-directional link, as well as the existence of a link that is non-significant from the statistic viewpoint. As Amin (2011) mentions, it is difficult to determine if expenses related to consumption influence the economic growth or if, on the contrary, the economy influences the consumption expenses.

In turn, the GDP is also seen as a factor that influences the expenses related to consumption, both at the households and public administration levels. Almasifard (2013) also considers that the GDP growth ratio and the GDP per capita positively influence the final consumption expenses (calculated as percentage of GDP), even if the effect is not significant. Gerstberger and Yaneva (2013) discuss a moderate impact of the economic crisis on the household's consumption, and Tulsidharan (2006) is of the opinion that during periods of economic growth, the expenses of the same type increase at the level of the public sectors. The authors consider that the indicators of the final consumption (both for the one related to the public administration, as well as the one of households) contribute to the formation of the GDP and influence this macroeconomic indicator. In this paper, it is evaluated whether this link can be verified under the shape of Granger-type causality (desideratum formulated through the research hypotheses H1, regarding the role of consumption in the public sector as factor that causes, in Granger sense, the GDP, and H2, respectively Granger causality of the households' expenses for final consumption on the GDP).

Among the factors that positively influence the GDP variation, the *level of capital formation* is also identified (Adhikary, 2011). But the link between GDP and capital formation can also be bidirectional. Thus, the GDO growth rate can influence the capital investments or the gross formation of fixed capital (Kononenko and Repin, 2016). Based on these results, the H3 research hypothesis has been defined, regarding the fact that the gross formation of fixed capital causes, in Granger sense, the GDP.

Other authors also recognize *changes in inventories* as factors that influence the GDP's evolution. The analysis made by Dudu and Moscu (2016) reveals the fact that changes in inventories, along with household consumption, gross investments, net exports and gross disposable income influence in an extended manner the GDP variation. Khan and Thomas (2007) also see changes in inventories as an important element in the understanding of aggregate fluctuation, considering that investments in changes in inventories are a cause of a raise in the GDP volatility. Cecchetti, Flores-Lagunes and Krause (2006) consider that management policies regarding changes in inventories may have an impact on GDP's volatility due to the importance in the aggregate fluctuation of inventories. Management methods regarding changes in inventories are seen as possible reasons for a decrease in GDP volatility (Buckle, Haugh and Thomson, 2003). Based on these results, according to the declared research objective, the H4 hypothesis related to the Granger causality that is established between the changes in inventories (as causal variable) and GDP of the respective country (the dependent variable).

The link between net exports and GDP is also recognized in the literature. The analysis performed by Chisăgiu (2012) for Romania indicates that in the situation in which exports are lower than imports, the difference has a negative impact on the GDP growth, thus it can be concluded that net exports influence in a positive manner the GDP. Moreover, as Ioan and Ioan (2013) suggest, for Romania, an increase of the GDP will determine a decrease of the trade deficit, an increase of net export, and also an increase of the consumption. In general, exports (Narayan and Smyth, 2009) exercise an influence on the GDP. In the opinion of the authors, if the exports do influence the GDP, then the external balance of goods and services

have the capacity to determine the formation and the values of this indicator, aspect reflected in the research hypotheses H5, which emphasizes the Granger causality between the external balance – goods and H6, through which it is analysed the possibility that the external balance – services to cause, in Granger acceptance, the GDP.

The connection between income and GDP is also addressed in international literature, thus, for Germany, the study of Klinger and Weber (2020) discusses about a decoupling effect between the GDP and employment of the labor force. Angeles (2008) reports a difference between the evolution of the GDP per capita and the real salaries, mainly due to the modification of the labour offer per capita. Diacon and Mana (2015) consider that both the income, and the consumption influence the GDP per capita, if the level of incomes is considered. An analysis based on the Toda-Yamamoto method is used to estimate the Granger causality and to evaluate the impact of remittances on GDP and households' final consumption in the European Union, and to support the positive impact, in the case of Italy, Czech Republic, Germany and Greece (Păunică, et al., 2019).

Taxation is also considered a factor that determines the modifications of the GDP. It has been demonstrated that direct taxes (Stoilova and Patonov, 2013) and selective taxes on consumption, together with the taxation of property and personal incomes (Stoilova, 2017) contribute in a greater extent to the economic growth, compared to other fiscal incomes, such as the tax on companies' profit or the value added tax. The GDP growth can be obtained through taxation, preferably through taxes on imports, production and corporation income, according to the results obtained by Karagianni, Pempetzoglou and Saraidaris (2012). The authors consider that personal income taxes can be used to achieve GDP stability, that's why an increased attention should be paid to tax reduction. Some studies indicate that, on the short run, the reduction of taxes leads to the increase of the GDP, but on the long run it determines a decrease (Seip, 2019). Starting from these considerations, the authors consider that the salaries (as incomes), and the contributions associated to them (that can be included in the taxes' category) have the capacity to exercise an influence on the GDP. Consequently, there have been formulated and tested the research hypotheses H7, through which it is verified if the wages and salaries cause, in the sense of Granger causality the GDP and H8, through which it is tested the Granger causality from employers' social contributions towards the GDP of the same country.

