# Heterodox macroeconomic model for the Greek economy.

# HMM-GR

*Work package No.2*

***Database Development***

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Το έργο υλοποιείται στο πλαίσιο της Δράσης
**«Ενίσχυση Βασικής και Εφαρμοσμένης Έρευνας»**
του Ταμείου Ανάκαμψης και Ανθεκτικότητας

H.F.R.I.
Hellenic Foundation for Research & Innovation

ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ ΑΝΑΠΤΥΞΗΣ

Ελλάδα 2.0
ΕΘΝΙΚΟ ΣΧΕΔΙΟ ΑΝΑΚΑΜΨΗΣ ΚΑΙ ΑΝΘΕΚΤΙΚΟΤΗΤΑΣ

Με τη χρηματοδότηση της Ευρωπαϊκής Ένωσης
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**Abstract.** This paper develops a long-run macroeconomic database for constructing a heterodox macroeconomic model for the Greek economy. Firstly, data sources and major data series are identified. Secondly, the data are reconstructed to ensure accounting consistency. This involves ensuring compatibility of data retrieved from different databases and constructing a transactions flow matrix that guarantees every transaction has two counterparts. Subsequently, Bai-Perron multiple breakpoint and unit root tests are applied to all variables to investigate their stationarity and the presence of any structural breaks. In the presence of structural breaks, breakpoint unit root tests are applied.

# 1. Introduction

The construction of a growth model requires a dataset with a time span that allows for the robust estimation of long-term behavioral equations. A prerequisite for this is the development of long-term time series to ensure that estimations of behavioral patterns are not affected by short-term deviations from long-term trends that might occur over minor periods.[1] Nonetheless, retrieving long-term data is not an easy task, especially for economies like Greece, whose national statistics have been developed relatively recently compared to those of the US and the UK. The further back the databases delve, the less detailed the data become.

Additionally, constructing a growth model with a Marxian flavor presents further difficulties. Variables of main interest are not found in the available databases and must be estimated given the limited data availability. In this respect, there is a trade-off between the robustness of the estimations, ensured only by a dataset with a large time dimension, and the availability of essential variables for constructing the model. The choice of the time dimension must respect this trade-off.

In this context, the paper develops a database from 1960 to 2022[2]. This time span is adequate for robustly estimating long-term behavioral relationships and allows for the construction of key variables, in line with the aforementioned trade-off. Once the database is constructed, it is tested for stock-flow consistency (SFC). The latter term is mostly associated with theoretical or empirical models within the Post-Keynesian school of thought. However, this need not be the case, as the nature of the model is largely decided

[1] For instance, in the case of Greece, Papadmitiriou et al. (2013) and Pierros (2020) estimate the exact same private expenditure function but retrieve very different results. The former use data that commence from 1960, while the latter uses data from 1997. The shorter time dimension yields an unsustainable pattern of expenditure due to the accumulating debt that burst out in 2009. This is not the case, however, with the longer set of data.

[2] An additional sectoral database is described in the Appendix

by its closure.[3] In the present case, I use only the accounting structure of the SFC models to ensure that each transaction has two counterparts and that there are no black holes in the database (Godley 1996). As a final step, the paper provides a statistical analysis of all variables, including breakpoint and unit root tests.

The paper is structured as follows. Section 2 is dedicated to the collection of data from various databases and the construction of key variables. Section 3 examines the stock-flow consistency of the underlying transactions and amends the variables to ensure that every transaction is an inflow for one sector and an outflow for another. Section 4 examines the presence of any structural breaks, while Section 5 applies unit root tests to examine the stationarity of the variables. In the case of structural breaks, breakpoint unit root tests are then applied. Finally, Section 6 provides some concluding remarks.

## 2. Retrieving and Reconstructing the Data

As mentioned in the introduction, the purpose of this section is to identify, retrieve, and reconstruct data that cover the longest available period to build a growth model. Each class of growth models requires the input of key variables for its function. In this context, the development of this database is such that it potentially allows the construction of two different growth models. The first is a New-Keynesian (NK) type growth model that consists of two time dimensions. The first is the short-term dimension, where the properties of the model could be broadly termed as Keynesian, e.g., the economy operates below full capacity utilization levels and is thus demand-driven. The second is the long-term dimension, which is Neoclassical, e.g., potential output is determined by a Cobb-Douglas production function. The exact behavioral patterns to be estimated are not known beforehand. However, for constructing

[3] See Caverzasi and Godin (2015) for a very brief discussion of SFC models that do not belong in the Post-Keynesian domain.

an appropriate database, I use as a benchmark the adaptation of the ECB's Area Wide Model on Greece (Sideris and Zonzilos 2005).

The second class of growth model that this database aims to accommodate belongs to the Classical Political Economy tradition (MRX). For this purpose, the database must provide appropriate data to construct key Marxian variables such as the Marxian profit rate, and the technical and organic composition of capital. This section is dedicated to extracting and reconstructing data to provide the appropriate variables for both classes of growth models.

