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Greek Public Sector's Efficient Resource Allocation: Key Findings and Policy Management

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Abstract: The public sector has limited resources, and how these resources are allocated in expenditures and investments is crucial. Our article focuses on controlling this allocation for the Greek economy from 2000 to 2021, which includes the country's debt crisis. To do so, we utilized data from national accounts, categorized inputs and outputs, and examined their volatility and stability over time using statistical and mathematical methods. Our analysis revealed that the crisis impacted the size and allocation of public inputs and outputs. While some sectors of the Greek economy displayed stability in financing over time, others were more volatile. Using a mathematical accounting approach contributes to the academic discourse on rational resource allocation in the public sector. Our results validate the tax hypothesis for primary revenues and expenditures and advocate that it is necessary to make targeted recruitments in the sector that is needed each time while keeping the total number constant, which leads to the need to redistribute public sector workers. In the same way, public projects should not only focus on infrastructure projects but should also be spread to new areas related to climate change and the agricultural sector.

Keywords: public revenues; public expenditures; national budget; mathematical and quantitative methods

JEL Classification: H20; H50; H61; C38

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1. Introduction

This article aims to investigate the relationship between Public Expenditures–Public Revenues–GDP and use them for the implementation of modern decision-making processes in public management for the public. The accounting data used in the research were found in the Greek general budget, budget execution, and annual balance sheets for 2000–2021. In 2019, to promote a more comprehensive public's easy understanding of public accounts and their comparability with those of other European countries, the content of the new General Government Accounting Framework was defined based on the internationally accepted accounting standards of the Hellenic Ministry of Finance (minifin). The transformation of accounts is necessary to obtain a continuous and comparable measure for the whole examination period. Our article examines whether there were enough signs of economic crisis and whether the policy management followed was appropriate. Using the relevant data, we found that under time series and statistical analysis, there were signs related to Greek state's inefficiency. During the period under review, the country faced an unprecedented debt crisis. Because public management theory does not analyze abnormal situations, it is helpful to see what happens.

Greek evidence has been used for twenty-one years, and the essential tool to attain this paper's target is the time series analysis of public expenditure and revenues. Each type of revenue or expenditure was named as a separate variable, and general revenue

and public expenditure, such as financing methods, were all examined using appropriate financial techniques. Firstly, it was investigated through time series analysis of the public revenue and expenditure outcome, the primary surplus/deficit, and the debt/GDP (gross domestic income) the effect of the crisis afterwards. Our empirical results indicate a unidirectional causality running from expenditures to revenues, therefore validating the spend-tax hypothesis (Friedman 1972). Determining the causal relationship between these two macroeconomic measures is vital to ensure and adopt the most suitable tax policy. From our results, the increase in government expenditures by 1% will cause an increase in government revenues by approximately 0.35% in the long run.

Over the period 2000–2008, the average annual growth rate of expenditure increased at twice the rate of revenue growth by 8% and 4%, respectively. The average annual growth rate of GDP was 7%, and the maintenance of fiscal stability was mainly due to GDP growth, especially consumption. The prevailing consensus posits that enhancing long-term economic efficiency necessitates substantially reducing government involvement. Considering our research, any endeavor to mitigate deficits without substantially reducing government expenditure will likely be ineffective.

From the above analysis, we found out that the point where economic growth is maximized for PS is 8.3%, and today, we are at that rate, and the corresponding point for PIPP payments is 4.4%. It is necessary to make targeted recruitments in the sector that is needed each time while keeping the total number constant, which leads to the need for a redistribution of public sector workers. In the same way, public projects should not only focus on infrastructure projects but should also be spread to new areas related to climate change and the agricultural sector.

We apply a stability analysis of each ministry's expenditure over time and then a separation of ministries as productive or not with the criterion of whether we produce public good. Through this, we will see the connection between the expenditures of each ministry and the economy and analyze the results for appropriate policy actions in each ministry. Ministries closely linked to the provision of public sector services have an expected expenditure behaviour, while more managerial ministries also move similarly. Also, the two ministries related to public projects (MDI, MIT) have a common behaviour.

The Greek economy in the investigation time horizon has been dealing with a sovereign crisis that started concurrently with the global financial crisis in 2008 and the crisis of the coronavirus. The inability of the public sector to support public funding continues to be the main issue facing the Greek economy. Numerous political initiatives have been taken to deal with this challenging situation, but weak and highly leveraged public finance remains vulnerable. In this paper, the data are modified to the form of an old general government accounting framework for the overtime comparison of measures. Using modern quantitative tools shows that the signs of the upcoming debt crisis were obvious.

2. Literature Review

The scientific literature offers two conflicting perspectives on the correlation between public expenditure and economic growth. According to the Keynesian view, public expenditure is an external factor that can be utilized as a policy tool to influence economic growth. Conversely, the Wagner view considers public expenditure as an endogenous factor that results in, rather than is the cause of, economic growth.

Keynesian theory suggests that public expenditure is an external factor that can be utilized as a policy tool to influence economic growth (Ansari et al. 1997). Public expenditures play a significant role in achieving macroeconomic goals, as stated by Danladi et al. (2015). Empirical research indicates that public expenditure is crucial in determining economic growth in numerous developing nations (Sinha 1998). Despite considerable empirical studies on the impact of public expenditure on economic growth, the findings could be more consistent. These studies suggest that increasing government spending on productive activities such as physical infrastructure, healthcare, defence, education, and research and development can steer the direction of economic growth. Conversely,

an increase in public expenditure based on non-productive activities like consumption expenditure has no impact on economic growth, according to Mendoza (1997).

According to Wagner (1967), there is a positive correlation between real GDP and public spending: the growth of public expenditures is not a smooth linear process but is instead punctuated by breaks caused by extraordinary events such as natural disasters, economic crises, social unrest, and wars. Economic development leads to increased public spending, but this trend may experience interruptions due to unforeseeable events.

Contrary to this theory, Friedman (1972) says spending should follow revenues. If revenues (taxes) increase, the government can increase spending. So, revenues are a remedy for minimizing public deficits. Thus, there is a positive causal relationship between revenues and spending. Taxes have a positive causal relationship with government spending. Dritsaki (2018), in a case study of Greece, found a co-integrated relationship between government spending and revenues. Also, the causality test showed a unidirectional causal relationship between spending and revenues in Greece, with direction from government revenues towards spending.

The relationship between government expenditure and taxes is subject to varying interpretations, and this has been debated. Therefore, researchers who aim to determine the direction of causality for the validity of Keynesian or Wagner views constantly give mixed results.

In contrast to the Keynesian perspective, the Wagner hypothesis posits that public expenditure results from economic growth. This implies that public expenditure cannot be viewed as an external policy tool but is an endogenous factor. Hossain (2013) explains that Wagner argues that economic growth is the driving force behind the expanding public expenditure and government involvement in the economy.

According to Laffer, reducing taxes increases government revenue (tax revenue). At a zero-tax rate, the government has zero revenue, while on the opposite side, when the tax rate is 100%, there is no incentive to work and produce; again, tax revenue is zero (Laffer 2004). According to Begg et al. (2003), in the beginning, a slight increase in the tax rate yields some tax revenue. Still beyond the optimal tax rate, higher taxes have a significant disincentive and revenue decreases. Laffer's basic idea was that big government with a high tax rate was above optimal, so they had to reduce tax rates. By lowering tax distortion and increasing the amount of work, the lower taxes would be offset by the higher income to be taxed. By reducing income tax rates, there will likely also be a reduction in the deadweight of distortionary taxation.

The second view is supported by Peacock and Wiseman (1961), claiming that increases in government spending generate increases in revenues. According to this view, the level of expenditure is first determined by the government, and the revenues tax policy is defined to accommodate the desired level of spending.

The third view is the fiscal synchronization hypothesis, which states that the government can change spending and revenues (taxes) simultaneously, according to Musgrave (1966). This model is based on the Ricardian equivalence and supports the idea that the deficit financed by the government's expenditure today results in future tax increases.

The last view by Baghestani and McNown (1994) refers to the fact that government expenditures and revenues depend on long-run economic growth, so no causal relationship exists between revenues and expenses.

Dritsakis and Adamopoulos (2004) analyzed the relationship between public expenditure and economic growth in the Greek economy from 1960 to 2001. Variables were cointegrated in the long run, but in the short run, the causality test results validated the Keynesian hypothesis.

Considering this situation, Yinusa et al. (2017), used the asymmetric cointegration test in their study. Their results using the TAR and MTAR models suggest that a relationship exists between revenues and expenditures, consistent with the tax–expenditure hypothesis. Irandoust (2018) discussed the relationship between government spending and govern-

ment revenues in Sweden from 1722 to 2011. The results showed a bidirectional causal relationship between government spending and government income.

Generally, in some causality tests, researchers have concluded that economic growth is the cause of government expenditures. (Williams and Abere 2019; Chirwa and Odhiambo 2019), whereas others have found the opposite (Karagianni et al. 2019; Okere et al. 2019; Rasaily and Paudel 2019; Sedrakyan and Varela-Candamio 2019). In most studies investigating cointegration, researchers have found a coexistence and similar movement between government expenditures and economic growth.

There is a consensus in the literature on the positive effects of taxes on economic growth (Karagianni et al. 2012). Kusi (1998) states that many countries need tax revenues for sustainable economic development. Effective and sustainable tax policies are crucial for a country's competitive advantage by enabling the government to meet its projected expenses (Ofoegbu et al. 2016). In addition, government spending aimed at maintaining domestic demand can have a positive impact on economic growth. Hence, it is essential to investigate the correlation between economic growth, tax revenues, and government expenditure.

The size of the public sector is one of the most intriguing topics in which economists differ in their view of the state's role in the economy. Generally, old classical economists, with the principle of economic freedom, suggest that the government should maintain a neutral financial activity and aim to minimize costs, such as reducing taxes to finance only essential public expenditures. They also support the idea of a balanced budget where public expenditure does not exceed public revenues. The Keynesian theory advocates for state intervention in the economy in addition to the private sector. This intervention, not interfering with economic freedom, aims to boost the overall demand for goods and services.

Despite the prevailing economic thought and its practical implementation, we observe continued growth in the role of the government in the economy. This is evident in the ratio of public spending to GDP, which has consistently increased in all countries over the past years, as noted by Mauro et al. (2015). Many economists have recently focused on the negative impact of the growing role of the state in the economy on economic growth. They are interested in determining the optimal size of the state in the economy, which will ensure maximum economic growth rates. Armey (1995) concluded that the relationship between government size and economic growth takes the form of an inverted (U) shape. All field studies except the study conducted by Fallahi and Shoorkchali (2012) have proved the validity of Armey's relationship, which is an inverse relationship between the size of the government as measured by the ratio of public expenditure to GDP and the rate of economic growth, as stated by Aljaloudi and Warrad (2020).

The Greek economy faces a financial debt crisis with three memorandums, capital controls, and the coronavirus pandemic. Because our data are annual, and components of the budget are flow variables that take the value zero at the beginning of the time and the most significant value at the end, only a trend component exists in the time series analysis. For the above reasons, it is evident that we must take into consideration the concept of structural break as stated by Asemota and Agbailu (2017). In a time series analysis, a structural break refers to a significant change in time series data's underlying structure or behaviour. This occurs for various reasons, such as changes in economic policies, external shocks, or technological advancements.

Greece's case gained much attention for managing the economic crisis in 2010, and a lot of studies were occupied with the macroeconomic variable effect, especially for the debt, as seen in La Torre and Marsiglio (2020). Migkos et al. (2022) aimed to estimate the effects of the macroeconomic figures of Greece by the 2010 Memorandum.

The research field covered in this article is diverse and deep. The above literature review provides a detailed description of the main issues and studies related to the country in question and internationally.

3. Explanatory Data Analysis (EDA)

3.1. Data Preprocessing

The data of our investigation mainly came from the Greek ministry budget execution from 2000 to 2021 and the GDB from the Hellenic Statistical Authority, which we define as real growth DRGDP. The data refer to the state's revenues and expenses, and the amounts have been converted into euros using the fixed rate: 1 euro = 340.75 drachmae. To obtain a general overview of the state's budget, we transformed the national accounts into a uniform form before 2019.

To promote the easy understanding of the public accounts to a broader public and their comparability with those of other European countries, the content of the new General Government Accounting Framework was defined based on internationally accepted accounting standards. However, to provide the time needed to develop the necessary procedures and systems for the proper presentation of the financial and general assets of the General Government, it was determined that the new Accounting Framework should be applied first by the Central Administration, namely gradually from 1 January 2019. In parallel, for the proper structure and detailed classification of the State Budget revenues and expenditures, it is foreseen to match the new budget revenue and expenditure account numbers (ΑΛΕ) with the previously existing revenue and expenditure code numbers (ΑΛΕ). According to this new classification of the State Budget revenues and expenditures, the RCE is familiar with the Regular Budget and the Public Finance Program (KAE).

To make them comparable financial statements for 2019 to 2021, data have been restated in prior period statements In order to present them based on the measurement required by the Accounting Policy for the First Implementation of the General Government Accounting Framework:

Revenues:

- Direct taxes (DT)—as income tax on individuals and income tax on legal entities and social levies.
- Indirect taxes (IT)—duties and taxes imposed on imported goods, taxes on local production and consumption of goods and services, and other taxes imposed during transactions.
- Property and business income (PBI)—sales of goods and services and fixed assets.
- Other non-tax revenue (ONTR)—other current revenue except interest rates and transfers except current transfers from EU agencies and Member States and domestic investment grants and investment grants from the EU.
- Current transfers from EU agencies and Member States (TEU)
- Credit and other revenue from public debt (CPD)—as financial liabilities (loans, debt securities from liabilities, and financial derivatives)
- Sundries special non-tax revenue (SNTR)—financial assets (equity securities, investment fund shares, and debt securities)
- Revenue of public investment program (RPIP)—domestic investment grants, investment grants from the EU, refund of transfers for the execution of investment projects, and charges and credit revenues for programs.
- Taxes (T).
- Non-taxes revenue (NT).
- Total regular revenue (TRR).
- Total revenue of regular budget (TRB).
- Total Revenue of General Budget (TR).
- Divestiture of public property (DPP).
- Primary revenue (PR).

Expenditures:

- Payments for services (P.S.)—employee and social benefits, payments for services, and rents.

- Supplies Of goods and capital equipment (SGCE)—purchases of goods and services except payments for services and rents and purchases of fixed assets.
- Transfer payments (T.P.)—transfers, except NATO expenditures, and returns, especially to the EU, except consideration for the assets of the PPC personnel insurance sectors incorporated in PPC S.A. (Article 34 of Law 2773/99) and compensations plus subsidies and prepayments and other receivables.
- Payments from earned income (PEI)—returns, especially to E.U, consideration for the assets of the PPC personnel insurance sectors incorporated in PPC S.A. (Article 34 of Law 2773/99), compensations and other expenditures.
- NATO expenditures (N.E.).
- Expenditures not included in other categories (O.E.)—credits to be allocated.
- Payments for credit servicing public debt (PPD)—interests and financial liabilities.
- Expropriations and purchases (EXPP)—equity securities and investment fund shares, consideration for the assets of the PPC Personnel Insurance Sectors incorporated in PPC S.A. (Article 34 of Law 2773/99), and compensations.
- Payments of public investment program (PPIP).
- Total expenditures (T.E.).
- Primary expenditures (P.E.).