The energy is a vital resource for any economy. Dudau and Nedelcu (2016) emphasize the importance of energy security. The production and use of energy (and the associated economic benefits) must be balanced by keeping a sustainable environment. Şanta (2019) analyses the perspectives of a common European energy market, capable to address the security and sustainability concerns through more powerful policies, with greater impact. Various types of the relationships between indicators of the energy field and the economic growth have been also widely studied. Heidari, Katircioğlu and Saeidpour (2015, cited by Zortuk and Ceken, 2016), by using "Panel Smooth Transition Regression", have discovered the existence of a non-linear relationship between the energy consumption and the GDP per capita, while Zortuk and Çeken (2016) emphasize the correlation between GDP per capita and emissions of carbon dioxide per capita. Magazzino (2018) has studied the case of Italy for the variables GDP and energy consumption and demonstrates that the variables are integrated of order one, that is stationary at the level of the first difference, while the consumption of energy is influenced by the real GDP. Thus, the authors have decided to include two variables with energy-related significance in this study, considering that the indicators of energy consumption can exercise a significant impact on the GDP (by defining

and testing the hypotheses H9, which emphasizes the Granger causality between the final consumption of energy – total, at the level of the entire economy, and, respectively, H10, through which is verified the position of final consumption of energy for the industrial branch against the GDP, in the sense of Granger causality.

Given the information presented in the scientific literature, in the next section the research hypotheses are defined, which aim to analyse the influence of the mentioned factors on the GDP, with the purpose to achieve conclusive results, which could be capitalized for each country in order to support the national economies in their demarches oriented towards economic growth and resilience. The expected results, given the statistic-economic correlations already demonstrated between the indicators, should indicate the presence of the causality in Granger sense, at least with the GDP in the position of dependent variable.

## **2. Research methodology**

The research approach is experimental (because it analyses a particular aspect of GDP's formation and evolution, the authors apply a set of already validated knowledge in order to study a cause-effect-type relationship) and has been structured like this: the delimitation of the research problem, analysis of the status of knowledge relevant for the research problem, statement of the objective and hypotheses, gathering of the data, analysis of data according to the chosen methodology, the interpretation of the results, correlation of the research's results with results previously obtained, described in the scientific literature.

The hypotheses are formulated starting from the results presented in the scientific literature review section, regarding the relationship between the GDP and the variables used in this study. As it has been previously mentioned, the causal indicators for the first eight hypotheses are components of the GDP, and the link between these elements and the GDP has been intensely addressed in the scientific literature. The hypotheses H1, related to the influence, of Granger causality-type of the final consumption of the public administration on the GDP, and H2, through which is verified the same type of connection, but with the households' expenses regarding the final consumption as causal variable, are defined on the basis of the idea of consumption-led growth. Ten research hypotheses were formulated, each one having a factor as causal variable for the GDP.

H1. Final consumption expenditure of general government causes, in Granger sense, the GDP.

H2. Final consumption expenditure of households causes, in Granger sense, the GDP.

H3. Gross fixed capital formation causes, in Granger sense, the GDP.

H4. Changes in inventories causes, in Granger sense, the GDP.

H5. External balance – Goods causes, in Granger sense, the GDP.

H6. External balance – Services causes, in Granger sense, the GDP.

H7. Wages and Salaries cause, in Granger sense, the GDP

H8. Employers' social contributions cause, in Granger sense, the GDP.

H9. Final energy consumption causes, in Granger sense, the GDP.

H10. Final consumption - industry sector - energy use causes, in Granger sense, the GDP.



The research method used involves testing of Granger causality, on long term, between the GDP and the selected factors for EU28 (code EUR), and each of the countries member of the European Union in 2019: Belgium (BEL), Bulgaria (BUL), Czech (CZE), Denmark (DEN), Germany (GER), Estonia (EST), Ireland (IRE), Greece (GRE), Spain (SPA), France (FRA), Croatia (CRO), Italy (ITA), Cyprus (CYP), Latvia (LAT), Lithuania (LIT), Luxembourg (LUX), Hungary (HUN), Malta (MAL), Netherlands (NET), Austria (AUS), Poland (POL), Portugal (POR), Romania (ROM), Slovenia (SLO), Slovakia (SVK), Finland (FIN), Sweden (SWE), United Kingdom (UNI). All data were extracted from the EUROSTAT database, and were processed by using EViews® (registered trademark of HIS Global Inc.). The values, for the GDP and the causality factors that participate in its formation, have been extracted as updated on April 27, 2021, and the source dataset in Eurostat is “GDP and main components (output, expenditure and income) [nama\_10\_gdp]”. For the indicators of energy consumption, the dataset is “Simplified energy balances [nrg\_bal\_s]”, last update on June 6, 2021, values expressed in gigawatt-hour. All values from both sources, have been considered as they are, regardless of their character of provisional, estimated data etc. The use of a single data source, which is also official, together with the unitary application of the data processing procedures, confers, in the opinion of the authors, a reasonable degree of confidence in the validity of both entry and exit data.