To ensure data consistency, the main economic variables, such as GDP and its demand and income components, should be retrieved from the same database. The Ameco database provides such data, in both nominal and real terms. Ameco's available data cover the period between 1960 and 2022.[4] Simply put, both the availability of macroeconomic variables and their time span are suitable for my purpose. Table 1 provides a list of all the variables retrieved from Ameco. Specifically, it includes GDP and all its demand components. Additionally, it includes the net capital stock of the total economy, labor market statistics such as the number of total employed persons, wage earners, and the unemployed, as well as components of the current account. Finally, I have included data on the compensation of employees, indirect taxes and subsidies, the consumer price index, and the adjusted labor share, which is the wage share excluding the income of the self-employed.

Some remarks are in order. GDP from the income side lacks the gross operating surplus and mixed income, though this can be easily deduced from national account identities. According to equation (1), the gross operating surplus and mixed income (GOS) at time t can be found by deducting the compensation of employees (WIN) and indirect taxes (TAX), and adding subsidies (SUB) to GDP (YEN).[5]

[4] At the time of the writing, data for 2023 reflected estimates of the European Commission, rather than actual data.

[5] The full list of all estimated variables is provided in Table 4 below.

$$GOS_t = YEN_t - WIN_t - TAX_t + SUB_t \quad (1)$$

Secondly, the compensation of employees might include a portion of the mixed income received by the self-employed. While a precise distinction may not be of great importance for the NK model, it could prove crucial for the MRX model. To achieve a more consistent measure of wages paid in each period, the GDP could be multiplied by the adjusted labor share.

*Table 1. Variables Retrieved from Ameco Database*

| Name | Unit | Description | Name | Unit | Description |
|---|---|---|---|---|---|
| PCR | Bn. Euro | Private consumption, constant prices | YEDEF | Index | Gross domestic product, deflator |
| PCN | Bn. Euro | Private consumption, current prices | KSR | Bn. Euro | Net capital stock, constant prices |
| ITR | Bn. Euro | Gross fixed capital formation, constant prices | LNN | Thousand persons | Civilian employment |
| ITN | Bn. Euro | Gross fixed capital formation, current prices | UN | Thousand persons | Unemployment, total |
| GCR | Bn. Euro | Public consumption, constant prices | EMPE | Thousand persons | Wage and salary earners |
| GCN | Bn. Euro | Public consumption, current prices | WIN | Bn. Euro | Compensation of employees, current prices |
| XTR | Bn. Euro | Exports of goods and services, constant prices | TAX | Bn. Euro | Taxes linked to imports and productions, current prices |
| XTN | Bn. Euro | Exports of goods and services, current prices | SUB | Bn. Euro | Subsidies, current prices |
| CXD | Index | Exports of goods and services, deflator | NFN | Bn. Euro | Net primary income from abroad, current prices |
| MTR | Bn. Euro | Imports of goods and services, constant prices | TWN | Bn. Euro | Net current transfers from the rest of the world, current prices |
| MTN | Bn. Euro | Imports of goods and services, current prices | CPI | Index | Consumer price index |

| | | | | | |
|---|---|---|---|---|---|
| CMD | Index | Imports of goods and services, deflator | LABSH | Ratio | Adjusted wage share %GDP |
| YER | Bn. Euro | Gross domestic product, constant prices | YEN | Bn. Euro | Gross domestic product, current prices |

*Note: Reference year for constant prices 2015*

Thirdly, when considering the GDP identity from the demand side, each component is usually deflated according to its own deflator. However, using different deflators generates inconsistencies between the sum of the components and the aggregate variable, which is the real GDP. In fact, this discrepancy somewhat corresponds to the change in inventories in nominal terms, reflecting discrepancies between the GDP from the demand side and the GDP from the income side. To correct this inconsistency, I generated an additional variable, which is essentially the GDP residual in real terms (YERES). Equation (2) presents the estimation of this residual. Note that all variables are expressed in 2015 constant prices.

$$YERES_t = YER_t - PCR_t - ITR_t - GCR_t - XTR_t + MTR_t \quad (2)$$

Another issue to address is the size of self-employment, which can be easily calculated by deducting the number of wage earners from total employment. Finally, it is crucial to ensure the stock-flow consistency of the net capital stock.[6] The data provided by Ameco include real and nominal gross fixed capital formation, changes in inventories, the investment deflator, and the real net capital stock. Depreciation of the capital stock is omitted from the database and thus must be constructed. According to equation (3), the depreciation of real capital stock (DEP) is given by the difference between the change in real net capital stock on one hand and the real investment and the change in real

[6] For a detailed exposition of the stock-flow consistent principles see next section.

inventories, on the other. The latter term is deflated by the gross fixed capital formation deflator. It is worth noting that for estimating nominal depreciation of capital stock, one must include the change in the price of capital.