The Public Investment Budget, which finances the Public Investment Program (PIP), is part of the single State Budget. Consequently, the main revenues of the PIP are derived from the major categories and subcategories of budget revenues and domestic or European Union investment grants and other current revenues. Any shortfall between the revenue and expenditure of the PDB shall be financed by (a) revenue from financial transactions (government borrowing), (b) cash resources, and (c) revenue from any category of the State Budget, such as tax revenues or revenues from the sale of goods and services. In the fiscal year 2021, resources implementing projects financed by the Recovery and Resilience Fund are added to the available resources of the PDB. The corresponding revenue received has been recorded as Regular Budget revenue in the transfers category. In the State Budget, there are detailed expenditure accounts under the heading C29, in which appropriations are budgeted under allocations to transfer to other ALEs, where they are used to realise related expenditures. The zero payments, therefore, shown in the individual categories of the C29 ALE do not account for the non-allocation of the appropriations concerned, since the difference between the amount budgeted and the amount at which the number of appropriations in this ABA corresponds to the appropriations carried over to other AODs of implementation of expenditure. All the above information came from the report of the audit committee.

Since the configuration of ministries has changed numerous times during the 21 years under review, we have created a breakdown of expenses based on the current structure based on certain assumptions.

- Ministry of Interior (MI): expenditure of the Ministry of Interior minus in the period 2007–2016 and expenditure for administrative reform plus General Secretariat of Macedonia and Thrace.
- Ministry of Foreign Affairs (MFA): for all periods of expenditure of the Ministry of Foreign Affairs and before the 2011 period, the expenditure of delegations abroad from the Ministry of Finance.
- Ministry of National Defense (MNF): expenditures are the same for the whole period.
- Ministry of Health (MH): expenditures for health minus expenditure on sports and welfare.
- Ministry of Justice (MJ): expenditures for justice and expenditures of Responses of the Independent Administrative Authority for the Protection of Privacy of Communications from the Ministry of Interior.
- Ministry of Education and Religious Affairs (ME): expenditures for education minus the General Secretariat for Research and Technology.
- Ministry of Culture and Sports (MCS): expenditure for sports and culture minus the Tourism and National Radiocommunications Council.

- Ministry of Finance (MF): expenditures of the Ministry of Finance plus the national radiocommunications council and General Secretariat for Information and Communication minus the General Secretariat of Informative Systems.
- Ministry of Rural Development and Food (MRD): expenditures are the same for the whole period.
- Ministry of the Environment and Energy (MEE): expenditure for the environment and energy minus expenditures for public projects.
- Ministry of Labor and Social Affairs (MLSA): expenditure for labor plus welfare.
- Ministry of Development and Investment (MDI): expenditure for development and investment plus the General Secretariat for Research and Technology.
- Ministry of Infrastructure and Transportation (MIT): expenditure for infrastructure and transportation plus expenditures for public projects.
- Ministry of Maritime Affairs and Insular Policy (MMI): expenditure for island policy and the Aegean.
- Ministry of Citizen Protection (MCP): expenditures for police.
- Ministry of Tourism (MT): expenditure for tourism.
- Ministry of Migration and Asylum (MMA): expenditure for migration and asylum, mainly in the past years by the Ministry of Citizen Protection.
- Ministry of Digital Governance (MDG): expenditure for digital governance minus the National Radiocommunications Council and the General Secretariat for Information and Communication plus the General Secretariat of Informative Systems, and in the period 2007–2016, expenditure for administrative reform.
- Ministry of Climate Change and Civil Protection (MCC): expenditures for civil protection and the Fire Department.

The Ministry of Digital Governance expenditure began after 2007 because the NSRF (National Strategic Reference Framework) ran from 2007–2013, with an emphasis on digital transformation.

Financial statements for the period 2019–2021 data have been restated in prior period statements to make them as comparable as possible. To present them based on the measurement required by the Accounting Policy for the First Implementation of the General Government Accounting Framework we have the following:

$$T = DT + IT \tag{1}$$

$$NT = PBI + ONTR + TEU \tag{2}$$

$$TRR = T + NT \tag{3}$$

$$TRB = TR + CPD + SNTR \tag{4}$$

$$TR = TRB + RPIP \tag{5}$$

$$Debt = Debtt - 1 + SURPLUS/DEFICIT \tag{6}$$

$$PRIMARY\ SURPLUS/DEFICIT(PSR) = (TGB - DPP - CPD) - (TE - PPD) \tag{7}$$

$$SURPLUS/DEFICIT(TSR) = TGB - TE \tag{8}$$

3.2. Data Visualization

We represent the evolution of the Greek Ministry's public budgeting measures in the period 2000–2021, the data are provided by (minifin) and are taken from the files of the General State Audit Office (GAO).

In Figure 1. we represent the time evolution of the central government's debt and GDP. We observe that in 2008–2009, there was a considerable rise in debt in relation to the GDP at a rate of 17%, and the GDP in 2008 took the max value of EUR 241,990,389,906.67. From then on, the GDP decreased until to 2019, which was stopped due to the coronavirus crisis.

In contrast, the debt has a continuously increasing trend, which reached, in 2021, 213.82% of the GDP.

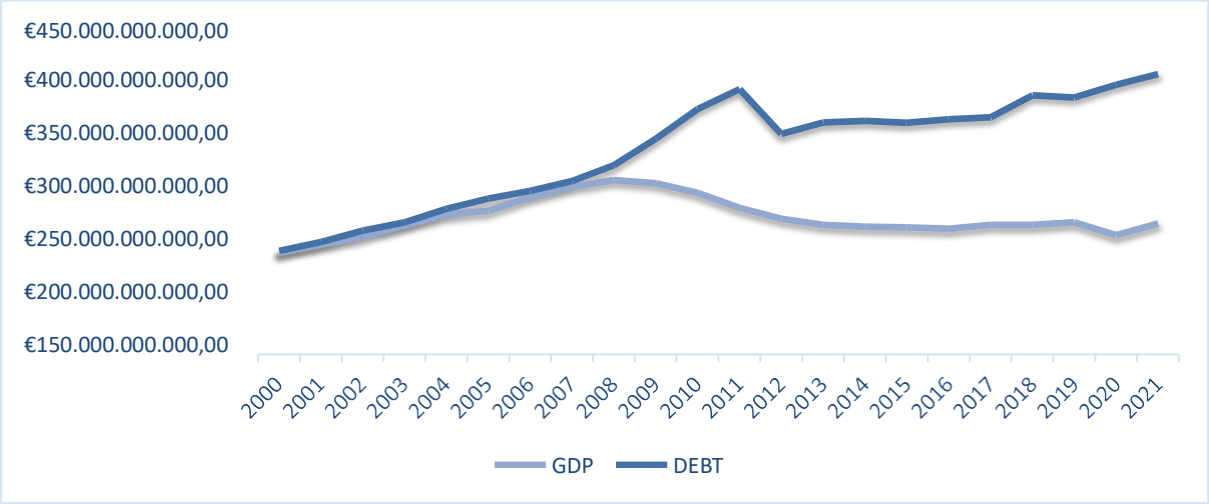

Figure 1. DEBT-GDP.

In Figure 2. we provide the chart of the taxes; it is evident that in 2009, after a steady increase in indirect taxes there was a decline due to the economic crisis. In 2019, indirect taxes have recovered a significant part of their revenue since 2008, while direct taxes have increased in relation to the corresponding year. In this year, it sharply declined due to the coronavirus pandemic.

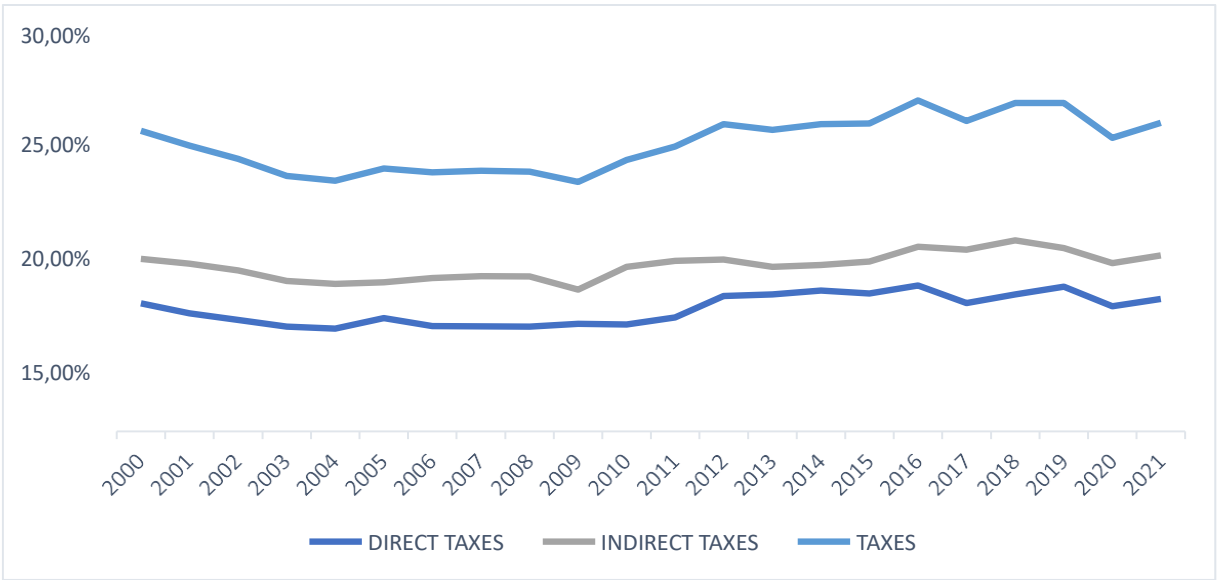

Figure 2. Taxes.

In Figure 3. we present the chart of non-tax revenue. In 2013, there was a sharp rise due to the repayment of amounts from the Eurozone Central Banks (ANFA) holding Greek Government Bonds (Eurogroup decision 21 February 2012). Sundries' special non-tax revenue had an unexpected rise in the year 2015 to EUR 13,041,356,162.62. This is due to the returns of the share capital of non-listed companies; in 2015, Greece returned the bank capital it had received during the 2008–2009 economic crisis.

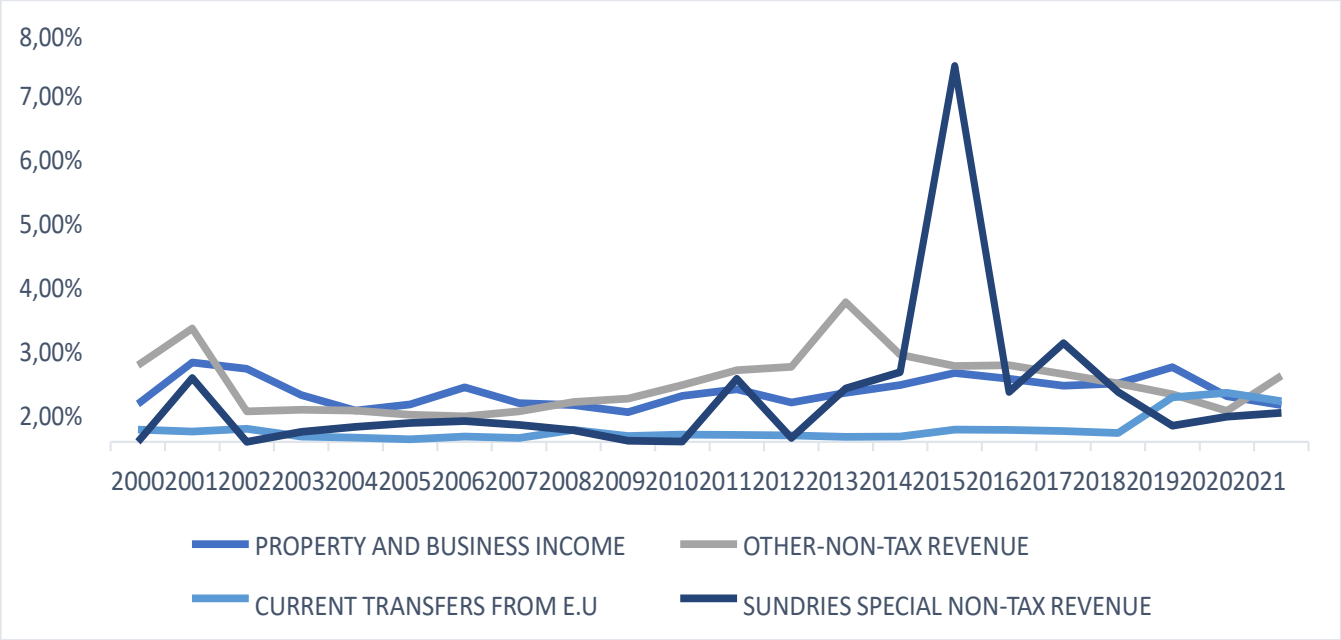

Figure 3. Non-tax revenue.

In Figure 4. presents the time evolution of public investment programs; until 2010, the program was self-financing. After 2010, any deficit between the revenues and expenditures of the PIP was financed by (a) revenues from financial transactions (government borrowing), (b) cash, and (c) revenues from any category of the State Budget, such as tax revenues or revenues from the sale of goods and services.

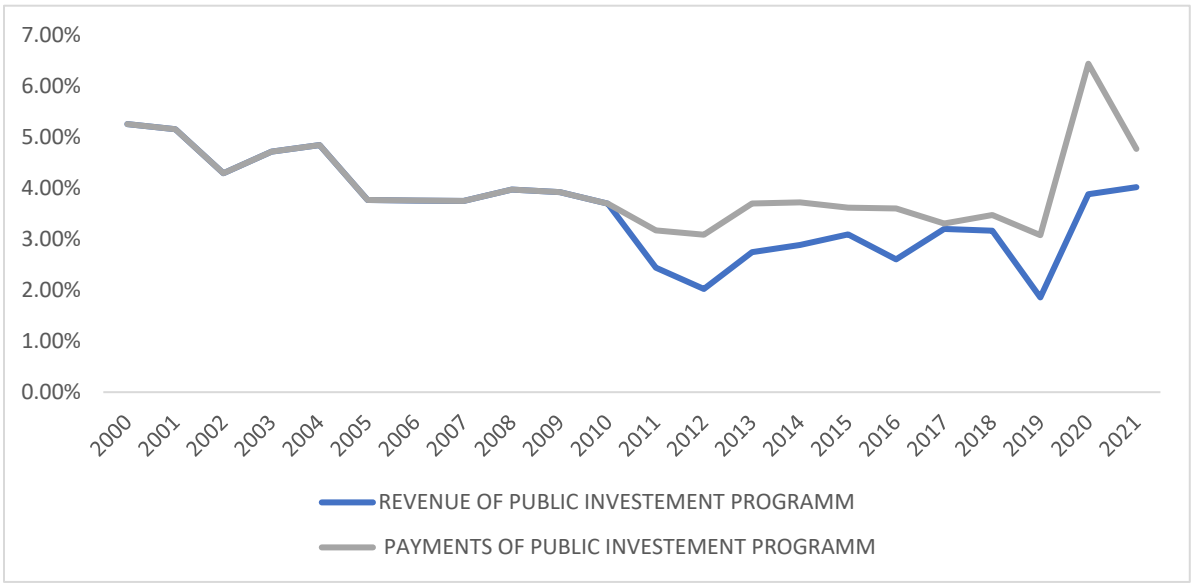

Figure 4. Public investment program.