All monetary data are unadjusted and are measured in current prices, million euros. Because most of the variables have different orders of integration, the authors chose to apply the Toda-Yamamoto approach of the Granger causality, because it allows the analysis of nominal variables, without resorting to differences, and allows for testing in such situations (Giles, 2011; Chirila and Chirila, 2017). Another form of testing for Granger causality involves cointegrated variables and assumes the use of Vector Error Correction (VECM) models but, because the possibility, for some pairs of variables, to be not cointegrated has been considered, this method is in the attention of the authors for future researches.

The opportunity to use regression was also taken into account in the initial stage, but it was not further pursued, out of similar reasons: different orders of integration, which would diminish the possibility to apply regression for all cases and, also (for regression at the differences of order 1 or 2), there is a low probability that the results would allow the statement of reliable comparisons.

The Toda-Yamamoto (Toda and Yamamoto, 1995) involves the construction of a VAR( $p_o+oi_{max}$ ) model between the independent variable and the dependent one, model for which the number of lags is given by the number corresponding to a well-specified model ( $p_o$ , in this paper, for evaluating the models, the statements of Giles (2011) and Hacker and Hatemi-J (2003), quoted in Hatemi-J (2004), have been considered, as it will be shown subsequently, to which additional lags are added, for the number representing the maximum order of integration, obtained following the test of the individual order of integration of each variable ( $oi_{max}$ ). The shape of this model is materialized in two equations of the following shape (adaptation after Giles, 2011):

$$Dv_n = a_{Dv} + \sum_{i=1}^{p_o+oi_{max}} b_i * Dv_{t-i} + \sum_{i=1}^{p_o+oi_{max}} c_i * Iv_{t-i} + \varepsilon_{Dvn} \quad (1)$$

$$Iv_n = a_{Iv} + \sum_{i=1}^{p_o+oi_{max}} d_i * Iv_{t-i} + \sum_{i=1}^{p_o+oi_{max}} f_i * Dv_{t-i} + \varepsilon_{Ivn} \quad (2)$$

where:

$Dv_n$  = the dependent variable;

$Iv_n$  = the independent variable;

$\varepsilon$  = the “white noise”;

$b_i, d_i$  = the coefficients of the caused variable in each equation (including of its lags);

$c_i, f_i$  = the coefficients of the causal variable in each equation (including its lags).

It is observed the fact that the dependent and independent variables from the first equation practically shift their role between them in the second equation. The authors have chosen such notation in order to emphasize the fact that the main purpose of the research is the uni-directional type of causality.

According to Giles (2011), the models are evaluated with the MWald test (Wald test modified for the Toda-Yamamoto procedure) for Granger causality, which aims the test of the significance of parameters  $c_i$  and  $f_i$  (the null hypothesis of the test is the absence of Granger causality, respectively the fact that the independent variable does not Granger cause the dependent one, therefore the equalities  $c_1 = c_2 = \dots = c_n = 0$ , respectively  $f_1 = f_2 = \dots = f_n = 0$ , where  $n=p_o$ , express the absence of causality). As Toda and Yamamoto (1995) state, the lags added to the model, which reflect values according to the maximum order of integration, are not considered. If the value of the MWald test (noted *Chi-sq* in the article) is higher than the table value of  $\chi^2$  (depending on the degrees of freedom), and the *p-value* is lower than the chosen significance level, the null hypothesis is rejected and the causality is admitted between the two variables, as Giles (2011) states: the value of the test for which the probability of occurrence is extremely low if the null hypothesis is accepted, in other words, the alternative hypothesis can be accepted, the existence of Granger causality. As they are defined, the research hypotheses in this article correspond to the alternative hypothesis of the MWald test.

The Augmented Dickey-Fuller (ADF) test, presented in Dickey and Fuller (1981), is a unit root test, having as null hypothesis the existence of the unit root, that is, the tested variable is not stationary, and the alternative hypothesis is the absence of the unit root, in other words, the variable is stationary. If the value of the ADF test is lower than the critical value and *p-value* is inferior to the significance level, the null hypothesis is rejected, and the variable is considered as stationary. The Phillips-Perron test (Phillips and Perron, 1988) represent a correction of the value of the Dickey-Fuller when serial correlation, respectively heteroskedasticity exists, and the rule of interpretation for the resulted statistic's value is identical.

