Fiscal sustainability, monetary policy and economic growth in the Euro Area: In search of the ultimate causal path

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Abstract

To assess the ultimate causal flow between monetary policy indicators, fiscal sustainability and economic growth has been deeply studied in the literature. However, this issue is still open to discussion due to mixed results and caveats/limitations of existing studies. Importantly, previous analyses mostly focus on bivariate/trivariate systems, missing a relevant piece of economic drivers. We analyze jointly these interdependencies by applying multivariate Granger Causality and determining an ultimate "causality path" excluding redundant relationships. Thus, we combine recent developments introduced to estimate the Granger causality procedure based on Meta-analysis in heterogeneous mixed panels and graphical models searching iteratively for the existing dependencies between a multivariate set of information. Our results provide novel empirical evidence suggesting that monetary policy variables play a leading role in the resulting complex economic system. Furthermore, we do find evidence supporting the role of Total Expenditure as a driver of fiscal policy.

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1. Introduction

The creation of the European Monetary Union (EMU, hereafter) meant a change in both monetary and economic policies for its member countries. This is joined by a series of rules in which countries were aspiring to join the EMU, where it is worth highlighting the fiscal policies. However, during the first decade of the ’00s until the beginning of the Great Recession, many euro area countries followed a risky/procyclical budgetary path, which provoked accumulated imbalances after the Great Recession -see Hauptmeier et al. (2011, 2015) for a deep discussion about the trends of fiscal elements in euro area countries up to 2009/10-. Indeed, many European countries tried to face the Great Recession aftermath by the application of various extraordinary expansionary fiscal policies, which deepened those imbalances and triggered doubts and a lack of confidence in the solvency of public finances in some peripheral European countries like Greece, Ireland, Portugal, or Spain, producing events of high-risk premia in those countries (Paniagua et al., 2017). This sovereign debt crisis was overcome thanks to ECB President Mario Draghi's speech -on 26 July 2012-, when the so-called “whatever it takes” speech, was followed by the announcement of non-conventional policies as of the Outright Monetary Transactions Programme (OMT) tool. This made explicit a very strong commitment of the ECB to Europe and the euro area providing not only stability to financial markets but also higher confidence in Euro area countries' fiscal sustainability (European Parliament, 2022).

More recently, the COVID-19 outbreak brought a severe impact on public finances. It is well-known the policies applied by governments to face the aftermaths derived from this COVID-19 outbreak, i.e., population lockdown, and closing the borders, among others. These policies caused the economies around the world to slow down. Hence, the different euro-area governments urged the European Central Bank (henceforth, ECB) and the European Commission (EC) to undertake extraordinary steps to recover the economies in the euro area. In this sense, the Pandemic Emergency Purchase Programme (PEPP) or the European Stability Mechanism (ESM), as well as the “Next Generation E.U.”, were released by European authorities in that period (Fendel et al., 2021).

Following Afonso and Coelho (2023), focusing the analysis on the Eurozone is justified because there exists a single, common monetary policy among the country members; a common fiscal framework; a financial market integration, which provides net welfare improvements and improves the macro-economic coherence of the monetary union (Lane, 2008); and the existence of feedback and spillover effects among the members.

The literature on public finance sustainability has focused on the possibility of both public revenues and expenditures being balanced over time and following their pattern of growth (Afonso et al., 2023) or otherwise, it is said that debt is sustainable if fiscal authorities have room to increase primary balances when facing growing debt-to-GDP ratios (Bohn, 1998). Furthermore, based on causality tests as conducted in our study, if expenditures lead to revenues, it implies that the fiscal authority is generating only the revenues necessary to finance the decided expenditures. This indicates that fiscal budgets are not under control, and hence fiscal sustainability is endangered. In such a scenario, a reduction in the budget deficit can only be achieved through cuts in government expenditures (Afonso and Jalles, 2016).

In this regard, a growing body of literature has emerged to provide insights into the effects that risky fiscal sustainability policies - where medium and long-term prospects of public revenues and expenditures are separated - have on different macroeconomic variables, such as output and monetary policy indicators, including interest rates and prices. Furthermore, variables such as interest payments or implicit interest rates could serve as proxies for the cost of debt service. Unfortunately, the literature on this topic mostly relies on bivariate or trivariate analyses, such as examining the relationship between government expenditures and revenues, or the relationship between expenditures, prices, and output. These analyses employ causality techniques to conclude.