In Figure 5. presents the time evolution of all expenditures except for credit debt and PIP. We observe that payments for services have had a steady decline since 2010, and this is explained by the need to rationalize public expenditure due to the economic crisis. The payments for supplies and goods are stable over time, but in 2021 there was an unexpected rise, which is mainly due to the purchase of armament systems worth 2,525,529,539.73 €. Transfer payments had a steady decline from 2010 to 2014, specifically in 2020, with an abnormal rise of approximately 10,000,000,000 €, and this is due to the coronavirus crisis.

Finally, expropriations and purchases had an abnormal rise in the year 2012 to the amount of 42,574,119,530.32 € the main effect due to Greek banks being recapitalized through PSI (Private Sector Involvement) and the EFSF (European Financial Stability Facility).

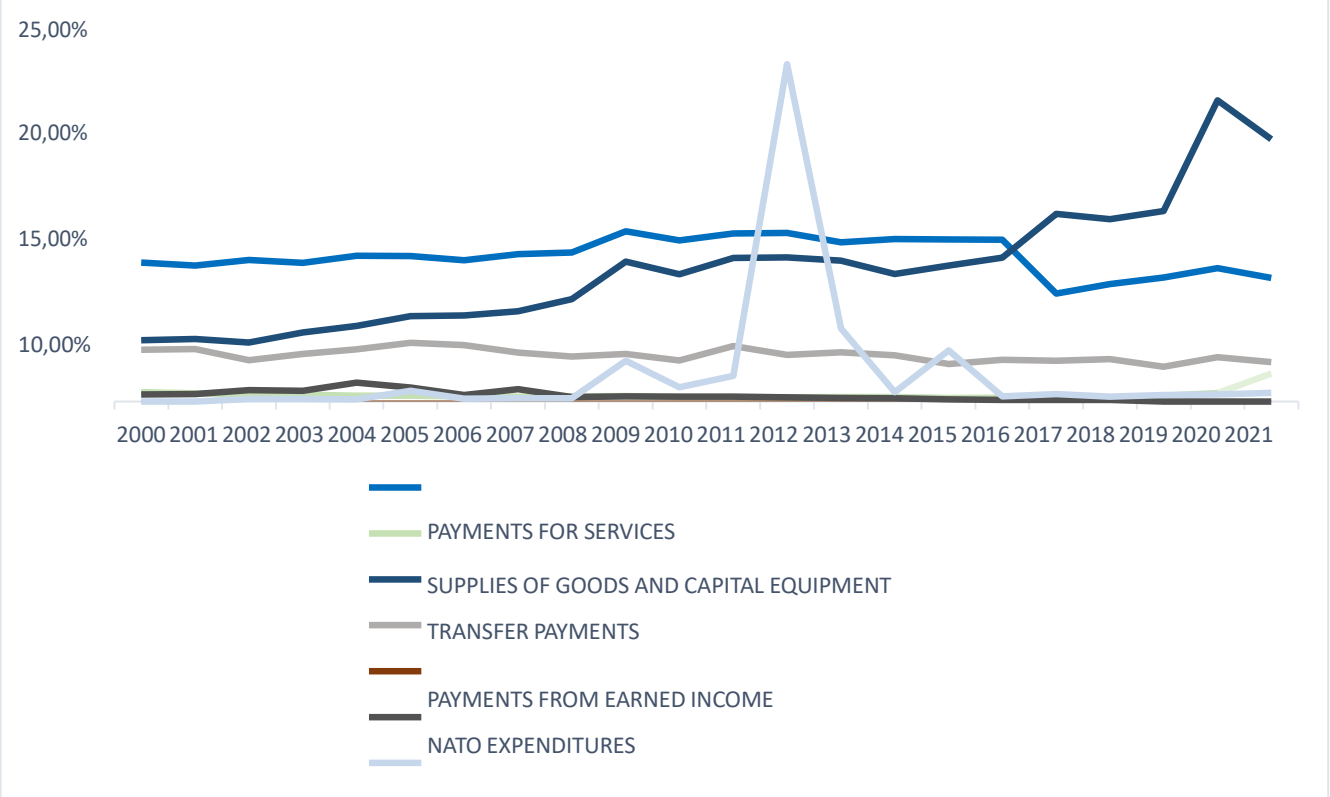

Figure 5. Expenditures except credit debt and PIP.

In Figure 6. presents the time evolution of credit debt payments and credit revenue, and a significant rise was observed in 2015. This is explained because of the political turmoil with the referendum. Until 30 June 2015, the packaged instalments of the loan to the IMF were not paid, resulting in Greece, from 1 July 2015, being considered a bankrupt country, according to the regulations of the International Monetary Fund, and on 13 July 2015, the third memorandum was signed.

In Figure 7. we represent the deficit/surplus of the General Budget until the 2010 budget was balanced after 2010. A significant point is the year 2018, which saw a surplus of EUR 26,131,386,983.36, corresponding to 14.5% of the GDP.

In Figure 8. we represent the primary deficit/surplus; we observe that from 2003 to 2013, there existed a primary deficit with a significant point of view in 2009 in the amount of EUR 20,748,474,727.93 due to the recapitalization of Greek Banks through PSI and the EFSF. In 2014 to 2019 there was a primary surplus, and finally, in 2020 to 2021 there were significant primary deficit orders of EUR 21,026,932,701.34 and 11,521,304,045.05, correspondingly. This is due to the coronavirus crisis and the grants given, such as the refundable deposit.

3.3. Descriptive Analysis

3.3.1. Stability Analysis

In this section, we investigate the stability of both revenue and expenditure in relation to total revenue/expenditures, except revenue/payments of credit debt. In the second part we investigate the stability of the ministries. For every category, we present the appropriate table of descriptive statistics.

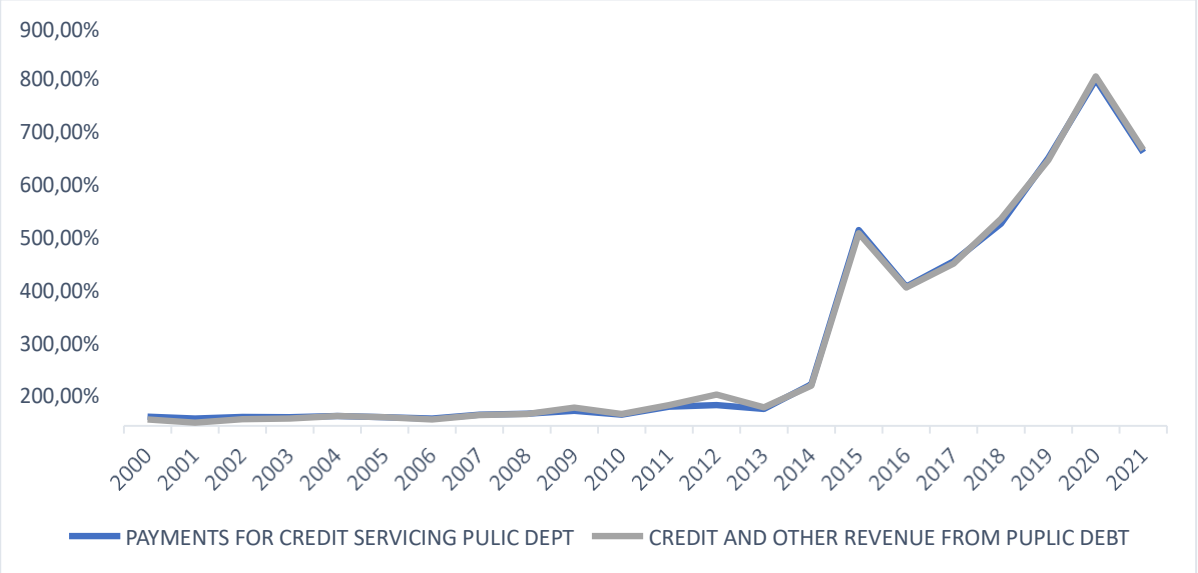

Figure 6. Credit payments and credit revenue.

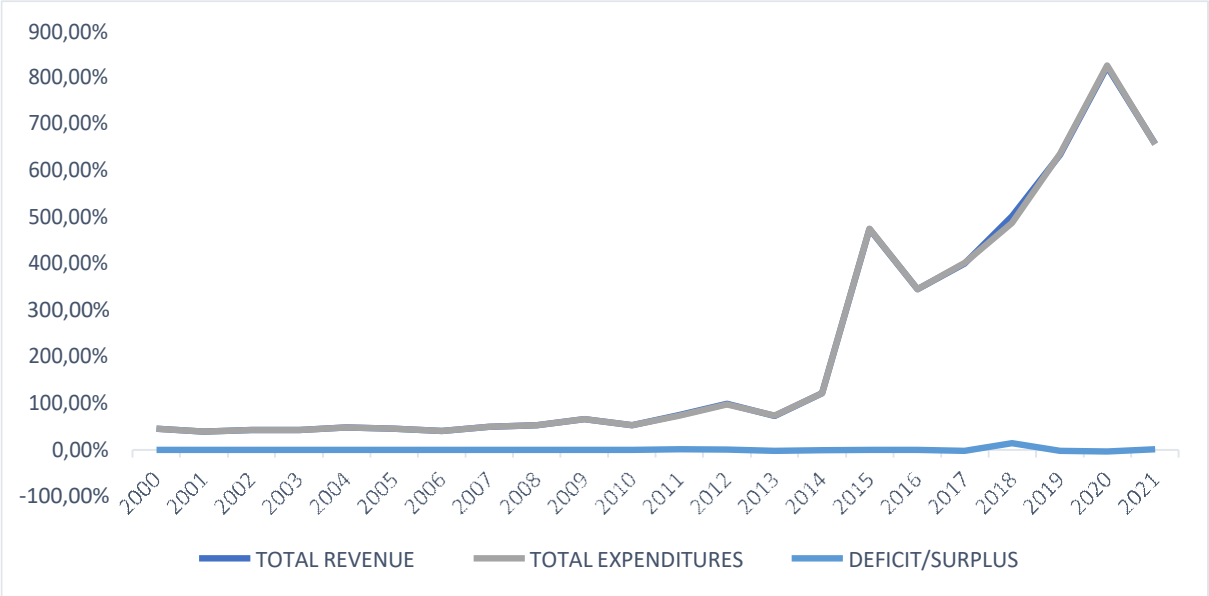

Figure 7. Surplus/deficit.

Table 1 presents the stability of revenue in relation to total revenue except revenue of credit debt. The first observation is that taxes represent 76.1% of the total revenue, and the revenue from PIP is 12.7%. According to this, it is obvious that all other categories have a low impact on total revenue.

Table 1. Revenue stability as a percentage of total revenue except debt.

	DT	*IT*	*T*	*PBI*	*ONTR*	*TEU*	*SNTR*	*RPIP*
Mean	32.2%	43.9%	76.1%	3.5%	4.0%	0.9%	2.8%	12.8%
StandardError	0.5%	0.6%	0.9%	0.2%	0.4%	0.2%	0.9%	0.8%
Median	31.7%	44.1%	76.6%	3.5%	3.9%	0.6%	1.6%	13.7%
Standard Deviation	2.3%	2.8%	4.3%	0.8%	1.8%	0.9%	4.2%	3.8%
Sample Variance	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.2%	0.1%

Table 1. *Cont.*

	DT	*IT*	*T*	*PBI*	*ONTR*	*TEU*	*SNTR*	*RPIP*
Kurtosis	−0.07	4.19	4.10	−0.04	1.88	3.41	14.35	−1.30
Skewness	0.22	−1.78	−1.46	0.66	1.21	2.12	3.53	−0.14
Range	9.0%	12.2%	20.7%	2.9%	7.1%	3.1%	20.1%	12.9%
Minimum	27.9%	34.8%	63.1%	2.4%	2.0%	0.2%	0.0%	6.1%
Maximum	36.9%	47.1%	83.8%	5.3%	9.1%	3.3%	20.1%	19.1%

Source: calculated by author.

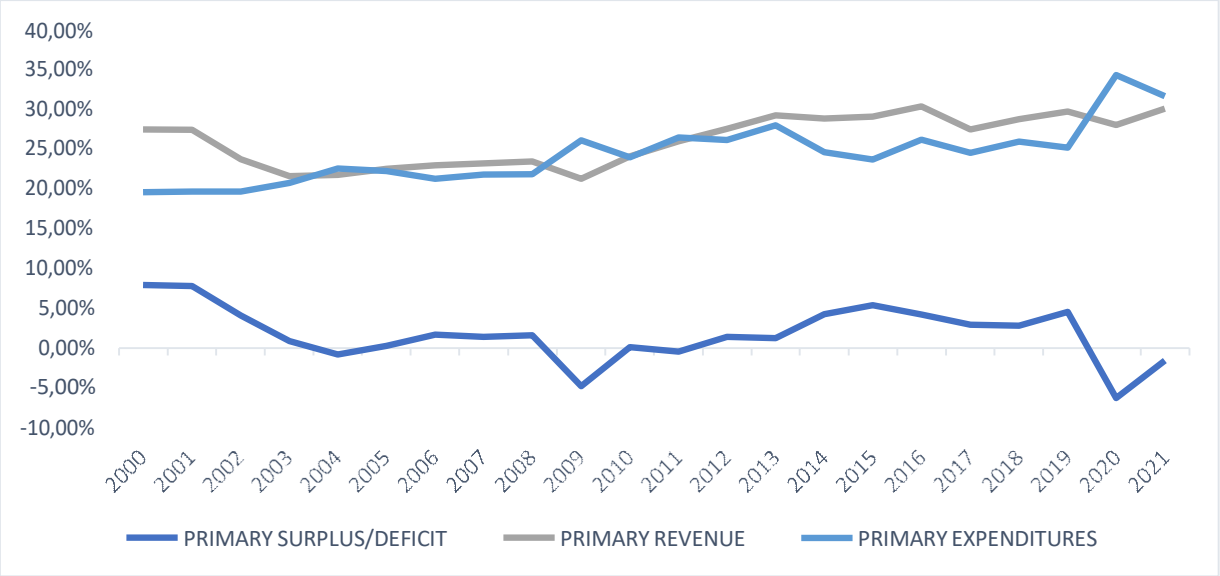

Figure 8. Primary revenue-expenditures and deficit/surplus.

Table 2 shows that payments for services and transfer payments represent 65% of total expenditures except for debt, but the standard deviation is 6.6% and 10.73%, respectively. This indicates a high timeless variability of expenses as revenue.