According to Giles (2011), the stability AR Roots test is applied due to the instability indicating the fact that the model is not well-specified. The authors agree with this approach, the test has been performed for all models. For the absolute value of the AR Roots, the critical value is 1, if all coefficients are less than unit in module, the model is considered stable (Lütkepohl, 2005). The autocorrelation Lagrange Multiplier tests identifies the presence of serial correlation between residuals (which forms the alternative hypothesis of the test). The null hypothesis is the non-existence of serial correlation (Giles, 2011), and depending on the *p-value* coefficients, compared to the selected significance level, the null hypothesis is admitted or rejected up to a specified number of lags. As Giles (2011) indicates, there are accepted only models free from autocorrelation, and the existence of autocorrelation makes

mandatory the re-resign of the model (by adding an additional lag), this solution, valid also for unstable models, can be capitalized only if the dataset allows for it.

For the normality test, the null hypothesis is that the errors are normally distributed. In the case in which the probability associated to the value of the normality test is less than the significance level, the null hypothesis is rejected, and it can be discussed of non-normality (Marinaş, 2012). The heteroskedasticity test (Marinaş, 2012) is interpreted in a similar manner (the null hypothesis is that the random errors are homoscedastic, the presence of *p-value* lower than the significance level indicates heteroskedasticity). The authors have applied these tests too, through the view of the results of Hacker and Hatemi-J (2003), quoted in Hatemi-J (2004) regarding the possibility of some distortion of the conclusions in the cases the last two tests are not respected.

For all tests applied in this article, the significance level is considered the value 5%.

The Toda-Yamamoto methodology was implemented in this study by following the steps described below (adapted from Giles, 2011):

- Measurement of the order of integration for the causal and independent variable. The maximum of the two values is retained for the final steps. The authors have used the Augmented Dickey-Fuller test, the option “trend and intercept”, automatic lag selection based on the Schwarz Info Criterion from a maximum of 5 lags, and crosschecked with the Phillips-Perron test, in its default configuration. In case of divergent results of the two tests, the order corresponding to the difference at which both variables are stationary has been accepted.

- Estimation of the VAR model for each pair of variables corresponding to a hypothesis and case (country, respectively EU28), and then, if necessary, re-configuration according to the optimum lag length specified by the Schwarz Criterion.

- Test of the VAR’s reliability: *AR roots* test, autocorrelation LM test (for the default number of lags, as defined by the software), normality of residuals test (first option, “*Cholesky of covariance*”) and White heteroskedasticity test, “no cross terms” option. Only the VAR models that successfully passed all tests are considered for the next step (in some cases, the final test cannot be applied, as the maximum lag is 7, because of the number of observations, these models were passed to the next steps, and the results evaluated with caution).

- Re-shape of the correctly specified VARs by including additional lags (corresponding to the maximum order of integration), as exogenous variables (in order to allow, according to Giles (2011), the test as it has been defined by Toda and Yamamoto (1995)).

- Application of the Wald test for Granger causality and interpretation of results.

### 3. Results and discussions

The presentation of the results is focused on the models that allowed the application of the Granger causality test.

- H1 research hypothesis

Among the best specified models is the one for Cyprus, which complies with all tests. The Czech model becomes stable as VAR(5), a configuration which leads successfully across the autocorrelation, normality test, the heteroskedasticity test produces an error message, caused by

the extended lag length compared to the dimension of the dataset. The model built on the Italian data passes the four tests. For the Dutch variables, the model presents autocorrelation in residuals at lag 3, but when re-configured as VAR(5) there is no autocorrelation, it is stable, and responds to the normality and heteroskedasticity tests in the same manner as the Czech model. The model designed for Slovenian variables behaves properly against all four tests after being updated as VAR(4). Spain’s dataset delivers a stable model, autocorrelation is solved for a number of six lags, proper normality test coefficients, but the heteroskedasticity test cannot be applied, and when the model is used for testing Granger causality, the number of observations proves insufficient. The models for Slovakia and Sweden models pass all tests in their initial lag settings. All other models cannot be set in a properly specified configuration.

The coefficients for the Granger causality tests for the H1 hypothesis were then calculated (table no. 1).