$$DEP_t = \Delta(KSR)_t - ITR_t - INVR_t \quad (3)$$

Table 2 presents fiscal variables retrieved from the Hellenic Ministry of Economics and Finance - MinFin (1991). These variables correspond to all the main functions of the general government in terms of flows and cover the 1960-1999 period. However, the data are not consistent with the respective data from Ameco. In particular, fiscal variables from the latter database commence from 1995. Between 1995 and 1999 there are large discrepancies between the two datasets. To amend this inconsistency, the inverse growth rates of the variables included in the MinFin database are used to extrapolate the fiscal variables provided by Ameco backwards. According to equation (4), the previous period value of each variable Y depends on the nominal value at time t, as reported by Ameco, divided by the previous period's growth rate g, as reported by the MinFin. Note that this is an approximation of actual values, but not their precise estimation.

$$Y_{t-1} = \frac{Y_t}{(1+g_{Y,t-1})} \quad (4)$$

*Table 2. Variables Retrieved from MinFin*

| Name | Unit | Description | Name | Unit | Description |
|---|---|---|---|---|---|
| TXI | Bn. Euro | Taxes linked to imports and production, current prices | TRN | Bn. Euro | Social benefits other than social transfers in kind, current prices |
| PDN | Bn. Euro | Current taxes on income and wealth, current prices | INN | Bn. Euro | Interest, current prices |
| EC | Bn. Euro | Net social contributions received, current prices | SUBN | Bn. Euro | Subsidies, current prices |

| | | | | | |
|---|---|---|---|---|---|
| RCO | Bn. Euro | Other current revenue including sales, current prices | OCN | Bn. Euro | Other current expenditure, current prices |
| CATR | Bn. Euro | Capital transfers received, current prices | GCFP | Bn. Euro | Gross fixed capital formation, current prices |
| GCN | Bn. Euro | Final consumption expenditure, current prices | OCE | Bn. Euro | Other capital expenditure, including capital transfers, current prices |

The above data include all the main variables for the construction of both classes of models, in both macroeconomic and fiscal terms. However, they still lack a set of crucial variables for the determination of demand components. These are presented in Table 3. I have retrieved the gross public debt as a percentage of GDP from the IMF database to calculate the evolution of public debt in terms of stocks. This could prove important for any out-of-sample projections regarding the interest payments of the public sector. Neither of the two types of models is dedicated to the examination of the stocks of other financial assets, thus the stock of public debt suffices for my purposes.

*Table 3. Variables Retrieved from Other Databases*

| Database | Name | Unit | Description |
|---|---|---|---|
| IMF | Public debt | Ratio | Gross public debt, %GDP |
| FRED St Louis | EXR | Rate | Exchange rate of national currency to dollar |
| FRED St Louis | STIN | Rate | Interest rate, interbank lending rate |
| FRED St Louis | POILU | Index | Spot crude oil price |
| AIAS-OECD | COLLBARG | Ratio | Adjusted coverage ratio of collective agreements |
| AIAS-OECD | TUD | Ratio | Trade union density |
| PENN World | IRR | Ratio | Internal rate of return |
| World Bank | YWR | Mrd US dollars | Real World GDP (const. 2015) |
| World Bank | YW | Mrd US dollars | World GDP |

The inclusion of the central bank policy rate is proposed as a candidate instrument for the implementation of policy scenarios. World GDP, the exchange rate, and the price of oil are essential for estimating the export and import functions. Trade union density and the collective bargaining coverage rate are included in the dataset as determinants of wage formation. For instance, they could function as proxies for shifting regimes in the wage negotiation process. Finally, the internal rate of return could prove useful in the MRX model for determining unequal exchange between Greece and its trading partners.[7]

A set of variables are not available in databases but need to be estimated. These are presented in Table 4. Some of them have already been discussed above. An additional variable essential for determining the consumption function, at least in the NK model, is the net wealth of households. Sideris and Zonzilos (2005) use the net capital stock as a proxy for households' net wealth, though the underlying assumptions in their consumption function are strong. In the formal version of the model (Fagan et al. 2005), the underlying assumption in the consumption function is that households own all net capital stock, thus their net wealth consists of the economy's capital stock and their accumulated savings. Again, this assumption is too strong, as it implicitly assumes that households pierce the corporate veil and can use the capital stock as leverage to increase their consumer lending. The foundations of these assumptions are weak, both theoretically and empirically. Access to capital is far from equal across households; they can only use equities as leverage to increase their lending, the price of which clearly deviates from the replacement cost of capital. Their holdings are not symmetrical, and consumer loans in Greece have not been significant over time.

To retrieve a more consistent value of households' financial wealth, I make use of Eurostat's financial accounts data and Godley's sectoral balance identity (Godley 1999). The latter is provided in equation (5), in which the financial

[7] For instance, see Carchedi and Roberts (2021).