Table 2. Expenditure stability as percentage of total expenditures except debt.

	PS	*SGCE*	*TP*	*PEI*	*NE*	*OE*	*EXPP*	*PPIP*
Mean	34.9%	1.5%	30.1%	11.3%	0.2%	1.5%	4.8%	14.6%
Standard Error	1.4%	0.2%	2.3%	0.6%	0.0%	0.3%	2.0%	0.9%
Median	38.0%	1.4%	28.8%	10.6%	0.1%	1.1%	1.4%	13.4%
Standard Deviation	6.6%	1.0%	10.7%	2.9%	0.1%	1.4%	9.6%	4.1%
Sample Variance	0.4%	0.0%	1.2%	0.1%	0.0%	0.0%	0.9%	0.2%
Kurtosis	−0.62	8.89	−0.62	−1.09	−0.30	0.28	15.06	−0.07
Skewness	−0.92	2.65	0.74	0.06	0.90	1.05	3.70	0.35
Range	20.9%	4.7%	33.4%	9.8%	0.2%	5.1%	44.4%	16.5%
Minimum	22.2%	0.5%	17.6%	6.2%	0.1%	0.0%	0.0%	6.1%
Maximum	43.1%	5.2%	51.0%	15.9%	0.3%	5.1%	44.4%	22.5%
Maximum	43.1%	5.2%	51.0%	15.9%	0.3%	5.1%	44.4%	22.5%

Source: calculated by author.

The next step is the stability analysis of the general expenditures of the ministries. According to Table 3, the first observation is that the high percentage of total expenditures is in the Ministry of Labor and Social Affairs, with a mean of 29.5%; the high-level concentration begins at a level of 46% in 2017 and continues until now. We observe that the Ministry of Health has high variability but with a steady and significant decline from 2017 until 2021. The Ministry of Defense presents two phases, one until 2009 and one after that presenting a significant decline apart from 2021; this indicate that this ministry has been the most influenced by the economic crisis. The last point is that the Ministry of Education significantly declined in 2020–2021.

Table 3. General ministry's expenditures.

	MI	*MFA*	*MNF*	*MH*	*MJ*	*ME*	*MCS*	*MF*	*MRD*	*MEE*	*MLSA*	*MDI*	*MIT*	*MMI*	*MCP*	*MT*	*MMA*	*MDG*	*MCC*
Mean	7.7%	0.9%	10.7%	10.3%	1.4%	12.4%	0.8%	14.8%	1.9%	0.3%	29.5%	0.5%	1.6%	1.9%	3.8%	0.1%	0.0%	0.1%	0.9%
Standard Error	0.2%	0.1%	0.6%	0.6%	0.0%	0.5%	0.0%	1.2%	0.1%	0.0%	2.3%	0.1%	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%
Median	8.1%	0.8%	9.9%	9.7%	1.4%	11.9%	0.8%	17.1%	2.1%	0.3%	29.7%	0.5%	1.5%	2.5%	3.7%	0.1%	0.0%	0.1%	0.9%
Standard Deviation	1.1%	0.3%	3.0%	2.8%	0.2%	2.1%	0.1%	5.8%	0.7%	0.1%	10.7%	0.3%	0.2%	1.1%	0.4%	0.0%	0.0%	0.1%	0.2%
Sample Variance	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Kurtosis	−0.07	−0.36	−1.14	2.01	0.32	−1.18	0.87	−0.07	−1.25	−0.99	−1.19	3.28	−0.48	−1.92	−0.48	−1.07	5.27	2.50	3.86
Skewness	−0.67	0.90	0.47	1.43	−0.92	0.04	1.23	−0.99	−0.47	0.20	0.44	1.80	0.38	−0.27	0.13	0.17	2.40	1.50	1.30
Range	4.3%	1.0%	9.1%	11.4%	0.7%	7.0%	0.5%	19.5%	2.0%	0.3%	30.1%	1.0%	0.9%	2.8%	1.6%	0.1%	0.2%	0.5%	0.8%
Minimum	5.5%	0.5%	7.1%	6.8%	1.0%	8.7%	0.7%	2.7%	0.7%	0.1%	17.0%	0.3%	1.2%	0.5%	2.9%	0.0%	0.0%	0.0%	0.6%
Maximum	9.8%	1.5%	16.2%	18.2%	1.6%	15.7%	1.2%	22.2%	2.7%	0.5%	47.1%	1.3%	2.1%	3.2%	4.5%	0.2%	0.2%	0.5%	1.4%

Source: calculated by author.

According to Table 4, to the expenditures of the public investment programs, the highest percentage was for the Ministry of Investment and Infrastructure, with 27% and 25%, respectively. Among the ministries with a significant percentage of total expenditures of PIP, the Ministry of Education had the lowest std; this indicates that the investment in education was less affected by the successive crisis. The Ministry of Environment had a significant percentage until 2009, but from 2010, a dramatic decline occurred, which cannot be explained despite the successive crises. The Ministry of Infrastructure showed a considerable decline from 2017 to 20% in relation to 2016, especially in 2019–2021; it is the first time it has fallen to a single-digit percentage.

Table 4. PIP ministry's expenditures.

	MI	*MFA*	*MNF*	*MH*	*MJ*	*ME*	*MCS*	*MF*	*MRD*	*MEE*	*MLSA*	*MDI*	*MIT*	*MMI*	*MCP*	*MT*	*MMA*	*MDG*	*MCC*
Mean	8.5%	0.1%	0.4%	1.4%	0.4%	7.6%	3.3%	1.9%	6.8%	9.7%	5.2%	26.9%	25.2%	0.7%	0.7%	0.6%	0.2%	0.5%	0.0%
Standard Error	1.0%	0.0%	0.1%	0.2%	0.1%	0.4%	0.7%	1.0%	0.7%	1.4%	0.4%	2.5%	2.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%
Median	8.8%	0.1%	0.1%	1.4%	0.2%	7.8%	2.3%	0.2%	6.3%	8.0%	4.9%	26.6%	25.4%	0.5%	0.6%	0.5%	0.0%	0.5%	0.0%
Standard Deviation	4.7%	0.1%	0.4%	0.9%	0.4%	2.0%	3.4%	4.5%	3.1%	6.8%	1.9%	11.7%	9.3%	0.6%	0.4%	0.4%	0.5%	0.5%	0.0%
Sample Variance	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%	0.5%	0.0%	1.4%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Kurtosis	−1.5	4.6	−0.1	−0.2	1.5	−0.8	3.0	7.8	−0.7	0.9	−0.2	−0.3	0.8	2.0	2.1	−0.8	17.8	−0.3	22.0
Skewness	−0.1	1.7	1.2	0.6	1.4	−0.3	1.8	2.9	0.5	1.3	0.3	0.4	−0.2	1.6	1.4	0.6	4.1	0.8	4.7
Range	13.3%	0.4%	1.3%	3.4%	1.5%	6.8%	13.2%	16.9%	10.8%	23.8%	7.3%	43.8%	40.3%	2.4%	1.5%	1.3%	2.4%	1.5%	0.1%
Minimum	1.7%	0.0%	0.0%	0.1%	0.0%	4.0%	0.3%	0.0%	2.1%	2.8%	1.7%	8.8%	5.8%	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%
Maximum	15.0%	0.5%	1.3%	3.5%	1.6%	10.7%	13.4%	16.9%	12.9%	26.5%	9.0%	52.6%	46.1%	2.4%	1.7%	1.3%	2.4%	1.5%	0.1%

Source: calculated by author.

Table 5 provides the expenditures as compared to the GDP for ministries' primary expenditures, primary revenues, and the real GDP percent. We observe that MNF, MH, and MLSA have a significant std. This indicates that these ministries needed an integrated policy throughout the period and were influenced more by external effects such as crises.

Table 5. Ministry's expenditures as to GDP.

	MI	*MFA*	*MN F*	*MH*	*MJ*	*ME*	*MCS*	*MF*	*MR D*	*MEE*	*MLSA*	*MDI*	*MIT*	*MM I*	*MCP*	*MT*	*MM A*	*MD G*	*MCC*	*DRGD p*	*PE*	*PR*
Mean	1.98	0.18	2.27	2.35	0.32	2.93	0.31	3.24	0.64	0.43	7.02	1.14	1.26	0.42	0.85	0.04	0.01	0.05	0.21	0.30%	24.35	26.09
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%		%	%
Standard Error	0.05	0.01	0.08	0.17	0.01	0.04	0.03	0.27	0.02	0.07	0.74	0.14	0.07	0.04	0.03	0.00	0.01	0.01	0.01	1.06%	0.80	0.66
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%		%	%
Median	2.00	0.17	2.32	2.36	0.32	2.94	0.25	3.50	0.66	0.32	6.90	0.98	1.24	0.47	0.82	0.04	0.00	0.04	0.18	0.85%	24.24	27.43
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%		%	%
Standard	0.25	0.04	0.39	0.78	0.04	0.17	0.13	1.25	0.09	0.31	3.48	0.64	0.31	0.20	0.14	0.02	0.04	0.06	0.06	4.96%	3.74	3.10
Deviation	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%		%	%
Sample	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25%	0.14	0.10
Variance	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%		%	%
Kurtosis	- 0.20	- 0.39	- 0.21	0.80	- 0.49	1.50	4.41	0.27	- 1.25	0.23	−0.51	8.03	0.30	- 1.53	1.24	- 1.39	11.4 4	5.25	9.17	−0.22	1.30	−1.55
Skewness	- 0.18	0.79	0.49	0.72	0.00	0.36	2.17	- 0.79	- 0.31	1.27	0.64	2.48	0.49	- 0.01	1.29	0.29	3.32	1.93	2.87	−0.64	1.01	−0.24
Range	0.88	0.11	1.47	3.12	0.14	0.78	0.53	4.87	0.29	0.98	11.59	3.01	1.32	0.57	0.49	0.05	0.16	0.24	0.27	18.50	14.73	9.09
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Minimum	1.55	0.14	1.74	1.27	0.25	2.62	0.20	0.62	0.48	0.12	3.00	0.47	0.68	0.17	0.71	0.03	0.00	0.00	0.16	- 10.10	19.56	21.26
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Maximum	2.44	0.25	3.22	4.39	0.40	3.40	0.73	5.49	0.77	1.11	14.59	3.48	2.00	0.74	1.21	0.07	0.16	0.24	0.43	8.40%	34.29	30.35
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%		%	%

Source: calculated by author.

3.3.2. Correlation Analysis

This section provides the correlation matrix to investigate the relationship between variables in a first-order order. We chose and highlighted the variables with a strong relationship, negative (−1, −0.7) or positive (0.7, 1).

In the Table 6, we observed that tax revenue has a strong positive relationship with primary revenue (0.9); this finding is consistent with the long-standing policy of governments where the primary source of revenue is through taxation.

Table 6. Correlation matrix.

	DT	IT	T	PBI	ONTR	TEU	CPD	SNTR	RPIP	TR	PS	SGCE	TP	PEI	NE	OE	EXPP	PPIP	PPD	TE	PE	PR	drgdp
DT	1.00																						
IT	0.80	1.00																					
T	0.96	0.94	1.00																				
PBI	0.42	0.51	0.49	1.00																			
ONTR	0.58	0.42	0.53	0.31	1.00																		
TEU	0.38	0.42	0.42	0.17	−0.12	1.00																	
CPD	0.59	0.62	0.63	0.23	−0.04	0.84	1.00																
SNTR	0.37	0.23	0.32	0.41	0.31	−0.03	0.29	1.00															
RPIP	−0.60	−0.48	−0.57	−0.24	−0.24	−0.12	−0.32	−0.21	1.00														
TR	0.59	0.63	0.64	0.24	−0.03	0.84	1.00	0.29	−0.32	1.00													
PS	−0.11	−0.39	−0.25	−0.22	0.20	−0.46	−0.50	0.11	−0.24	−0.50	1.00												
SGCE	0.05	0.08	0.07	−0.21	−0.01	0.54	0.35	−0.17	0.33	0.35	−0.34	1.00											
TP	0.50	0.51	0.53	−0.04	0.05	0.75	0.88	0.10	−0.43	0.88	−0.29	0.37	1.00										
PEI	−0.50	−0.55	−0.55	−0.37	−0.05	−0.54	−0.65	−0.30	0.35	−0.65	0.26	−0.14	−0.51	1.00									
NE	−0.39	−0.45	−0.44	0.08	0.00	−0.36	−0.60	−0.24	0.72	−0.60	0.02	0.06	−0.75	0.43	1.00								
OE	−0.69	−0.70	−0.73	−0.31	−0.40	−0.54	−0.67	−0.28	0.56	−0.67	0.12	−0.14	−0.74	0.59	0.66	1.00							
EXPP	0.25	0.08	0.18	−0.17	0.25	−0.14	−0.11	0.01	−0.45	−0.10	0.41	−0.15	0.07	0.00	−0.22	−0.13	1.00						
PPIP	−0.23	−0.22	−0.24	−0.17	−0.14	0.39	0.17	−0.18	0.75	0.17	−0.26	0.45	0.10	0.15	0.43	0.18	−0.32	1.00					
PPD	0.58	0.62	0.63	0.24	−0.04	0.84	1.00	0.30	−0.31	1.00	−0.51	0.35	0.87	−0.65	−0.59	−0.67	−0.13	0.18	1.00				
TE	0.59	0.62	0.64	0.23	−0.03	0.84	1.00	0.29	−0.32	1.00	−0.50	0.35	0.88	−0.65	−0.60	−0.67	−0.10	0.18	1.00	1.00			
PE	0.44	0.35	0.42	−0.19	0.15	0.61	0.72	0.04	−0.44	0.72	−0.02	0.34	0.93	−0.33	−0.67	−0.63	0.18	0.13	0.70	0.72	1.00		
PR	0.93	0.87	0.95	0.47	0.65	0.49	0.64	0.37	−0.49	0.65	−0.19	0.21	0.57	−0.50	−0.42	−0.76	0.15	−0.08	0.64	0.65	0.50	1.00	
drgdp	−0.10	−0.08	−0.10	0.12	−0.16	−0.03	−0.07	−0.04	0.51	−0.07	−0.53	0.41	−0.35	−0.02	0.47	0.34	−0.43	0.18	−0.06	−0.07	−0.48	−0.10	1.00

Source: calculated by author.

3.4. Pattern Recognition and Outliers-Anomalies

3.4.1. Stationarity Test

In time series analysis, a dataset is considered stationary if its properties, such as mean, variance, and covariance, remain constant over time and tend to revert to its long-term average value. Conversely, non-stationary time series do not revert to their long-term average value, and their properties change over time. Non-stationary series are said to have a unit root. To determine the stationarity of a time series, econometricians use unit root tests. Because we use only annual data, a trend only exists and is sustained long term in an upward or downward movement in a time series. Graphs are a valuable tool to visualize the properties of a series, but statistical tests are needed to confirm the results. Unit root tests provide statistical evidence to determine the stationarity of a given time series. We perform the Augmented Dickey–Fuller (ADF) test because our data has a short volume. The ADF Dickey and Fuller (1979) report is more reliable than other stationary tests for this situation. In the following empirical analysis, all measurements expressed as a percentage of GDP and L are natural logarithms. This data transformation occurred to reduce the heteroscedasticity problem, as shown by Gujarati (2004).