**Table no. 1. Modified Wald tests’ results, H1 research hypothesis**

Model name	Optimum number of lags	Maximum order of integration	Chi-sq	p-value
VAR_HI_CYP	2	2	0.466086	0.7921
VAR_HI_CZE	5	2	1.879344	0.8656
VAR_HI_ITA	1	2	0.909048	0.3404
VAR_HI_NET	5	2	130.1371	0.0000
VAR_HI_SLO	4	2	4.506672	0.3418
VAR_HI_SVK	1	2	0.122876	0.7259
VAR_HI_SWE	1	1	1.239965	0.2655

After being updated, the Cyprus VAR reveals that Granger causality exists, but as reverse (Gross Domestic Product causes the Final consumption expenditure of general government). Both Czech and Italian cases indicate the absence of Granger causality. The test applied on the updated model of the Netherlands indicate bi-directional Granger causality (however, the confidence in this conclusion is uncertain, because the model could not be tested against heteroskedasticity). The Slovenian model reveals no Granger causality in the way pursued by the hypothesis, but in the reverse way (that is, GDP causes FCEGG, with  $Chi-sq = 93.17106$ , and a probability of 0%), the same observation applies in the case of Slovakia ( $Chi-sq = 7.488268$ ,  $p-value = 0.62\%$ ). No Granger causality is outlined for the Swedish variables.

The results obtained after processing the entire testing methodology align partially with the expectations of the authors, the hypothesis being validated only for Netherlands (but with due caution, explained above). Instead, the causality determined by the GDP on the final consumption of the public sector concurs with the conclusions of Tulsidharan (2006), in the sense that economic growth has the potential to dynamize the public expenses. Bi-directional causality is an indicator of the fact that not only public consumption determines the GDP, but also the economic growth increases the inclination of the governments towards consumption, which does not represent, in the opinion of the authors, an unfavourable conclusion.

- H2 research hypothesis

The model for Cyprus allows testing without any modification, its optimum number of lags remain the one established by the SIC, it validates H2 and also demonstrates reverse Granger causality (that is, the causality relation is bidirectional). In the sense of the research hypothesis,  $p-value$  indicates that the probability for the  $Chi-sq$  (12.49501) value to occur, if the null value is accepted, is 0.19%, which leads to the rejection of the null hypothesis of

non-causality, and the acceptance of the alternative hypothesis, respectively the validation of the research hypothesis. (Table no. 2)

**Table no. 2. Modified Wald tests' results, H2 research hypothesis**

Model name	Optimum number of lags	Maximum order of integration	Chi-sq	p-value
<i>VAR_H2_CYP</i>	2	2	12.49501	0.0019
<i>VAR_H2_CZE</i>	5	1	17.32839	0.0039
<i>VAR_H2_EST</i>	5	2	37.61273	0.0000
<i>VAR_H2_GRE</i>	1	2	4.08E-05	0.9949
<i>VAR_H2_LAT</i>	2	2	7.130585	0.0283
<i>VAR_H2_POR</i>	1	2	4.088316	0.0432
<i>VAR_H2_UNI</i>	1	1	0.331583	0.5647

In the case of the Czech dataset, the VAR model becomes stable once lag length is established at 1...5, no autocorrelation is observed up to lag 6, the residuals are normally distributed, but the heteroskedasticity test cannot be applied. The modified Wald test indicates bidirectional Granger causality, thus validating the research hypothesis (these results are considered with caution). A stable model for Estonia is designed with lag length 1...5, passes the autocorrelation and normality test, but cannot be subjected to the heteroskedasticity tests and indicates the presence of bidirectional Granger causality (also, these results are accepted with caution). The Greek and Latvian models can be tested for Granger causality: in Greece, the GDP is found to Granger cause the final consumption of the households (that is the reverse of the H2 hypothesis, and the *Chi-sq* is 10.79067, however, the dataset is affected by a break in time series, which can cause distortions in the model's behaviour, leading to a cautionary interpretation of results), and in Latvia the research hypothesis is validated. For Portugal's VAR model, Granger causality is outlined in both ways, and, for Sweden, the same type of causality as in Greece. Even if the UK model is properly specified without any modification, the modified Wald test reveals no Granger causality.

As for the majority of models, the effective test stage cannot be pursued, because of the restrictions regarding the specification tests, the authors consider that the results are convergent with those of Amin (2011), as in the present article it cannot be established a general conclusion for the existence of Granger causality and its sense, observation valid for the H1 research hypothesis too. The results regarding the Granger causality demonstrated according to the H2 research hypothesis converge with the conclusions of Gerstberger and Yaneva (2013), Dudu and Moscu (2016). Thus, five out of the seven cases in which the models could be tested have indicated the presence of Granger causality, testifying for the idea of consumption-led economic growth, on the long term in the respective countries, while the validation of the bi-directional causality or the reverse one is an indication of the fact that when the economy grows, consumption is encouraged, as Almasifard (2013) shows, referring to the effect of the economic growth indicators on the consumption at the level of households.