wealth of the private sector (NLB) is given by the difference between the current account (CA) and the fiscal budget (FB).[8]

$$NLB_t = CA_t - FB_t \quad (5)$$

*Table 4. Estimated Variables*

| Name | Unit | Description | Name | Unit | Description |
|---|---|---|---|---|---|
| PCDEF | Index | Private consumtpion, deflator | SELF | Thousand persons | Self-employed persons |
| ITDEF | Index | Gross fixed capital formation, deflator | GOS | Bn. Euro | Gross operating surplus and mixed income, current prices |
| GCDEF | Index | Public consumption, deflator | CAB | Bn. Euro | Current account balance, current prices |
| INV | Bn. Euro | Inventories, current prices | FB | Bn. Euro | Fiscal budget, current prices |
| YERES | Bn. Euro | Gross domestic product residual, constant prices | NFW | Bn. Euro | Net financial wealth of the private sector, current prices |
| DEP | Bn. Euro | Depreciation of capital stock and other changes, constant prices | GVAPRR | Ratio | Share of productive activities in aggregate GVA, constant prices |
| GVAPR | Ratio | Share of productive activities in aggregate GVA, current prices | QPRR | Ratio | Share of productive activities in aggregate Output, constant prices |
| QPR | Ratio | Share of productive activities in aggregate Output, current prices | INTCPRR | Ratio | Share of productive activities in aggregate Intermediate consumption, constant prices |
| INTCPR | Ratio | Share of productive activities in aggregate Intermediate consumption, current prices | CONFKPRR | Ratio | Share of productive activities in aggregate consumption of fixed capital, constant prices |
| WINPR | Ratio | Share of productive activities in aggregate compensation of employees, current prices | INVPR | Ratio | Share of productive activities in aggregate Gross fixed capital formation, current prices |
| CONFKPR | Ratio | Share of productive activities in aggregate consumption of fixed capital, current prices | INVPRR | Ratio | Share of productive activities in aggregate Gross fixed capital formation, constant prices |

[8] This equation is the formal form of the standard national accounts identity (S-I) + (T-G) + (M-X) = 0, with the first parenthesis denoting the private sector's financial balance (net lending/borrowing position), the second is the fiscal budget, while the third is a simplified form of the inverse current account. For a detailed exposition of sector financial balances and their estimation see Zezza (2013).

| | | | | | |
|---|---|---|---|---|---|
| NOSPR | Ratio | Share of productive activities in aggregate net operating surplus, current prices | EMPEPR | Ratio | Share of productive activities in total employees |
| SELFPR | Ratio | Share of productive activities in total self-employment | HWSELFPR | Ratio | Share of productive activities in hours worked, self-employment |
| HWLABPR | Ratio | Share of productive activities in hours worked, employees | | | |

*Note: Shares of productive activities span from 1995 to 2022.*

In turn, the financial balance of the private sector is used to extrapolate backwards the net financial wealth, which is the difference between the stock of financial assets held by the private sector and the financial liabilities of the private sector towards the other two sectors of the economy. The net financial wealth of the private sector includes debt from households and firms to the banking sector. Through this estimation technique, the debt cancels out. Nonetheless, the actual value of the private sector's financial wealth differs significantly from that of households. Still, this approach constitutes a more consistent estimate of households' financial wealth compared to the aforementioned approaches.

A final important issue that needs to be addressed in this paper concerns the distinction between productive and unproductive activities, which are essential for constructing the MRX model.[9] Unfortunately, none of the publicly available databases include information on sectoral data from the 1960. This is a significant drawback for estimating key Marxian variables. To address this, some assumptions are made. I use sectoral data provided by Eurostat, which commence from 1995, to calculate the shares of productive activities in total gross value added, output, intermediate consumption, compensation of employees, net operating surplus, and consumption of fixed capital, both in real and nominal terms.[10] Furthermore, the shares are estimated for gross fixed capital formation and the number of employees and self-employed. Productive

[9] See Maniatis and Passas (2013) and Paitaridis (2018)

[10] The difference between net operating surplus and profits is the inclusion of the rest indirect taxes and subsidies on production and imports in the former variable.

activities consist of the primary and secondary sectors and some sub-sectors of services. The latter include the Information and Communication Technologies sector, Technical, Scientific and Professional Service Activities (excluding administrative and supporting activities), and the Health and Education sectors. In Greece, the latter two sectors have traditionally been public, though recent decades have seen waves of privatization, gradually increasing private sector involvement. Regarding the use of this data, they could prove significant for out-of-sample projections, though their backward extrapolation is infeasible for covering the pre-1995 period.[11] Due to their limited time dimension, I abstract from any further discussion on these shares for the remainder of this paper.

## 3. Stock-flow Consistency

The term stock-flow consistency is usually associated with Post-Keynesian models. However, as noted in the introduction, the term is not necessarily constrained to this specific school of thought. It is true that in the vast majority of SFC models, the behavioural framework is rooted in Post-Keynesian principles. Nevertheless, the term SFC broadly refers to a model built upon a set of accounting structures that reduce the degrees of freedom of the behavioural set of equations (Dos Santos 2006, Ehnts 2019). In this respect, an SFC model could fall under different domains as long as it maintains specific stock-flow consistent principles.

Nikiforos and Zezza (2017) and Zezza and Zezza (2019) outline a set of five principles that ensure stock-flow consistency. These include: a) horizontal consistency, e.g., a transaction is an inflow for one sector/agent and an outflow for another; b) vertical consistency, e.g., all non-financial transactions of a sector/agent have a financial counterpart; c) stock-to-stock consistency, e.g., a financial stock is an asset for one sector/agent and a liability for another; d)

[11] For the sake of completeness, one could assume constant shares for the 1960-1994 period, which are equal to the average of the 1995-1999 period, though acknowledging that this assumption is too strong.

flow-to-stock consistency, e.g., each flow variable accumulates into its corresponding stock variable; and e) stock-to-flow feedbacks, e.g., stocks dictate future payments from one sector/agent to another, thus generating path dependency.