We find that expenditures and revenues are (1) the results presented in Tables 7 and 8 through the ADF test, and because TP the results are controversial, we use Phillips and Perron's (1988) test to validate this.

Table 7. Unit root test.

Variables	Constant	Constant and Trend	None
DRGDP	0.1112	0.3857	0.0106 **
PE	0.5632	0.0775 *	0.9712
PR	0.7476	0.2399	0.7389
T	0.6363	0.1865	0.6709
TEU	0.7998	0.6856	0.6419
RPIP	0.1599	0.4630	0.3092
PPIP	0.0383 **	0.1800	0.5938
PPD	0.9223	0.6306	0.8244
DEBT	0.9012	0.2819	0.9718
PS	0.4098	0.6575	0.5190
ΔDRGDP	0.0003 ***	0.0024 ***	0.0000 ***
ΔPE	0.0000 ***	0.0003 ***	0.0000 ***
ΔPR	0.0061 ***	0.0159 **	0.0003 ***
ΔT	0.0009 ***	0.0045 ***	0.0000 ***
ΔTEU	0.0027 ***	0.0462 **	0.0002 ***
ΔRPIP	0.0004 ***	0.0064 ***	0.0000 ***
ΔPPIP	0.0000 ***	0.0000 ***	0.0000 ***
ΔPPD	0.0010 ***	0.0023 ***	0.0001 ***
ΔDEBT	0.0002 ***	0.0014 ***	0.0001 ***
ΔPS	0.0005 ***	0.0022 ***	0.0000 ***

Source: Calculated by author. Notes: a: (*) significant at 10%; (**) significant at 5%; (***) significant at 1%; and (no) not significant. b: Lag length based on SIC. c: Probability based on MacKinnon's (1996) one-sided *p*-values.

Table 8. Unit Root test.

Variables	Constant	Constant and Trend	None
LPE	0.5789	0.0767 *	0.0700 *
LPR	0.7326	0.2404	0.5365
LT	0.6511	0.1937	0.6099
LTP	0.8883	0.1972	0.0259 **
LRPIP	0.1253	0.2585	0.6848
LPPIP	0.0531 *	0.2394	0.6379
LPPD	0.9424	0.4328	0.4601
LDEBT	0.9012	0.2819	0.9718
LPS	0.3758	0.6004	0. 7211
ΔLPE	0.0000 ***	0.0001 ***	0.0000 ***
ΔLPR	0.0079 ***	0.0208 **	0.0004 ***
ΔLT	0.0009 ***	0.0045 ***	0.0000 ***
ΔLTP	0.0001 ***	0.0010 **	0.0001 ***
ΔLRPIP	0.0022 ***	0.0079 ***	0.0001 ***
ΔLPPIP	0.0000 ***	0.0001 ***	0.0000 ***
ΔLPPD	0.0024 ***	0.0121 **	0.0005 ***
ΔLDEBT	0.0002 ***	0.0014 ***	0.0001 ***
ΔLPS	0.0005 ***	0.0023 ***	0.0000 ***

Source: Calculated by author. Notes: a: (*) significant at 10%; (**) significant at 5%; (***) significant at 1%; and (no) not significant. b: Lag length based on SIC. c: Probability based on MacKinnon's (1996) one-sided *p*-values.

3.4.2. Breakpoint Unit Root Test for Structural Break

A structural break is a sudden and significant change in an economic time series that various factors, such as policy changes, external shocks, or shifts in the underlying regime, can cause. These breaks can affect both the intercept and trend of the series. If a stationary series experiences a structural break, it may no longer be considered stationary with traditional unit root test methods, as these methods do not account for such breaks. To address this issue, Perron (1989) developed a unit root test that considers the presence of a known structural break in the time series with exogenous structural break in the Augmented Dickey–Fuller (ADF) tests. However, some tests were developed to determine the breakpoint 'endogenously' from the data if changing is unknown. The structural breakpoint is chosen based on the minimum (most negative) t-statistic from the ADF test for a unit root. This is done because the selection of the break time is considered the result of an estimation procedure rather than being predetermined externally; the AO model allows for a sudden change in mean (crash model), while the IO model allows for more gradual changes. Generally, most macroeconomic variables are not stationary at level I (0) (Trend and random walks), see Nelson and Plosser (1982), and this variable is trend stationary with a structural break.

According to Table 9, PE with 10% significance had a breakpoint in 2019; the coronavirus crisis explains this. PR indicates a breakpoint date in 2010, and especially for taxes, we observe that 2014 has a breakpoint date similar to that of PPD. The TP use of unit root tests that do not adequately consider the potential for structural breaks can result in inaccurate conclusions, which is significant for macroeconomic policymaking, modelling, and forecasting. Therefore, econometric analyses of macroeconomic variables should consider the possibility of structural breaks to avoid such misleading inferences. These results are valid for the fact of year 2012 when the Greek banks were recapitalized through PSI (Private Sector Involvement) and the EFSF (European Financial Stability Facility) because of the political turmoil with the referendum and because, until 30 June 2015, the packaged instalments of the loan to the IMF were not paid, resulting in Greece, from 1 July 2015, to be considered a bankrupt country according to the regulations of the International Monetary Fund. Afterwards, on 13 July 2015, the third memorandum was signed. Debt had a breakpoint in 2009 due to the economic crisis, RPIP had a breakpoint in 2010 or 2011, and PPIP in 2019, which is the only variable with a breakpoint for all models.

Table 9. Breakpoint unit root test.

	Model A		**Model B**		**Model C**		**Model D**	
Variables	p	T_b	p	T_b	p	T_b	p	T_b
LPE	0.8243	2008	0.0832 *	2019	0.1522	2014	0.1118	2020
LPR	0.0149 **	2010	0.0434 **	2010	0.4323	2011	0.4299	2004
LT	0.0617 *	2014	0.001 ***	2014	0.8080	2009	0.3265	2011
LTP	0.999	2016	0.0801 *	2013	0.0361 **	2013	0.6372	2019
LRPIP	0.0886 *	2010	0.6007	2019	0.0156	2011	0.1087	2020
LPPIP	0.0497 **	2019	0.001 ***	2019	0.0909 *	2017	0.001 ***	2019
LPPD	0.0841 *	2014	0.001 ***	2014	0.001 ***	2014	0.6903	2011
LDEBT	0.7300	2009	0.2241	2010	0.0126 **	2009	0.8183	2005
LPS	0.0789 *	2016	0.001 ***	2016	0.001 ***	2016	0.0232 **	2015

Source: Calculated by author. Notes: a: (*) significant at 10%; (**) significant at 5%; (***) significant at 1%; and (no) not significant. b: Lag length based on SIC. c: Probability based on MacKinnon's (1996) one-sided p-values. d. T_b denotes the time of break. e. Model A allows change in the level of series; Model B allows change in the level of the trend of series; Model c allows change in the in the level and slope of the trend of the series; Model D allows change in the slope of the trend of the series.

4. Models and Algorithms

4.1. Econometric Analysis

4.1.1. Model Specification-Selection

Choosing the appropriate model is crucial, and the wrong choice can lead to biased and unreliable estimates, as noted by Shrestha and Bhatta (2018). The first step is to check the stationarity of the data. While analyzing the relationship between variables may be simple by taking the difference of non-stationary time series and using the OLS method after making all variables stationary, this approach has limitations. The difference between the two observations only captures the short-term changes and ignores the long-term patterns in the data. As a result, important information related to long-term trends can be lost by this method. If we use a non-stationary time series in the OLS method, we have a spurious regression (R^2 > DW) because the variables used in the relationship have no interrelationships. In some cases, two or more variables can have a long-term equilibrium relationship, even though they may deviate from this equilibrium in the short run. When two or more variables are interconnected to form an equilibrium relationship that extends over the long run, they are cointegrated. In such a scenario, one variable's behaviour can influence the other variable's behaviour over time, leading to a shared movement between them. Essentially, one variable pulls the other towards a long-term equilibrium level. Engle and Granger (1987) and Johansen and Juselius (1990) are the most used cointegrated tests.

Cointegration indicates that causality exists between two series, but it fails to show the direction of the causal relationship. According to Granger (1969), if cointegration exists between two variables, there must be a unidirectional or bidirectional Granger causality between these variables. If current and lagged values of X improve the prediction of the future value of Y, then it is said that X Granger causes Y.

The (Johansen 1988) test is used for cointegration between two or more nonstationary variables. Cointegration exists if there is a linear combination of two or more stationary and nonstationary variables. In a long-run relationship, if the variables differ, the long-run relationship loses importance in small sample max eigenvalues and the method outlined by Hubrich et al. (2001) becomes a more appropriate criterion than a trace.

We use Dynamic OLS (DOLS) Saikkonen (1992), Stock and Watson (1993), and fully modified OLS (FMOLS) Phillips and Hansen (1990) because these methods are appropriate for estimating and testing single equation cointegrating relationships. They have a significant advantage, specifically in macroeconomic analysis with annual data, because they handle more efficiently small samples and endogeneity problems with leads and lags and FMOLS with non-parametric approaches. The main objective of the two above methods is to investigate the existence of a long-run relationship among variables.

FMOLS uses a semi-parametric correction to eliminate the problems caused by the long-run correlation between the cointegrating equation and stochastic regressor innovations. The resulting Fully Modified OLS (FMOLS) estimator is asymptotically unbiased and has a fully efficient mixture of normal asymptotics, allowing for standard Wald tests using asymptotic Chi-square statistical inference. The FMOLS estimator employs preliminary estimates of the residuals' symmetric and one-sided long-run covariance matrices.

A simple approach to constructing an asymptotically efficient estimator that eliminates the feedback in the cointegrating system has been advocated by Saikkonen (1992) and Stock and Watson (1993). Termed Dynamic OLS (DOLS), the method involves augmenting the cointegrating regression with lags and leads ΔX_t so that the resulting cointegrating equation error term is orthogonal to the entire history of the stochastic regressor innovations under the assumption that adding q lags and r leads of the differenced regressors soaks up all of the long-run correlation between the error terms and have the same asymptotic distribution as those obtained from FMOLS.

DOLS equation:

$$Y_t = \alpha + \beta x_t + \sum_{i=q}^{r} \delta \Delta x_{t-i} + \varepsilon_t \quad (9)$$

Afterwards, based on the mathematics of optimization, the estimation results can be used to answer the central question in the study: what is the rate of public spending that maximises the real economic growth rate? We calculate the optimal public spending ratio by taking the first and second derivatives of the estimated relationship and zero equality.

$$PE_{ps} = -\frac{b_1}{2b_2} \quad \text{and} \quad PE_{ppip} = -\frac{b_3}{2b_4} \tag{10}$$

1. Calculate second partial derivatives:
   - Compute the second partial derivatives of the function with respect to f_x and f_y.
2. Evaluate second partial derivatives at the critical point:
   - Plug the coordinates of the critical point into the second partial derivatives.
3. Calculate the discriminant:
   - Calculate the discriminant, $D = f_{xx} \times f_{yy} - \left(f_{xy}{}^2\right)$
4. Analyze the results:
   - If $D > 0$ *and* $f_{xx} > 0$ at the critical point, it indicates a local minimum.
   - If $D > 0$ *and* $f_{xx} < 0$ at the critical point, it indicates a local maximum.
   - If $D < 0$, it indicates a saddle point.
   - If $D = 0$, the test is inconclusive.

Based on the national accounts of Greece, we construct the following equations:

In model 1, we investigate the relationship between total revenues and total expenditures of the general government; because the sample size is small, only 21 observations from the period 2000–2021 are used, and the link between government spending and revenue is specified as follows:

$$L(PR) = a_1 + b_1 L(PE) + dummy(2010) + \varepsilon \tag{11}$$

PE and PR are the total expenditures and revenues as a percentage of GDP, and we expect that b_1, $b_2 > 0$ and L are natural logarithms. The logarithm of the overall government expenditures to GDP ratio and the overall government revenues to GDP ratio are used in the empirical analysis. This data transformation occurred to reduce the heteroscedasticity problem, and Gujarati (2004) and dummy (2010) show dates where we found a structural break in revenue.

In model 2, we try to investigate the optimal size of government to achieve maximum economic growth. The sample size is 21 observations from the period 2000–2021. It is evident that from economic theory there exists a direct relationship between the size of the government sector and the total production of the economy. According to Keynes a positive relationship exists between public spending and real economic growth, but this relationship only continues for a while. After a specific amount, the relationship will turn negative. The inverted non-linear quadratic u-shaped relationship is known as the Armey curve; balancing the volume of public and private spending is crucial for any economy as it directly impacts accurate economic growth rates. The relationship between spending and growth starts positively, with increased spending leading to higher growth rates. However, there is a point where further increases in spending lead to diminishing returns, causing growth rates to decline. Therefore, it is essential to find the optimal level of government spending that maximizes accurate growth rates. This requires careful consideration and balancing public and private spending to achieve sustainable and robust economic growth.

$$DRGDP = a_1 + b_1 PS + b_2 PS^2 + b_3 PPIP + b_4 PPIP^2 + \varepsilon \tag{12}$$

$$DRGDP = a_1 + b_1 TP_1 + b_2 INVPR + b_3 NX + \varepsilon \tag{13}$$

$$DRGDP = a_1 + b_1 TP_2 + b_2 INVPR + b_3 NX + \varepsilon \tag{14}$$

In model 5, The EU's treaties place two limitations on monetary policy: a government's debt-to-GDP ratio of no more than 60% and a deficit-to-GDP ratio of no more than 3%. In the wake of the financial and economic crisis, several European nations have had to significantly strengthen their fiscal infrastructure. The latest crisis has made it more evident how crucial budgetary sustainability is. The typical approach used in the literature to examine the sustainability of fiscal policies includes cointegration tests between public spending and revenue as well as stationarity and unit root tests for the public debt and deficit. We want to investigate the relationship between PSR PE and PR, but we chose specifically taxes as the central components of PR and TP, as well as PS and PPIP as main components of PE on this occasion.

$$PSR = a_1 + b_1T + b_2TP + b_3PS + b_4PPIP + \varepsilon \quad (15)$$

4.1.2. Estimations

We investigate the long-run or equilibrium relationship between variables PR and PE using the Johansen and Granger causality tests.

The results that are reported in Table 10 indicate that there is one cointegrated vector between variables. The results suggest that a null hypothesis of no co-integration between primary expenditures and primary revenues should be rejected and in the same manner between DRGDP PE and DRGDP and PR. A long-run relationship exists between the variables, and primary expenditures and primary revenues move together in the long run. Both the trace and maximum eigenvalue tests confirm this conclusion. This co-integrated test does not tell the direction of a relationship between variables; thus, we investigate this through the Granger causality test. Therefore, this test is applied to determine the existence of the Keynesian versus Wagner hypothesis.