- H3 research hypothesis

The Belgian VAR needs to be reconfigured as VAR(6), and it responds well to the first three tests, but returns no proof of Granger causality, as do the Cyprus and EU models (based on their initial configuration). Following a series of adjustments, the Greek VAR (5) is suitable for testing, with caution, but neither of its coefficients demonstrate Granger causality (there is a probability of 13.58%, above the significance level, to encounter the value of the MWald statistic lower than the reference value, which leads to the acceptance of the null hypothesis

and the rejection of the H3 hypothesis). The model designed for the Slovak dataset demonstrates that the GDP is the causal variable in the emphasized Granger causality, that is the opposite of the H3 hypothesis (for p-value = 3.79%, the alternative hypothesis is accepted, that is the existence of causality), a result that is similar to the one obtained by Kononenko and Repin (2016). (Table no. 3)

**Table no. 3. Modified Wald tests' results, H3 research hypothesis**

Model name	Optimum number of lags	Maximum order of integration	Chi-sq	p-value
<i>VAR_H3_BEL</i>	6	1	2.180662	0.9024
<i>VAR_H3_CYP</i>	3	2	2.242072	0.5237
<i>VAR_H3_EUR</i>	2	2	0.838137	0.6577
<i>VAR_H3_GRE</i>	5	2	8.395332	0.1358
<i>VAR_H3_SVK</i>	2	2	0.851551	0.6533

In the case of Spain, even if the model can be brought to a well-specified status, it cannot be updated with exogenous variables, as the lag length is too extended. No model shows causal influence of the fixed capital formation, and only one case indicates the reverse relationship (GDP causes GFCF), results that are different from the ones presented by Adhikary (2011). Poor response to statistical tests is, in the authors' opinion, a factor that prevented more causalities from being emphasized.

- H4 research hypothesis

A model that is proven to be well specified at the optimal lag is the Cyprus's one, and it testifies for the validity of the hypothesis (see table no. 4: the value of *Chi-sq*, together with the probability of occurrence in case of acceptance of the null hypothesis favours the rejection of the null hypothesis and the acceptance of the alternative one, identical, as it has been stated, to the research hypothesis). The model for Italy needed to be updated to a number of 2 lags (1...2) in order to eliminate the serial correlation, it complies with all specification tests, but does not allow the validation of any Granger causality.

**Table no. 4. Modified Wald tests' results, H4 research hypothesis**

Model name	Optimum number of lags	Maximum order of integration	Chi-sq	p-value
<i>VAR_H4_CYP</i>	2	2	12.81398	0.0016
<i>VAR_H4_ITA</i>	2	1	3.633595	0.1625

The tests' results concur in a small measure with the achievements described in Dudu and Moscu (2016) and Khan and Thomas (2007), as only one model out of 28 leads to Granger causality in the sense described by the research hypothesis. These results, together with the studies of Buckle, Haugh and Thomson (2003), Cecchetti, Flores-Lagunes and Krause (2006), along with the expected result in this case, respectively the validation of H4 form, for the authors of this paper, the premise of future researches on the links described by this hypothesis. In this case, too, the impossibility to validate the research hypothesis has been determined, in a significant way, by the behaviour of the models against the specification tests.

- H5 research hypothesis

The Czech test comes close to demonstrating a Granger-type causality, but the MWald test coefficient is lower than the acceptance level. For Finland, there is no causality either. The Greek and Latvian models can be configured to a close to well-specified state (except

heteroskedasticity, which cannot be tested), but the high number of lags and the dimension of the datasets do not allow the expansion of the models for the Wald Test (the caution because of the break in the Greek data series is also considered).

Even if they return favourable responses to the specification tests, the Slovak and UK models display no causality. There is only one country for which the indicators return a Granger causality (this conclusion is viewed with appropriate reserve – too few observations for heteroskedasticity), that is Portugal (*p-value* indicates a very low probability, of 0.01%, for the favourable value of the *Chi-sq* parameter to be observed, in the conditions in which non-causality is accepted, thus being justified the rejection of the null hypothesis and the validation of the research hypothesis). (Table no. 5)

**Table no. 5. Modified Wald tests' results, H5 research hypothesis**

Model name	Optimum number of lags	Maximum order of integration	Chi-sq	p-value
<i>VAR_H5_CZE</i>	4	1	8.390460	0.0783
<i>VAR_H5_FIN</i>	3	1	3.738763	0.2911
<i>VAR_H5_POR</i>	5	2	25.49014	0.0001
<i>VAR_H5_SVK</i>	4	2	4.371633	0.3580
<i>VAR_H5_UNI</i>	1	1	0.623213	0.4299

- H6 research hypothesis

The Czech model is well specified as VAR(4), and the modified Wald test does not indicate any causality. The VARs for Italy and Greece are compliant in their initial form, there is no causality uncovered by the modified Wald test (also, due caution is exercised in interpreting the behaviour of the Greek model). (Table no. 6)

**Table no. 6. Modified Wald tests' results, H6 research hypothesis**

Model name	Optimum number of lags	Maximum order of integration	Chi-sq	p-value
<i>VAR_H6_CZE</i>	4	2	2.361021	0.6697
<i>VAR_H6_GRE</i>	2	2	1.118534	0.5716
<i>VAR_H6_ITA</i>	1	2	0.250998	0.6164

In all three cases, a high probability (over 57%) is observed, to obtain non-significant values of the MWald test if the alternative hypothesis is rejected, which means the acceptance of the null hypothesis, thus the research hypothesis cannot be validated.