*Table 5. Transactions Flow Matrix*

| | | Production | Private Sector | Government | Rest of the World | Sum |
|---|---|---|---|---|---|---|
| GDP (demand side) | Consumption | +PCN | -PCN | | | 0 |
| | Investment | +ITN | -ITN | | | 0 |
| | Inventories | +INV | -INV | | | 0 |
| | Public investment | +GCFP | | -GCFP | | 0 |
| | Public consumption | +GCN | | -GCN | | 0 |
| | Exports | +XTN | | | -XTN | 0 |
| | Imports | -MTN | | | +MTN | 0 |
| Memo | [National income] | [YEN] | | | | |
| GDP (income side) | Compensation | -WIN | +WIN | | | 0 |
| | Taxes on production | -TAX | | +TAX | | 0 |
| | Subsidies | +SUBS | | -SUBS | | 0 |
| | Profits and mixed Y | -GOS | +GOS | | | 0 |
| Current Account | NetY from abroad | | +NFN | | -NFN | 0 |
| | Secondary Y from row | | | +TWN | -TWN | 0 |
| Redistribution of Income | Social contributions | | -EC | +EC | | 0 |
| | Direct taxes | | -PDN | +PDN | | 0 |
| | Social benefits | | +TRN | -TRN | | 0 |
| | Current trans. to GG | | | +RCO | -RCO | 0 |
| | Current trans. to PS | | +OCN | -OCN | | 0 |

| | | | | |
|---|---|---|---|---|
| Interest payments | +INN | -INN | | 0 |
| Capital trans. to PS | +OCE | -OCE | | 0 |
| Capital trans. To GG | | +CATR | -CATR | 0 |
| Sectoral balance | +NLB | +FB | -CA | 0 |

*Source: Own elaboration*

Regarding the purpose of the two types of growth models, the financial counterpart of the economy is of less importance. Therefore, not all SFC principles are crucial for the task at hand. The most important among them are horizontal and vertical consistency, which ensure that each transaction has two counterparts and allow for proper accounting regarding the transactions of each sector.

Table 5 presents a transaction flow matrix (TFM), which shows all the transactions that take place between sectors in one period. The plus sign indicates that the transaction is an inflow of funds for the sector at hand, and the minus sign indicates an outflow. The TFM is expressed in nominal terms, as it follows from the construction of national accounting. There are four sectors in the TFM: the production sector, the private sector (PS), the general government (GG), and the rest of the world (RoW).

The upper part of the TFM presents the flows corresponding to the components of GDP from the demand side. For instance, in the first row, private consumption is an outflow for the private sector and an inflow for production. This setup ensures the horizontal consistency of the model. Adding all elements of the first column yields the GDP in nominal terms. The second part of the TFM indicates how national income is distributed between wages, profits, and net indirect taxes. There is an important drawback with the current availability of data, as a part of the gross value added is produced by the public sector. A simplifying assumption is required, as the relevant data before 1995 are unavailable.

The third part includes the net primary and secondary income that are part of the current account. Due to the lack of more detailed data, I make the plausible assumption that the net primary income is paid from the external to the private sector, and the net secondary income from the RoW to the general government. The next part of the TFM is dedicated to the redistribution of income, where fiscal variables are of major importance. The TFM makes some simplifying assumptions regarding the direction of other current and capital transfers between sectors. Despite the plausibility of these assumptions, there is a risk of double accounting some transactions in the current format. For instance, interest payments are paid to both the private and the external sector and are included in the net secondary income. Similarly, a part of the current transactions poses a similar risk.

To deal with this issue, I make use of equation (5), which allows an unbiased estimation of the private sector's financial balance. This, in turn, enables obtaining a single variable that incorporates the current and capital transactions received by the private sector through simple accounting. Adding all sources of income and benefits and then deducting all expenditures yields a proxy of private sector savings. The difference between these estimated savings and the financial balance of the private sector corresponds to the current and capital transfers. In this respect, the vertical consistency allows the avoidance of double accounting of transactions and the prevention of black holes in the system.