Table 10. The Johansen co-integration test results for Equation (9).

Unrestricted Cointegration Rank Test (Trace)					Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No of CE(s)	**Eigenvalue**	**Trace Statistic**	**Critical Value 5%**	**Prob. ****	**Hypothesized No of CE(s)**	**Eigenvalue**	**Trace Statistic**	**Critical Value 5%**	**Prob. ****
PE-PR									
None *	0.684931	23.11552	15.49471	0.0029		0.684931	23.09928	14.26460	0.0016
At most 1 *	0.000812	0.016238	3.841466	0.8985		0.000812	0.016238	3.841466	0.8985
PE-DRGDP									
None *	0.569730	17.89647	15.49471	0.0213		0.569730	16.02351	14.26460	0.0261
At most 1 *	0.093874	1.872958	3.841466	0.1711		0.093874	1.872958	3.841466	0.1711
DRGDP-PR									
None *	0.687147	32.08073	25.87211	0.0074		0.687147	23.24047	19.38704	0.0131
At most 1 *	0.357259	8.840258	12.51798	0.1904		0.357259	8.840258	12.51798	0.1904

Source: Calculated by author. Notes: a: * indicates rejection of the hypotheses at five percent level of significance. b: Maximum eigenvalue test and trace test indicates two cointegrating equations (CEs) at a five percent level of significance. c: ** indicates Mac Kinnon–Haug–Michelis (1999) *p*-values.

According to Table 11, our empirical results indicate a unidirectional causality running from expenditures to revenues, validating the spend-tax hypothesis. Reducing government expenditure could improve fiscal budget deficits, allowing for the preservation of the overall strategy. This implies that the Greek political system determines the spending allocation and subsequently adapts tax policies and revenue streams to fund it. Our empirical results indicated a unidirectional causality from expenditures to the real GDP rate of change and a unidirectional causality from the real GDP rate of change to primary revenues.

Table 11. Results of Granger causality tests.

Variables	F-Statistics	*p*-Value	Decision	Causality
PE does not Granger Cause PR	12.6332	0.0023	Reject	Unidirectional PE → PR
PR does not Granger Cause PE	0.48939	0.4931	Do not reject	
DRGDP does not Granger Cause PE	0.27492	0.7634	DO not Reject	Unidirectional PE → DRGDP
PE does not Granger Cause DRGDP	5.02590	0.0213	Reject	
DRGDP does not Granger Cause PR	9.06765	0.0075	Reject	Unidirectional DRGDP → PR
PR does not Granger Cause DRGDP	0.11086	0.7430	Do not Reject	

Source: calculated by the author.

We use the DOLS method to capture the short-run effect with differences because this method is more efficient in small sample sizes.

The results in Table 12 show that both statistical and diagnostic tests are quite satisfying. So, an increase in government expenditures by 1% will cause an increase in government revenues by 0.35% in the long run approximately, and the coefficient of the short run effect is statistically significant by only 10% and has a negative effect.

In the Figures 9 and 10, we can see the dynamic stability of the restricted error correction model with the tests used in Brown et al. (1975).

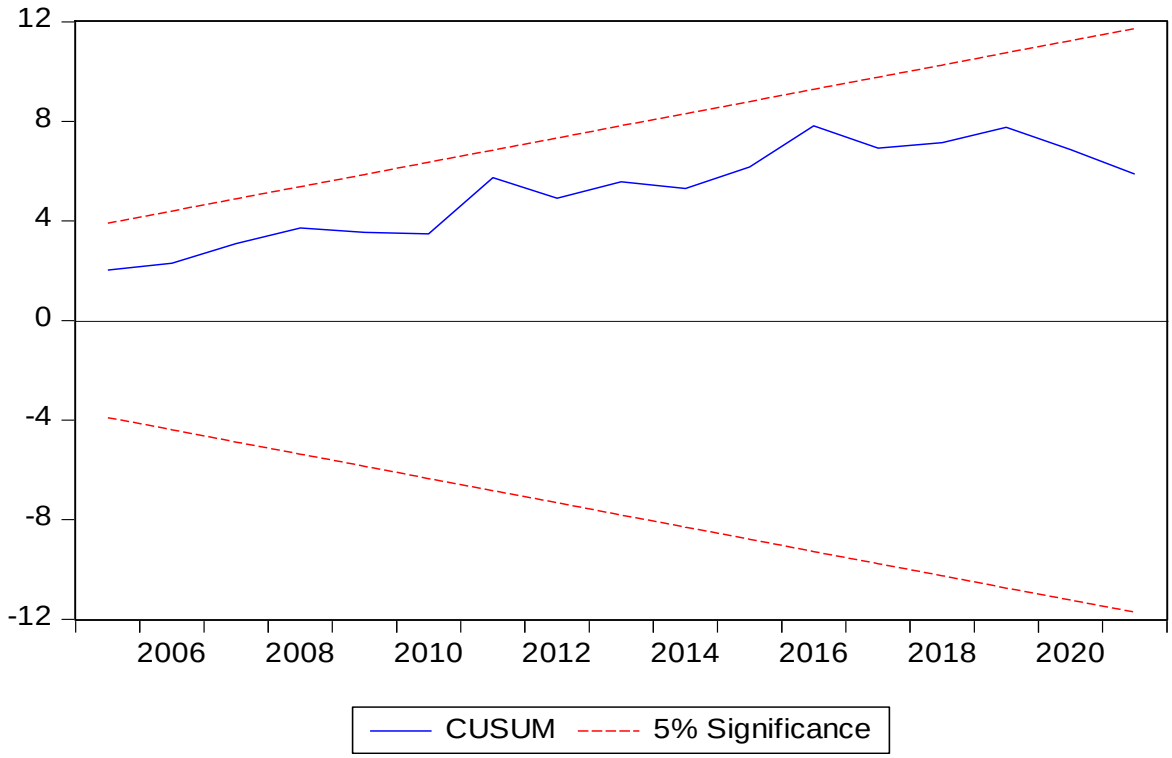

Figure 9. Plot of cumulative sum of recursive residuals.

Because the main component of primary revenues is taxes, we conclude that the increase in revenues due to the rise in expenditures mainly affected taxes for the rise in consumption or tax rates. Because the 1% expenditures increase will cause only a 0.33% ratio and the deficit-to-GDP ratio must be no more than 3%, the rest is captured by public lending. The above analysis supports the spend-tax hypothesis, which maintains that a political system somehow determines how much to spend and then makes the adjustments in tax policy and revenue sources to finance the government spending. Therefore, limitations in spending will be practical for the economy of Greece, however, no one can argue that

the limitations on taxation will be ineffective. The Greek government needs to identify the causal direction between government spending and tax revenues because the direction of causality provides valuable insights into how the country can manage their unsustainable budget deficits in the future.

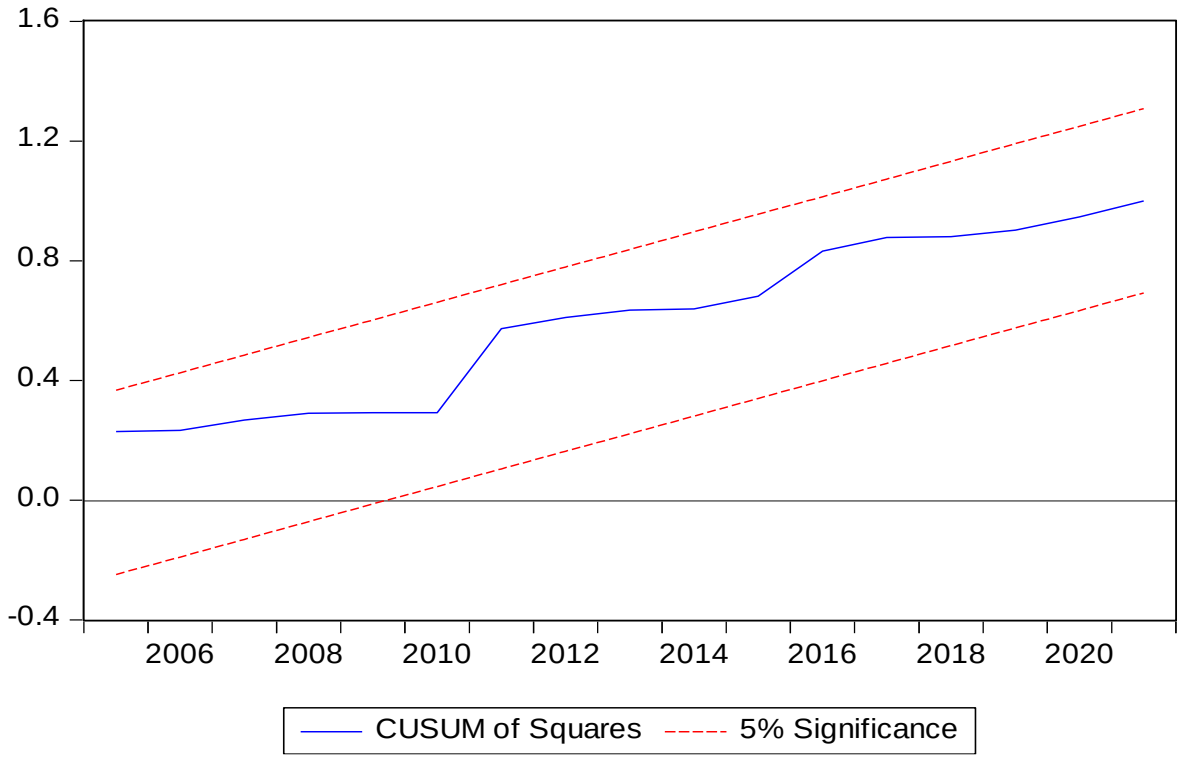

Figure 10. Plot of cumulative sum of squares of recursive residuals.

Table 12. Estimation of long-run relationship in Equation (11).

DOLS Method (Leads = 0 and Lags = 0)		
Variables	Coefficient	
Constant	−0.831241 ***	
LPE	0.350444 ***	
dummy (2010)	−0.175294 ***	
Δ(LPE)	−0.267537 *	
R^2	0.820305	
F-stat	25.86825	
D-W	1.982320	
Diagnostic Test	X^2	Probability
Normality	0.069870	0.9615648
Serial Corr.	0.163954 (2)	0.8503
ARCH	1.307502 (1)	0.2678

Notes: ***, and * show significance at the 1%, and 10% levels, respectively. Δ denotes the first difference operator, X^2 Normal is for normality test, X^2 Serial for LM serial correlation test, X^2 ARCH for autoregressive conditional heteroskedasticity, ( ) is the order of diagnostic tests.

We use the FMOLS method to estimate the optimal size of the public sector according to the Armey (1995) model because this method is more efficient in a small sample size.

We find above that PE has a long-run co-integration relationship with the real GDP rate of change. We proceed to estimate Equation (12).

The estimation results of Table 13 aligned with the theoretical quadratic relationship represented by Equation (12) and the R^2 (85%) is observed and is sufficient. All coefficients have a statistical significance of less than 5%; the estimated parameters are compatible in terms of the indication with the expectations of economic theory and the inverted relationship. We investigated including the TP variable in the above equation, but all results indicate it is non-significant.

Table 13. Estimation of the long-run relationship in Equation (12).

FMOLS Method		
Variables	Coefficient	
C	−1.254673 ***	
PS	14.37596 **	
PS^2	−88.99057 **	
PPIP	33.49567 ***	
$PPIP^2$	−376.9066 ***	
R^2	0.851408	
Diagnostic Test		Probability
Normality	1.394869	0.497861
Engle–Granger tau-statistic	−4.715468	0.0911 *
Engle–Granger z-statistic	−22.54700	0.0701 *

Notes: ***, **, and * show significance at the 1%, 5%, and 10% levels, respectively, FMOLS takes care of heteroscedasticity with a non-parametric approach and the absence of autocorrelation validation due to correlogram. Engle–Granger H_o: series not cointegrated.

The rate of public spending that maximizes growth is achieved when the ratio of PS to GDP is 8% and for PIP 4.44%. Figure 8 shows that for all years except 2017–2018 exceeded the limits, primarily until 2009 (economic crisis), and the percentage of expenditures was significantly higher and reached 11.4%. In the PPIP expenditures compared to GDP for the years 2005–2019, the above percent was not reached, and for previous and after-year periods, this was due to Olympic projects and the coronavirus crisis. These estimations showed that an economy must turn policy making for expenditures from payments for services and wages to public investment program expenditures.

The transfer payment consists of two main components: grants and income support (allowances) (TP_1) and contributions to social security funds (TP_2).

We observe that the relationship between DRGDP and TP is not parabolic, so we use the FMOLS method to investigate Equations (13) and (14). To avoid removing essential variables from the model, the CLASSICAL GROWTH MODEL has been completed by adding relevant variables, including INVPR (investment private) and NX (net exports).

Tables 14 and 15 show that grants and income support (allowances) have a high positive coefficient to real economic growth, approximately 1.7. In contrast, the coefficient of contributions to social security funds is lowered to 1 0.83.

We use the OLS method to investigate the effect of the main component of primary revenues and expenditures on primary surplus.

In the Table 16, a high positive coefficient of taxes indicates that we use taxes to raise tax rates for all governments to balance the deficit. The sign of the three coefficients of expenditures is, according to theory, negative; this reinforces the previous finding that all governments resort to raising taxes.

Table 14. Estimation of the long-run relationship in Equation (13).

FMOLS Method		
Variables	Coefficient	
C	−0.279354 ***	
TP_1	1.733156 **	
INVPR	2.092455 ***	
NX	2.464185 ***	
R^2	0.664528	
Diagnostic Test		Probability
Normality	1.116202	0.572295
Engle–Granger tau-statistic	−4.679671	0.0065 ***
Engle–Granger z-statistic	−28.81117	0.0001 ***

Notes: ***, **, and show significance at the 1%, 5%, and levels, respectively; FMOLS takes care of heteroscedasticity with a non-parametric approach and the absence of autocorrelation validation due to correlogram. Engle–Granger H_o: series not cointegrated.

Table 15. Estimation of the long-run relationship in Equation (14).

FMOLS Method		
Variables	Coefficient	
C	−0.271835 ***	
TP_2	0.830698 ***	
INVPR	2.044922 ***	
NX	2.204767 ***	
R^2	0.758035	
Diagnostic Test		Probability
Normality	1.250860	0.535031
Engle–Granger tau-statistic	−4.501221	0.0645 *
Engle–Granger z-statistic	−25.31284	0.0095 ***

Notes: *** and * show significance at the 1% and 10% levels, respectively; FMOLS takes care of heteroscedasticity with a non-parametric approach and the absence of autocorrelation validation due to correlogram. Engle–Granger H_o: series not cointegrated.

Table 16. Estimation of the relationship in Equation (15).