The research results for the hypotheses H5 and H6 do not correlate in a significant manner with the conclusions presented by Narayan and Smyth (2009), Chisăgiu (2012), Ioan and Ioan (2013), Dudu and Moscu (2016), as a single case of causality was identified, out of the ones corresponding to both hypotheses (another *Chi-sq* coefficient comes close to the favourable interval).

- H7 research hypothesis

In Finland, the MWald coefficient is close to the limit that testifies for Granger causality according to the hypothesis. However, the reverse causality is demonstrated: GDP Granger causes the Wages and salaries. This type of causality is also emphasized in Greece (with reserves). No causalities are validated by the Polish, Swedish and UK models. In Latvia, the causality is bidirectional. One-way causality according to the research hypothesis is

demonstrated for Slovakia, but this conclusion is treated with necessary precaution. (Table no. 7)

**Table no. 7. Modified Wald tests' results, H7 research hypothesis**

Model name	Optimum number of lags	Maximum order of integration	Chi-sq	p-value
<i>VAR_H7_FIN</i>	4	2	8.731544	0.0682
<i>VAR_H7_GRE</i>	2	2	0.039510	0.9804
<i>VAR_H7_LAT</i>	3	2	8.762701	0.0326
<i>VAR_H7_POL</i>	1	1	0.827120	0.3631
<i>VAR_H7_SVK</i>	5	2	11.91481	0.0360
<i>VAR_H7_SWE</i>	2	1	0.105787	0.9485
<i>VAR_H7_UNI</i>	1	1	0.132544	0.7158

In both cases in which the Granger causality is demonstrated, according to the research hypothesis, the conclusion is based on the joint interpretation of the *Chi-sq* and *p-value* parameters, respectively a probability lower than 4% to have the values of the MWald statistic (higher than the corresponding reference values), if the null hypothesis is accepted, therefore it is rejected, and the H7 hypothesis is validated.

There are verified, thus, causalities for only two cases, out of which one is characterized by bi-directional causality. It can be discussed of results similar with those of Diacon and Mana (2015) and results that are different from Păunică, et al. (2019), if it is taken into account that, normally, the level of incomes should have, towards the GDP, a behaviour relatively similar with the remittances, those can be influenced by the incomes (the income is the source of remittances for the transmitter and the remittance is a source of income for the receiver).

- H8 research hypothesis

In Greece, the GDP Granger causes the social contributions (this conclusion is regarded with reserves). The modified Wald test applied for Portugal and United Kingdom does not outline any Granger causality (table no. 8, high probabilities to achieve test values lower than the ones in the reference table when the null hypothesis is accepted). These results are not in line with Karagianni, Pempetzoglou and Saraidaris (2012), Stoilova (2017), and no result similar with Seip (2019) has been identified.

**Table no. 8. Modified Wald tests' results, H8 research hypothesis**

Model name	Optimum number of lags	Maximum order of integration	Chi-sq	p-value
<i>VAR_H8_GRE</i>	2	2	0.721620	0.6971
<i>VAR_H8_POR</i>	1	2	3.139149	0.0764
<i>VAR_H8_UNI</i>	1	1	0.003114	0.9555

- H9 research hypothesis

The only cases where the models have been tested are Cyprus, Czech Republic, Finland, Latvia, and also Poland and Romania with reserves because of improper heteroskedasticity response. (Table no. 9)



**Table no. 9. Modified Wald tests' results, H9 research hypothesis**

Model name	Optimum number of lags	Maximum order of integration	Chi-sq	p-value
<i>VAR_H9_CYP</i>	2	2	3.309208	0.1912
<i>VAR_H9_CZE</i>	3	1	3.039614	0.3856
<i>VAR_H9_FIN</i>	4	1	2.514969	0.6420
<i>VAR_H9_LAT</i>	3	2	1.309308	0.7269
<i>VAR_H9_POL</i>	5	1	6.356533	0.2731
<i>VAR_H9_ROM</i>	5	2	0.770998	0.9788

None of the models indicated the presence of Granger causality, either way. In this case too, the probabilities to record *Chi-sq* values that are not above the critical value are sensibly higher than the accepted level of significance (minimum 19% compared to 5%)

- H10 research hypothesis

The application of the test methodology led to the validation of only four models: for Bulgaria (with reserves - improper response by the heteroskedasticity test), Greece (also with reserves, because of the dataset), Romania and Slovakia. (Table no. 10)