## 4. Breakpoint Test

In long-time series, such as those included in this dataset, it is common for them to include breakpoints. These structural breaks can result from conditions that lie outside the internal function of the model. For instance, they could reflect changes in the international environment or be attributed to changes in political, institutional, or other economic and non-economic factors. Identifying these breakpoints is crucial for the robustness of the behavioral estimations. The Bai-Perron multiple breakpoint test (Bai Perron 1998) provides the

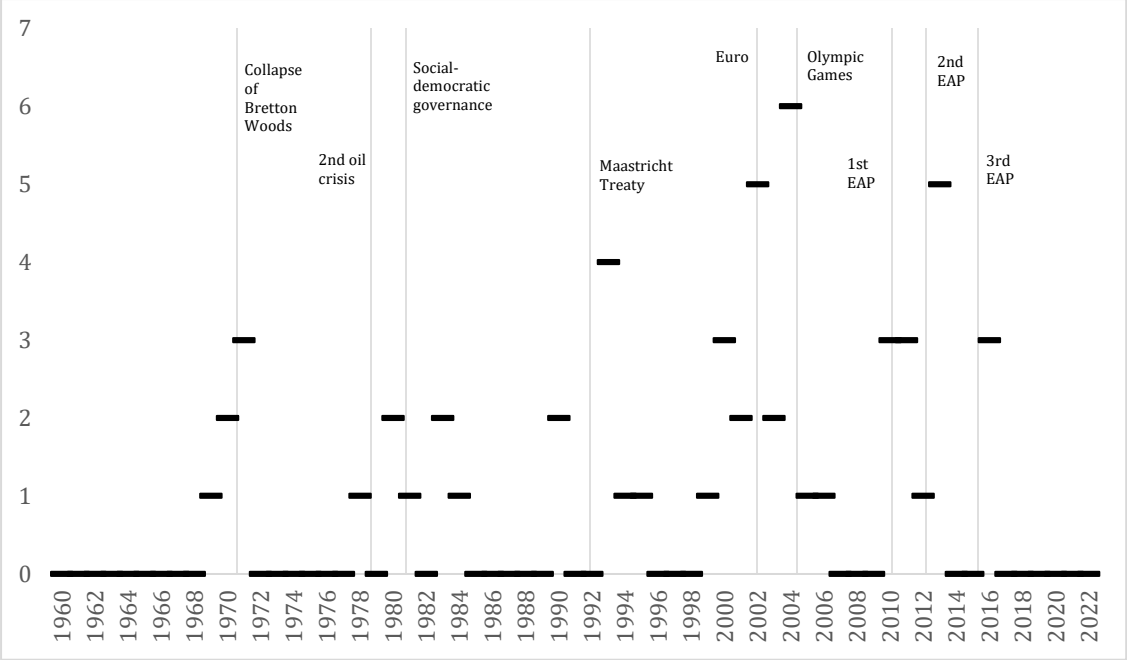
theoretical and computational framework for carrying out this task. Emphasis is laid on changes in the constant factor since structural breaks in trends could be estimated internally. A simplified form of the Bai-Perron test is presented in equation (6), in which Y is the variable under consideration, c is the constant term, and u is the error term. Note that each variable might present more than one breakpoint.

$$Y_t = c_t + u_t \quad (6)$$

Figure 1 presents the results of the breakpoint test for all variables. Specifically, it shows how many breakpoints occur in each year.[12] Additionally, the figure highlights specific events that took place in the years when most structural breaks occurred. The high international inflation rates and the associated collapse of Bretton Woods affected the Greek economy, with six breakpoints occurring between 1969 and 1971. The victory of PASOK in the 1981 elections brought about a change in the structure of the economy, as it marked the first implementation of social-democratic policies in Greece.[13] Even more breaks occur after the signing of the Maastricht Treaty and the subsequent institutional changes.

*Figure 1. Frequency of Breakpoints (1960-2022)*

[12] The full list of all breakpoint tests for all variables is included in the excel file that contains all data, which accompanies this paper.
[13] See Maniatis (2013) on how the net social wage shifted regime during this period.




*Source: Own estimations*

However, most structural breaks are present during the adoption of the euro currency in 2002 and the Olympic Games held in Athens two years later. Finally, as rather expected, multiple breakpoints occurred during the implementation of the three Economic Adjustment Programs (EAP). Figure 1 practically connects the presence of structural breaks with historic events. Nevertheless, these breakpoints refer to all the variables under consideration, with some being of less importance, at least in terms of breakpoints. Table 6 presents the breakpoints for the main macroeconomic variables, which are more crucial in the formation of the behavioral equations.

Real private consumption presents two breakpoints related to the adoption of the euro currency, which augmented the consumption opportunities of Greek households, and the deepening of the Greek debt crisis in 2011. Real investment presents three structural breaks. The second and third breaks are similar to those of consumption. Note that investments are more responsive to changes in the economic, political, or other environments, causing the breaks to appear one year earlier than those of consumption. 1969 is also a breakpoint for investment, possibly reflecting worsening conditions leading up to the Bretton Woods collapse.

Real exports and imports have almost the same breakpoints. The first is connected to the adoption of the euro currency, for apparent reasons, and the second occurs after the implementation of the third EAP and the imposition of capital controls in 2015. Note that exports present another breakpoint at the outbreak of the second oil crisis. The breakpoints of real GDP are practically a combination of all the breakpoints mentioned above, except those in 2015 and 2016. Finally, the gross operating surplus and mixed income present a breakpoint in 2003, a year before the Olympic Games and a year after the introduction of the euro currency. Additionally, they present another breakpoint, along with unemployment, after the signing of the Maastricht Treaty.