OLS Method	
Variables	Coefficient
constant	−0.201265 ***
TP	−0.853201 ***
PS	−0.594625 **
T	1.570488 ***
PPIP	−0.731867 *
R^2	0.914299
F-stat	45.34123
D-W	2.059257

Table 16. *Cont.*

OLS Method		
Diagnostic Test		Probability
Normality	0.591720	0.743831
Serial Corr	0.012791(2)	0.9873
ARCH	0.694649(1)	0.4149

Notes: ***, **, and * show significance at the 1%, 5%, and 10%, respectively. Δ denotes the first difference operator, X^2 Normal is for the normality test, X^2 Serial for LM serial correlation test, X^2 ARCH for autoregressive conditional heteroskedasticity, and ( ) is the order of diagnostic tests.

In the Figures 11 and 12, we can see the dynamic stability of the restricted error correction model with the tests used in Brown et al. (1975).

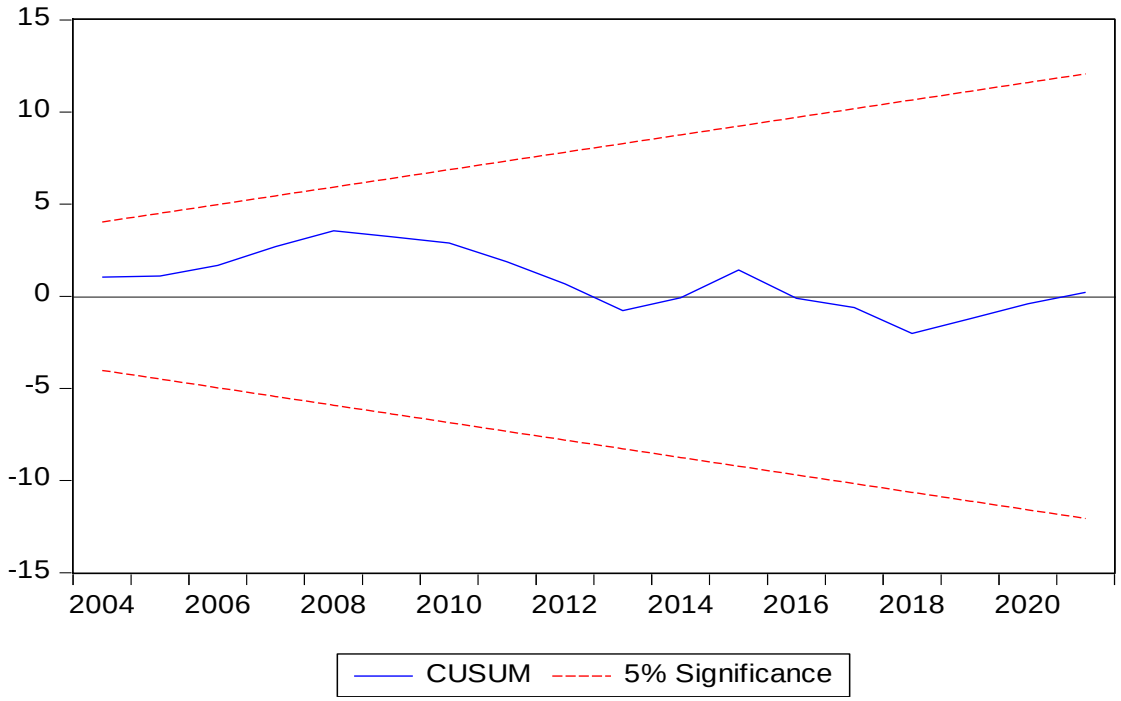

Figure 11. Plot of cumulative sum of recursive residuals.

4.2. Cluster Analysis

To investigate the similarities among the ministries regarding the expenditures in the sample period of 2000–2021, we used a cluster analysis; the main two categories are hierarchical and partitioning methods.

Hierarchical clustering methods create a nested tree structure of clusters, where each node in the tree represents a cluster, and the root node represents the entire dataset. The leaves of the tree are the individual data points. The internal nodes represent clusters of increasing size and complexity as one moves up the tree. Hierarchical clustering algorithms can be either agglomerative or divisive. Agglomerative algorithms start with each data point as its cluster, then iteratively merge the most similar clusters until several clusters are reached. Divisive algorithms start with the entire dataset as a single cluster and then iteratively split the cluster into smaller and smaller clusters until a desired number of clusters is reached. The choice of the appropriate hierarchical clustering algorithm and the number of clusters depends on the specific application. However, hierarchical clustering methods are generally well-suited for applications where it is essential to understand the relationships between different clusters, such as gene expression analysis and market segmentation.

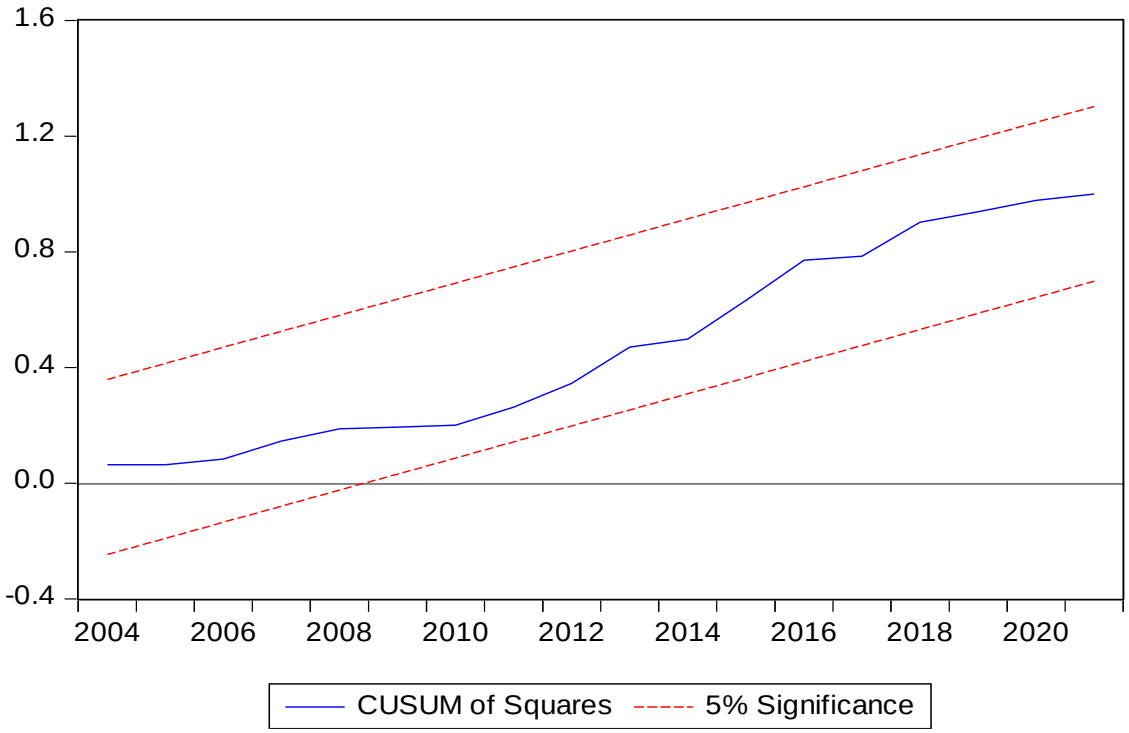

Figure 12. Plot of cumulative sum of squares of recursive residuals.

Partitioning clustering methods divides a dataset into k clusters, where k is a user-defined parameter. These methods typically work by iteratively moving objects from one cluster to another until a convergence criterion is met. The convergence criterion measures the clustering quality, such as the sum of squared distances between the objects and their cluster centroids.

The most well-known partitioning clustering algorithm is k-means. The k-means algorithm works by randomly initializing k-cluster centroids. Then, it iteratively assigns each object to the cluster with the closest centroid. After all objects have been assigned to clusters, the cluster centroids are updated by averaging the positions of the objects in each cluster. This process is repeated until the cluster centroids no longer change. Partitioning clustering methods are simple and can be very efficient for large datasets. However, they can be sensitive to the initial placement of the cluster centroids and can get stuck in local optima.

First, we used the two-step cluster method. Using a pre-clustering step, this method first reduces the data into a smaller set of clusters. Then, it applies a traditional clustering method on the pre-clustered data to decide the number of clusters. We implemented the K-means cluster method as outlined in MacQueen (1967). This method partitions data into K clusters, where K is a number chosen in advance. It iteratively assigns data points to clusters and updates the cluster centroids to minimize the within-cluster sum of squares.

Moreover, we used the hierarchical cluster method as outlined in Nielsen and Nielsen (2016); this method creates a tree-like diagram of the data, called a dendrogram, to show the arrangement of clusters at different levels. It starts with each data point in its cluster and then merges the closest clusters iteratively until there is only one cluster left. It provides a visual representation of the data's hierarchical structure, which can help us understand relationships at different levels of granularity. The agglomerative method is a "bottom-up" approach, where each observation starts in its cluster, and pairs of clusters are merged as one moves up the hierarchy. Considering potential outliers, the average linkage method might be more robust. It can handle outliers better compared to other methods like Ward's method. In terms of distance metrics, we used the Euclidean distance; since our data are standardized (all in thousands of euros) like z-scores, Euclidean distance should work well.

Accordinf to Table 17 and Figure 13, we observed that MH and MI have a solid relationship. This is due to the national healthcare system's behaviour and the high dependency on hiring. A solid relationship exists between ME and MNF. This indicates that governments that favour increasing the public sector are increasing overall spending on the main pillars. The Ministry of Development and the Ministry of Infrastructure have a strong relationship, which is reasonable because most of the overtime work has been related to road networks.

Table 17. K-mean clustering.

1	MI	5
2	MFA	2
3	MNF	5
4	MH	5
5	MJ	2
6	ME	5
7	MCS	2
8	MF	3
9	MRD	2
10	MEE	2
11	MLSA	4
12	MDI	1
13	MIT	1
14	MMI	2
15	MCP	1
16	MT	2
17	MMA	2
18	MDG	2
19	MCC	2

Source: Author's calculations.

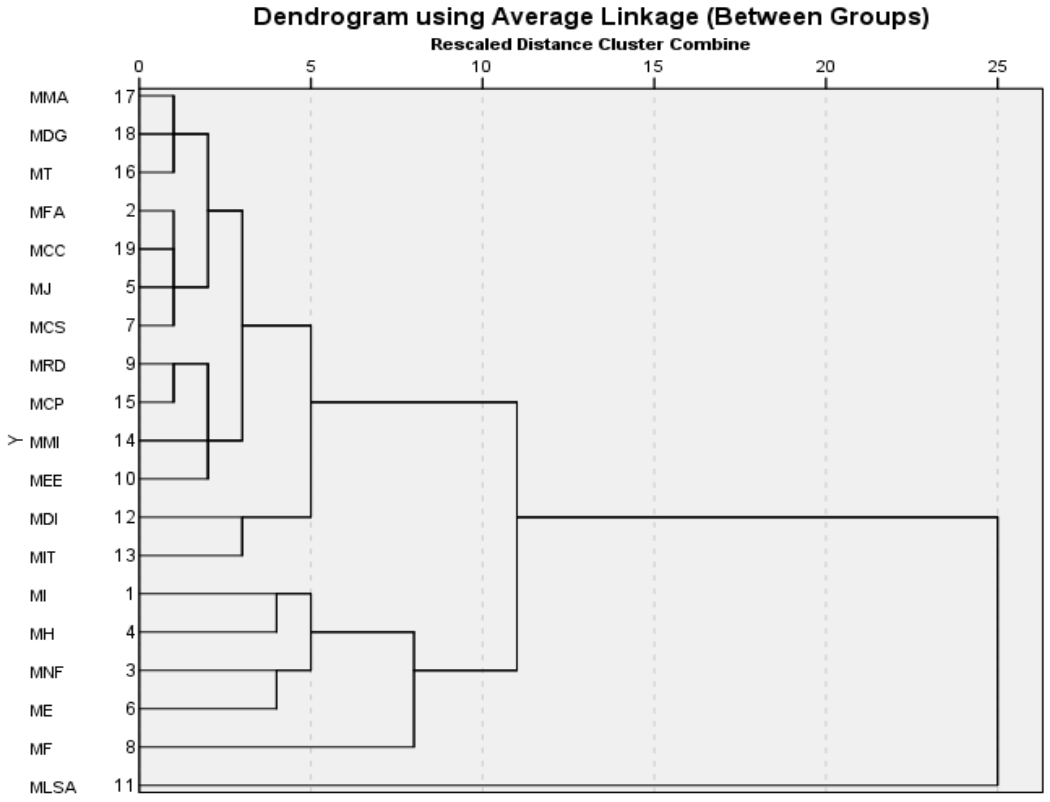

Figure 13. Dendrogram between ministries.

5. Conclusions and Discussion

5.1. Key Findings

First, this paper investigated the causal relationship between government spending and revenues in Greece. For this analysis, we used annual data for 2000–2021. We examined the relationship between government spending and revenues in Greece. We found a long-term relationship between budget expenditure and revenue for Greece. That is, the expenses determine the revenues for the budget. Afterwards, we tested the direction of causality among the examined variables, and our empirical results indicate a unidirectional causality running from expenditures to revenues, therefore validating the spend-tax hypothesis is by Richter and Paparas (2013), and on the opposite side with Dritsaki (2018). The extended period of elevated deficits in Greece primarily arises from expenditure-related determinants rather than being predominantly driven by the dynamics of government revenues. Over 2000–2008, expenditure's average annual growth rate increased at twice the revenue growth rate of 8% and 4%, respectively. The average annual growth rate of the GDP was 7%, and the maintenance of fiscal stability was mainly due to GDP growth, especially consumption. The prevailing consensus posits that enhancing long-term economic efficiency necessitates a substantial reduction in government involvement. Considering our research, any attempt to reduce deficits without substantially reducting government expenditure is likely to be ineffective.

Specifically, if there is a 1% increase in expenditure, this will be covered by 35% additional taxes and the rest by other sources, mainly borrowing. Because the 1% expenditures increase will cause only 0.35% and the deficit-to-GDP ratio must be no more than 3%, the rest is captured by public lending. According to this, the government should differentiate its economic strategy and seek other revenue streams (other than taxes) to close the gap between receipts and spending, thus lowering the budget deficit.

If taxes as a percentage of GDP increase by 1%, the primary surplus will increase accordingly or the primary deficit as a percentage of GDP will decrease by 1.6%. Suppose transfer payments or payments for wages and services or expenditures for public investment programs are increased by 1% as a percentage of GDP. In that case, we will decrease the primary surplus or an increase in the primary deficit by 0.85%, 0.6%, and 0.73%, respectively.

According to this, it is evident that a rise in expenditures for wages and hiring is a significant percentage of 40%, absorbed from a rise in taxes. The transfer payment is allocated more inefficiently according to the effect on taxes. Our data verify the relationship of the GDP effect of deficit budgets (the principle of deficit budgets according to fiscal theory) that the country had over time and, hence, expenditures.