**Table no. 10. Modified Wald tests' results, H10 research hypothesis**

Model name	Optimum number of lags	Maximum order of integration	Chi-sq	p-value
<i>VAR_H10_BUL</i>	6	1	1.523966	0.9579
<i>VAR_H10_GRE</i>	2	2	1.514708	0.4689
<i>VAR_H10_ROM</i>	4	2	1.809252	0.7708
<i>VAR_H10_SVK</i>	2	2	0.613647	0.7358

In the case of Greece, the reverse of the research hypothesis has been demonstrated, that is, GDP causes, in Granger sense, the final energy consumption in industry. The parameters of the tested models do not reflect but in small measure the importance of the energy as present and active factor in the national economy (it is taken into account that the values of the *Chi-sq* tests are lower than the ones in the reference table, with high probabilities to be observed in conditions according to the null hypothesis, thus the null hypothesis is accepted). The results from the study quoted by Zortuk and Çeken (2016) and in the paper of Magazzino (2018), which emphasize the existence of some connections between these phenomena, converge in small measure with the conclusions drawn from the testing of the H10 research hypothesis, as only the case of Greece offers a result that is similar with the one described by Magazzino (2018).

### Conclusions

Some of the research hypotheses have been partially validated, and, in some cases, causality relationships according to the hypotheses have not been identified for any pair of national variables (H3, H6, H8, H9, H10). There were thus indicated, as factors that cause the GDP in Granger sense, for the respective countries, the final consumption, the changes in inventories, the external balance – goods, the wages and salaries.

Most causalities were associated with the H2 research hypothesis, according to the influence factor “final consumption expenditure of households”, thus indicating the private consumption as the most relevant causality factor in the context of the present research. This result supports, for the respective countries, the theory of consumption-led growth, and the

similar conclusions from the scientific literature. The number of valid hypotheses (taking into account the situation of each hypothesis at the level of single case studied) does not reflect the expectation of the authors and indicate a low level of alignment towards the results demonstrated by the scientific literature. Also, the cases in which the causality in the opposite direction of the research hypothesis has been demonstrated are not numerous and are limited to a small extent to the conclusions of other researchers.

The results achieved are normal from the statistic-economic viewpoint, because the correlation between eight indicators and the GDP involve the existence of causality in Granger senses, but no approach towards generalization can be supported on the basis of what has been demonstrated in this paper. The methodology adapted on the Toda-Yamamoto method has been chosen because the studied variables have different integration orders, the variables have not been differentiated, and for the same reason the authors did not apply regression methods. The configuration of the dataset and the values included did not allow testing for a significant number of cases.

As the results of the researches indicate the fact that data do not support, in most cases, the presence of the Granger causality as a form of influence exercised by the chosen factors on the GDP, and the research hypotheses have been validated only for a small number of cases (countries), the authors consider that no significant *theoretical implications* can be emphasized.

The *managerial implications* of the research are found in the causalities that have been demonstrated, which, on the one hand, provides arguments for the adoption of courses of actions in the fields of which measurement the respective indicators contribute to and, on the other hand, form a motivation for re-running the study as the dataset is supplemented with new values reported over time, in order to evaluate if there are still valid the Granger causality-type relationships involved or if new causalities occur. As the values of the indicators for 2020 and beyond are affected by the COVID-19 pandemics and the measures taken to fight its negative effects and to ensure the resilience of the national economies, such analysis is expected to emphasize the economic impact of the medical crisis on the causality relationships. The authors appreciate that the results achieved form at least a collection of “pieces” for the great “puzzle” of the contemporary economy and, together with the conclusions emphasized by other researchers, they can provide support for coherent and constructive behaviours, oriented towards the economic resilience in the context full of challenges posed by the COVID-19 pandemics.

The main *limitations of the research* have been determined by the choice of the authors to test causality only by using well-specified models, which caused the impossibility to run the testing procedure until the end with all the models. Also, the low number of observations has determined, in some situations, the impossibility to make some corrections to the models.

The *perspectives of the research* are shaped, mainly, by the results already obtained, as well as by the conclusions emphasized by the scientific literature studied, mainly by the correlations identified at the level of the analysed indicators. In this way, the fact that some models passed the specification tests is encouraging, as the recording of more data in the future could lead to an improved behaviour of the models and a higher flexibility in re-designing them (by taking into account the problems of stability and autocorrelations), thus generating a solid foundation for future researches. Also, the complexity of the correlations between the analysed indicators requires the application of other methods / types of models to study the quantitative aspects of those correlations (mainly, other methods that approach

Granger causality, in order to continue the efforts objectified in this paper). A future research approach of the authors will be oriented towards the correlation between the indicators of the energy sector and the GDP, as the use of the energy is itself part of the economic resilience and sustainable development of mankind. The authors hope that future research, which they propose to address, can have both practical and theoretical implications, enabling countries to better identify the elements that influence economic development and adopt correction measures in order to ensure economic resilience and that are to contribute to the improvement of knowledge and scientific literature in the field of economic growth.

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