*Table 6. Breakpoints of Key Economic Variables*

| Name | No. of Breaks | Year | Coeff. |
|---|---|---|---|
| PCR | 2 | 2002 | 147.52*** |
| | | 2011 | 126.21*** |
| ITR | 3 | 1969 | 30.82*** |
| | | 2000 | 50.44*** |
| | | 2010 | 29.72** |
| XTR | 3 | 1979 | 17.27** |
| | | 1999 | 45.99*** |
| | | 2015 | 66.26*** |
| MTR | 2 | 1999 | 59.49*** |
| | | 2016 | 75.25*** |
| YER | 4 | 1969 | 101.25*** |
| | | 1978 | 135.52*** |
| | | 2002 | 221.99*** |

| | | | |
|---|---|---|---|
| | | 2011 | 182.76*** |
| UN | 1 | 1993 | 474.87*** |
| GOS | 2 | 1994 | 72.83** |
| | | 2003 | 117.13*** |

*Source: Own estimations. Note: t-stat's are reported in cells. *, **, *** correspond to 1%, 5% and 10% of statistical significance, HAC Newey West s.e., Global Information Criteria (LWZ criterion at 5% significance level).*

Overall, the dataset is characterized by a large set of structural breaks, the vast majority of which are connected to some historic event. Emphasizing the most important macroeconomic variables, it is suggested that the econometric specifications in the estimation of the behavioral equations should take into account a set of dummy variables. At minimum, these dummies should proxy the signing of the Maastricht Treaty in 1992, the adoption of the euro currency in 2002, and the outbreak of the Greek debt crisis in 2010.

## 5. Unit Root Tests

Having defined the breakpoints for all the variables, a final step includes examining whether the variables are stationary or include unit roots. To do this, I implement the standard version of the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests for the variables with no breaks and the Breakpoint Augmented Dickey-Fuller (BADF) test for the variables with a structural break. For variables with multiple breakpoints, the breakpoint in the BADF test is chosen according to the break year that has the minimum SIC.

*Table 7. Augmented Dickey Fuller and Phillips Perron Unit Root Tests*

| | COLLBARG | INV | NLB | PCDEF | PDN | SUBN | WIN |
|---|---|---|---|---|---|---|---|
| | | | Augmented Dickey Fuller | | | | |
| Level | 0.89 | -6.41*** | -2.89* | -0.28 | -0.59 | -0.72 | -0.57 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1st Diff. | -4.38*** | | | -2.57** | -5.97*** | 5.16 | -2.56 |
| Unit roots | I(1) | I(0) | I(0) | I(1) | I(1) | I(2) | I(2) |
| | | | Phillips Perron | | | | |
| Level | 0.45 | -5.39*** | -3.04** | 0.21 | 0.37 | -1.19 | -0.05 |
| 1st Diff. | -4.38*** | | | -2.46 | -5.96*** | -5.65*** | -2.69* |
| Unit roots | I(1) | I(0) | I(0) | I(2) | I(1) | I(1) | I(1) |

*Source: Own estimations. Note: t-stat's are reported in cells. *, **, *** correspond to 1%, 5% and 10% of statistical significance.*

Table 7 shows the unit root tests for the variables without breakpoints. Note that the ADF test is sensitive to the presence of autocorrelation in the residuals and thus is less efficient than the PP test. Inventories and the financial balance of the private sector are stationary series, while all the rest have one unit root. The private consumption deflator very likely contains two unit roots.

*Table 8. Breakpoint Augmented Dickey Fuller Test*

| | **CAB** | **CATR** | **CMD** | **CPI** | **CXD** | **DEP** | **EC** | **EMPE** | **EXR** | **FB** | **GCDEF** | **GCFP** | **GCN** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level | -4.22*** | -3.02 | -2.47 | -2.29 | -2.55 | -3.3 | -2.66 | -1.45 | -2.74 | -2.93 | -2.95 | -3.02 | -2.84 |
| 1st Diff. | | -10.58*** | -7.25*** | -3.79 | -6.64*** | -12.13*** | -5.2*** | -8.38*** | -6.53*** | -11.04*** | -5.31*** | -8.72*** | -5.27*** |
| URoot | I(0) | I(1) | I(1) | I(2) | I(1) | I(1) | I(1) | I(1) | I(1) | I(1) | I(1) | I(1) | I(1) |
| | **GCN01** | **GCR** | **GOS** | **INN** | **IRR** | **ITDEF** | **ITN** | **ITR** | **KSR** | **LABSH** | **LNN** | **MTN** | **MTR** |
| Level | -2.82 | -3.03 | -2.45 | -3.41 | -5.12*** | -2.7 | -3.21 | -3.34 | -5.97*** | -4,99*** | -3,21 | -6,29*** | -1,68 |
| 1st Diff. | -5.22*** | -6.39*** | -4.93** | -6.74*** | | -4.57** | -5.87*** | -7.17*** | -4,7** | | -6,98*** | | -4,87** |
| URoot | I(1) | I(1) | I(1) | I(1) | I(0) | I(1) | I(1) | I(1) | I(1) | I(0) | I(1) | I(0) | I(1) |
| | **NFN** | **NW** | **OCE** | **OCN** | **PCN** | **PCR** | **POILU** | **PUBD** | **RCO** | **SELF** | **STIN** | **SUB** | **TAX** |
| Level | -6,17*** | -3,19 | -6,63*** | -2,77 | -5,73*** | -2,43 | -3,57 | -1,94 | -3,97 | -6,83*** | -4,61** | -0,91 | -4,91*** |
| 1st Diff. | | -4,87** | | -7,78*** | | -4,69** | -8,67*** | -9,84*** | -10,79*** | | | -18,64*** | |
| URoot | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | I(1) | I(1) | I(1) | I(0) | I(0) | I(1) | I(0) |
| | **TRN** | **TWN** | **TXI** | **UN** | **XTN** | **XTR** | **YEDEF** | **YEN** | **YER** | **YERES** | **YW** | **YWR** | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level | -2,42 | -2,85 | -4,85** | -4,75** | 0,3 | -1,33 | -2,47 | -2,23 | -2,35 | -3,87 | -0,67 | 1,25 |
| 1st Diff. | -5,07*** | -11,56*** | | | -14,5*** | -11,82*** | -2,95 | -4,79** | -5,55*** | -9,05*** | -7,94*** | -7,37*** |
| URoot | I(1) | I(1) | I(0) | I(0) | I(1) | I(1) | I(2) | I(1) | I(1) | I(1) | I(1) | I(1) |