Wanting to calculate the optimal size of government, we consider the parabolic form of function—the Armey Curve. The optimal point of primary expenditure is approximately 30% of the GDP, as stated by Forte and Magazzino (2014). Altunc and Aydın (2013) find that Romania = 20.44%, Bulgaria = 22.45%, and Turkey = 25.21% with the ARDL cointegration method from 1995 to 2011 significantly lowering the optimal point for Greece. Asimakopoulos and Karavias (2016) and Rajput and Tariq (2019) find that optimal public spending is higher in developing countries than in developed ones. However, for their group of 129 countries, the optimal threshold level of government size is 18.04 percent of the GDP, according to Barrios et al. (2011). The countries are divided into four groups. The first group (consisting of Greece, Ireland, Portugal, and Italy) involves countries facing the most significant fiscal consolidation challenges. Italy and Greece, however, have more leeway than Ireland and Portugal.

We use the FMOLS method for calculating the optimal point of wages and the expenditures of public investment programs, similar to Kleynhans and Coetzee (2019), and find that South Africa = 18.5%, with the FMOLS method from 1992 to 2017. PPIP was calculated at 4.4% as a percentage of GDP, and the optimal point of expenditures of services and wages was calculated at approximately 8%.

In 2021, the percentage of expenditures of services and wages as a percentage of GDP was 8.3%, approximately the same as optimal. This reinforces the current national policy of one-on-one recruitment in the public sector by redistributing workers across agencies and hiring more workers in sectors in need while not replacing pension expenditures in others that can be replaced by technological development such as artificial intelligence. There needs to be a long-term policy specified in public projects and targeted interventions because the increase in the last few years has not come from spending on public projects but transfers.

Transfer payments do not follow parabolic forms compared to PS and PPIP. We find that a 1% rise in expenses of grants and income support (allowances) as to GDP had a rise of approximately 1.7% compared to real economic growth. In contrast, the 1% raise in expenses of contributions to social security funds has only a 0.83% increase. Increasing contributions and pension subsidies do not have a multiplier effect on the economy, whereas targeted subsidies and disincentives help the growth of economic activity and should, therefore, be strengthened.

Since the configuration of the ministries has changed many times during the 21 years under review, we have analysed expenditure based on the current structure and the assumptions mentioned above to make the results comparable and reliable. From the cluster analysis, ministries closely linked to the provision of public sector services have a common expenditure behaviour, while more managerial ministries also move similarily. Also, the two ministries related to public projects (MDI, MIT) have a common behaviour, while finally, the labour ministry moves in its own way. Combining the results of the cluster analysis with the above results of the general approach that must be followed for a more efficient role of the public sector, it is necessary to make targeted recruitments in the sector that is needed each time while keeping the total number constant, which leads to the need for a redistribution of public sector workers. In the same way, public projects should not only focus on infrastructure projects but should also be spread to new areas related to climate change and the agricultural sector.

5.2. Discussion

Our paper's contribution lies in verifying specific theories for the construction of the budget that are valid in Greece but also approximate estimates for its rational construction that contributes to an increase in GDP and the reduction in primary deficits. Firstly, reducing the deficit without reducing government spending will fail. According to this result, the reduction in the size of government is going in the right direction. Because taxes significantly impact the primary surplus, all governments resort to them to reduce the deficit either directly by raising tax rates or indirectly by increasing indirect tax revenues from increased consumption. Because the tax increase covers only 35% of an increase in expenditure, the government should differentiate its economic strategy and seek other revenue streams (other than taxes) to close the gap between receipts and spending, thus lowering the budget deficit. The optimal point of primary expenditure is approximately 30% of the GDP; specifically, in 2021, the percentage of expenditures of services and wages as a percentage of GDP was 8.3%, approximately the same as optimal. This reinforces the current national policy of one-on-one recruitment in the public sector by redistributing workers across agencies and hiring more workers in sectors in need while not replacing pension expenditures in others that can be replaced by technological development, such as artificial intelligence—the optimal point of expenditures.

Moreover, there needs to be a long-term policy specified in public projects and targeted interventions because the increase in the last few years has come from spending on public projects rather than transfers. It is also essential to continue targeted subsidies and disincentives to help the growth of economic activity and should, therefore, be strengthened. The cluster analysis shows that there needs to be a stable policy for each ministry according to its needs over time. Each government follows its policies by increasing or decreasing overall expenditure, which is necessary for change.

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References

Aljaloudi, Jameel J. A., and Taleb A. Warrad. 2020. Economic Growth and the Optimal Size of the Public sector in Jordan. *Financial Markets, Institutions and Risks* 4: 72–79. [CrossRef]

Altunc, O. Faruk, and Celil Aydın. 2013. The relationship between optimal size of government and Economic growth: Empirical evidence from Turkey, Romania and Bulgaria. *Procedia—Social and Behavioral Sciences* 92: 66–75. [CrossRef]

Ansari, Mohammed Ishaque, Daniel Vernon Gordon, and Christian Akuamoah. 1997. Keynes versus Wagner: Public expenditure and national income for three African countries. *Applied Economics* 29: 543–50. [CrossRef]

Armey, Dick. 1995. *The Freedom Revolution*. Washington, DC: Regnery. ISBN 978-0-89526-469-5. Available online: https://www.biblio.com/9780895264695 (accessed on 23 May 2023).

Asemota, Omorogbe Joseph, and Adejumo Oluwasegun Agbailu. 2017. Structural breaks and unit root in macroeconomic time series: Evidence from Nigeria. *Sri Lankan Journal of Applied Statistics* 18: 35–46. [CrossRef]

Asimakopoulos, Stylianos, and Yiannis Karavias. 2016. The impact of government size on economic growth: A threshold analysis. *Economics Letters* 139: 65–68. [CrossRef]

Baghestani, Hamid, and Robert McNown. 1994. Do revenues or expenditures respond to budgetary disequilibria? *Southern Economic Journal* 63: 311–22. [CrossRef]

Barrios, Salvador, Sven Langedijk, and Lucio R. Pench. 2011. *EU Fiscal Consolidation after the Financial Crisis: Lessons from Past Experiences*. European Economy Economic Papers, 418, July. Brussels: European Commission.

Begg, David, Stanley Fischer, and Rudiger Dornbusch. 2003. *Economics*. Cambridge: McGraw-Hill.

Brown, R. L., J. Durbin, and J. M. Evans. 1975. Techniques for testing the constancy of regression relationships over time. *Journal of the Royal Statistical Society Series B: Statistical Methodology* 37: 149–163. [CrossRef]

Chirwa, Themba G., and Nicholas M. Odhiambo. 2019. The nexus between key macroeconomic determinants and economic growth in Zambia: A dynamic multivariate Granger causality linkage. *Empirical Economics* 57: 301–27. [CrossRef]

Danladi, J. D., K. J. Akomolafe, Omolola S. Olarinde, and N. L. Anyadiegwu. 2015. Government Expenditure and Its Implication for Economic Growth: Evidence from Nigeria. *Journal of Economics and Sustainable Development* 6: 142–52.

Dickey, David A., and Wayne A. Fuller. 1979. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association* 74: 427–31.

Dritsaki, Chaido. 2018. Causality between spending and revenue in case of Greece through Toda and Yamamoto methodology. *Journal of Business and Economic Policy* 5: 9–21.

Dritsakis, Nikolaos, and Antonis Adamopoulos. 2004. A causal relationship between government spending; An empirical examination of the Greek economy. *Applied Economics* 36: 457–64. [CrossRef]

Engle, Robert F., and Clive W. J. Granger. 1987. Co-integration and error correction: Representation, estimation, and testing. *Econometrica* 55: 251–76. [CrossRef]

Fallahi, Firouz, and Jalal Montazeri Shoorkchali. 2012. Government Sixe and Economic Growth in Greece: A Smooth Transition Approach. Available online: https://mpra.ub.uni-muenchen.de/74078/ (accessed on 23 May 2023).

Forte, Francesco, and Cosimo Magazzino. 2014. Optimal size of governments and the optimal ratio between current and capital expenditure. In *A Handbook of Alternative Theories of Public Economics*. Edited by Forte Francesco, Navarra Pietro and Mudambi Ram. Cheltenham: Edward Elgar, pp. 342–67.

Friedman, Milton. 1972. *An Economist's Protest*. Glen Ridge, NJ: Thomas Horton and Company.

Granger, Clive W. J. 1969. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica* 37: 424–38.

Gujarati, Damodar N. 2004. *Basic Econometrics*. New York: Tata McGraw Hill.

Hossain, Mohammad I. 2013. Public Expenditure Effectiveness, Economic Growth, and Poverty in Bangladesh: An Assessment of the Impact of Government Spending and Intervention on Poor Citizens. Master's thesis. Available online: http://r-cube.ritsumei.ac.jp/bitstream/10367/5488/1/51211005.pdf (accessed on 23 May 2023).

Hubrich, Kirstin, Helmut Lütkepohl, and Pentti Saikkonen. 2001. A review of systems cointegration tests. *Econometric Reviews* 20: 247–318. [CrossRef]
Irandoust, Manuchehr. 2018. Government spending and revenues in Sweden 1722–2011: Evidence from hidden cointegration. *Empirica* 45: 543–57. [CrossRef]
Johansen, Soren, and Katarina Juselius. 1990. Maximum likelihood estimation and inference on cointegration—With applications to the demand for money. *Oxford Bulletin of Economics and statistics* 52: 169–210. [CrossRef]
Johansen, Søren. 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control* 12: 231–54. [CrossRef]
Karagianni, Stella, Maria Pempetzoglou, and Anastasios Saraidaris. 2012. Tax burden distribution and GDP growth: Nonlinear causality considerations in the USA. *International Review of Economics & Finance* 21: 186–94.
Karagianni, Stella, Maria Pempetzoglou, and Anastasios Saraidaris. 2019. Government expenditures and economic growth: A nonlinear causality investigation for the UK. *European Journal of Marketing and Economics* 2: 52–58. [CrossRef]
Kleynhans, Ewert P. J., and Clive Egbert Coetzee. 2019. Actual vs. optimal size of the public sector in South Africa. *Acta Universitatis Danubius* 11: 25–58.
Kusi, Newman Kwadwo. 1998. Tax reform and revenue productivity in Chana, Nairobi, Kenya: The African economic research consortium. *International Journal of Asian Social Science* 6: 604–13.
Laffer, Arthur B. 2004. *The Laffer Curve: Past, Present, and Future*. Washington, DC: The Heritage Foundation, No. 1765.
La Torre, Davide, and Simone Marsiglio. 2020. A note on optimal debt reduction policies. *Macroeconomic Dynamics* 24: 1850–60. [CrossRef]
MacKinnon, James G. 1996. Numerical distribution functions for unit root and cointegration tests. *Journal of Applied Econometrics* 11: 601–618. [CrossRef]
MacQueen, James. 1967. Some methods for classification and analysis of multivariate observations. In *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability*. Berkeley: University of California Press, vol. 1, pp. 281–97.
Mauro, Paolo, Rafael Romeu, Ariel Binder, and Asad Zaman. 2015. A modern history of fiscal prudence and profligacy. *Journal of Monetary Economics* 76: 55–70. [CrossRef]
Mendoza, Enrique G.-F. 1997. On the ineffectiveness of tax policy in altering long-run growth: Harberger's superneutrality conjecture. *Journal of Public Economics* 66: 99–126. [CrossRef]
Migkos, Stavros P., Damianos P. Sakas, Nikolaos T. Giannakopoulos, Georgios Konteos, and Anastasia Metsiou. 2022. Analyzing Greece 2010 Memorandum's Impact on Macroeconomic and Financial Figures through FCM. *Economies* 10: 178. [CrossRef]
Musgrave, Richard. 1966. Principles of budget determination. In *Public Finance: Selected Readings*. Edited by Helen Cameron and William Henderson. New York: Random House.
Nelson, Charles R., and Charles R. Plosser. 1982. Trends and random walks in macroeconomic time series. *Journal of Monetary Economics* 10: 139–62. [CrossRef]
Nielsen, Frank, and Frank Nielsen. 2016. Hierarchical clustering. In *Introduction to HPC with MPI for Data Science*. Cham: Springer, pp. 195–211.
Ofoegbu, Grace N., David O. Akwu, and O. Oliver. 2016. Empirical analysis of efect of tax revenue on economic development of Nigeria. *International Journal of Asian Social Science* 6: 604–13. [CrossRef]
Okere, P. A., L. N. Uzowuru, and J. C. Amako. 2019. Government expenditure and economic growth in Nigeria. *International Journal of Economics, Finance and Management* 4: 29–41.
Peacock, Alan T., and Jack Wiseman. 1961. *The Growth of Public Expenditure in the United Kingdom*. Princeton: Princeton University Press. Princeton: NBER.
Perron, Pierre. 1989. The great crash, the oil price shock, and the unit root hypothesis. *Econometrica* 57: 1361–401. [CrossRef]
Phillips, Peter C. B., and Bruce E. Hansen. 1990. Statistical Inference in Instrumental Variables Regression with I(1) Processes. *Review of Economics Studies* 57: 99–125. [CrossRef]
Phillips, Peter C. B., and Pierre Perron. 1988. Testing for a unit root in time series regression. *Biometrika* 75: 335–46. [CrossRef]
Rajput, Sheraz, and Aziz Tariq. 2019. Government size and economic growth: A panel data study comparing OECD and non-OECD countries. *Applied Economics Journal* 26: 22–37.
Rasaily, Anil, and Sandip Paudel. 2019. Impact of government expenditures on economic growth: Case of Nepal. *International European Extended Enablement in Science, Engineering & Management* 10: 167–74.
Richter, Christian, and Dimitrios Paparas. 2013. Tax and spend, spend and tax, fiscal synchronisation or institutional separation? Examining the case of Greece. *Romanian Journal of Fiscal Policy (RJFP)* 4: 1–17.
Saikkonen, Pentti. 1992. Estimation and Testing of Cointegrated Systems by an Autoregressive Approximation. *Econometric Theory* 8: 1–27. [CrossRef]
Sedrakyan, Gohar Samvel, and Laura Varela-Candamio. 2019. Wagner's law vs. Keynes' hypothesis in very diferent countries (Armenia and Spain). *Journal of Policy Modeling* 41: 747–62. [CrossRef]
Shrestha, Min B., and Guna R. Bhatta. 2018. Selecting appropriate methodological framework for time series data analysis. *The Journal of Finance and Data Science* 4: 71–89. [CrossRef]
Sinha, Dipendra. 1998. Government Expenditure and Economic Growth in Malaysia. *Journal of Economic Development* 23: 71–80.
Stock, James H., and Mark W. Watson. 1993. A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica: Journal of the Econometric Society* 61: 783–820. [CrossRef]

Wagner, Adolph. 1967. Three Extracts on Public Finance. In *R A Musgrave and A T Peacock Classics in the Theory of Public Finance*. New York: MacMillan, pp. 1–15.

Williams, O. D., and S. S. Abere. 2019. *Efect of Government Expenditure on Economic Growth in Nigeria*. Ijebu-Itele: Hallmark University, Ijebu-Itele, Ogun State Nigeria Copyright 2019.

Yinusa, Olumuyiwa Ganiyu, Olalekan Bashir Aworinde, and Isiaq Olasunkanmi Oseni. 2017. The revenue-expenditure nexus in Nigeria: Asymmetric cointegration approach. *South-Eastern Europe Journal of Economics* 15.