*Source: Own estimations. Note: t-stat's are reported in cells. *, **, *** correspond to 1%, 5% and 10% of statistical significance. Breakpoints follow from Table 7 above. In the case of multiple breakpoints, the selection is made according to the break with the lower SIC.*

Table 8 presents the BADF results. The most important macroeconomic variables in real terms have one unit root, while a few variables, including the number of unemployed persons, are stationary. Even fewer variables, such as the consumer price index, have two unit roots. Given these findings, the econometric specification of most behavioral equations should examine the presence of cointegration between the variables under consideration. In cases involving variables of varying stationarity, the AutoRegressive Distributed Lag (ARDL) econometric method is more appropriate.

## 6. Concluding Remarks

This paper has developed a comprehensive long-run macroeconomic database for constructing macroeconomic growth models of the Greek economy. By identifying and reconstructing data from various sources to ensure accounting consistency, the challenges of data availability and compatibility have been addressed. The dataset spans from 1960 to 2022, offering a robust foundation for estimating long-term behavioural relationships. Additionally, the stock-flow consistency of the data is ensured, following principles commonly associated with Post-Keynesian models but applicable to broader modelling frameworks.

The analysis identified significant structural breaks in the data, linked to historical events such as the adoption of the euro, the Greek debt crisis, and major policy shifts. These breakpoints are crucial for understanding the underlying dynamics of the Greek economy and must be considered in the econometric modelling process. The presence of these breaks suggests that

dummy variables should be incorporated into the behavioural equations to account for these structural changes, thereby improving the robustness of the model estimations.

Finally, the unit root tests indicate varying levels of stationarity among the variables, with most key macroeconomic variables exhibiting one unit root. This necessitates the examination of cointegration relationships when specifying econometric models. For variables with different stationarity levels, the AutoRegressive Distributed Lag (ARDL) method proves to be more suitable. This methodological approach allows for a more nuanced understanding of the long-term and short-term interactions within the Greek economy, enhancing the potential accuracy and relevance of the constructed macroeconomic models.

## 7. Appendix: The sectoral database

In addition to the main macroeconomic database, that we have constructed using data from AMECO and from the Ministry of Finance and spans the years between 1960 and 2022, we also construct a secondary database using data from EUKLEMS. This database has the novelty of splicing together data from the EUKLEMS 2011 release and from the EUKLEMS 2023 release, thus covering the period between 1970 and 2021. It includes data by economic sector on the compensation of employees, total and wage employment (both in number of persons and in hours worked), gross output, intermediate inputs and value added (in current prices, constant prices and the derived deflator series). Sectoral disaggregation is at the first digit, using NACE 2 (ISIC 4) sectoral classification. In addition, manufacturing is also disaggregated to the second digit of industrial classification.

The database is constructed using the method of retropolation, i.e. by using the growth rates of the older EUKLEMS 2011 series to the levels of the new EUKLEMS 2023 series. The cut off period being 1995. Deflators are spliced together after rebasing the newer series to 1995. The main issue that had to be resolved in order to perform the merging of the two database was to map the economic sectors of the EUKLEMS 2011 series, that used the older NACE 1 (ISIC 3) sectoral classification, to the economic sectors of the EUKLEMS 2023 series, that uses the newer NACE 2 (ISIC 4) sectoral classification. Given that both original datasets allow for at least second digit data this operation was fairly straight forward. For the mapping of ISIC 3 to ISIC 4, that is a many to one operation, we used the process as described in the EUKLEMS 2012 release.

The dataset compiled in the manner just described can be used to estimated ratios of variables relative to totals. Those ratios can then be used in combination with the dataset described in the main body of this work package and thus obtain a consistent sectoral dimension.

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