All in all, in this paper, we aim to assess the ultimate causal flow between monetary policy indicators, fiscal sustainability, and economic growth in the Euro area during the first two decades of EMU (1999/q1-2019/q4). We believe that having a comprehensive understanding of the transmission channels during this period, before the emergence of COVID-19, is a prerequisite for successfully addressing the current challenges faced by fiscal and monetary policy in promoting a more sustainable growth path in the short, medium, and long term. Additionally, we believe that this will aid in properly analyzing the significant impact of the COVID-19 period in future studies with better data availabity, considering the potential structural changes that current shocks, such as COVID-19 and the Ukraine War, may introduce in the Eurozone economy.

Thus, we have reviewed the existing literature to identify the elements necessary to consider all potential explanatory hypotheses on the links among economic output, prices, and fiscal policy sustainability for EMU countries within a complete system. In this sense, prices are currently playing a significant role in the design of macroeconomic policies.

As abovementioned, these variables must be included in an environment, where all of them are interrelated, making a complex dependency network. Indeed, Sims (1972) and Lütkepohl (1982) explained the necessity of incorporating other ‘exogenous’ variables to conduct an inference with a higher dimension system. i.e., omission of relevant variables can lead to biased results.

In this study, we adopt a new approach for testing Granger Causality in panel data within the context of Vector Autoregressive (VAR) models, which was introduced by Gil-Bermejo et al. (2022). This approach allows us to extend the number of relevant variables, which is generally limited to two or three. The approach is based on averaging individual Wald test statistics of cross-sectional units using Fisher's transformation framework proposed by Dumitrescu and Hurlin (2012) and Emirmahmutoglu and Kose (2011). In this regard, as suggested by Shojaie and Fox (2022), it is essential to consider all relevant variables that may provide pertinent information to identify accurate causal relations. Similarly, following Eichler (2012), we aim to identify possible causal relations. Thus, to the best of our knowledge, this is the first time that such a multivariate causal analysis has been applied to this topic.

Our results obtained indicate that monetary policy variables have the leading role in this causality flow, giving insights to policymakers in sustainability terms. We might indicate the need to consider prudent spending policies given that increases in expenditures would cause rises in pressures to increase revenues and, consequently, harm other indicators such as GDP. Additionally, as previously mentioned, it seems that monetary policy movements merely condition macroeconomic and fiscal dimensions, revealing that these indicators are dependent on the behaviour of monetary variables and the measures adopted to this end. In other words, our findings aim to identify the channels of the transmission mechanism during the first two decades of EMU and the need for coordinating fiscal–monetary policies. All in all, it seems to be important so, the latest steps taken towards fiscal policy synchronization and harmonization appear to be consistent with the results. Thus, our results might contribute importantly to the design and evaluation of policies.

Our results are also strongly related to some of the major policy actions taken during our sample period. First, our findings show that EMU implementation and the higher price stability registered for most of the countries (compared to the nineties, for instance) contributed positively not only to aggregated economic activity but also to the relationship with fiscal policy indicators (TE and TR).

Finally, in the aftermath of the Great Recession, our findings prove that increases in the cost of the public debt service (IIR) may have been undermining the prospects of macro and fiscal indicators during the period, also indicating the major impact of adopting non-conventional measures of monetary policies, starting with Draghi's statement "whatever it takes" (26 July 2012), as mentioned above.

The rest of the paper is organized as follows. In the next section, this paper proposes an empirical review of the literature concerning the relationship among variables that constitute part of public finances. Section 3 details the framework that allows us to construct our empirical strategy shown in Section 4. Section 5 presents the results obtained by our econometric approach that would be the source of the central conclusions and policy implications proposed in Section 6.

2. Literature review

The sustainability of public accounts is a fundamental issue in economics and public policy for governments, as it has been confirmed over time as an effective tool for developing their economies and protecting their welfare state. Nonetheless, the increase in public sector debt in many developed countries during the last decades of the 20th century and the beginning of the 21st century led to growing concern about the potentially adverse effects on economic growth, inflation, international competitiveness, productivity, and unemployment (Brady and Magazzino, 2018).

In contrast, the EU fiscal framework recognizes that member countries' governments use different fiscal policy tools to manage their revenues and public expenditures to achieve their national objectives, such as promoting economic growth, utilizing the resources of society, and maintaining price stability (Auerbach and Kotlikoff, 1987). However, the presence of significant fiscal imbalances in one member country can have negative spillover effects on other countries, which could jeopardize the overall credibility of the common currency. On the contrary, a balanced budget deficit ensures fiscal discipline and, therefore monetary policy could be implemented more effectively, either domestically or in the context of a monetary union (Trachanas and Katrakilidis, 2014). Thus, early studies concerning fiscal policy and its implications have been focused on the relationship between different macroeconomic variables such as expenditures, revenues, output, or inflation, among others, resulting in different hypotheses.

The expenditures and revenues nexus

First, we can highlight the relationship between expenditures and revenues[2], where different hypotheses emerge in the literature, such as the tax-and-spend hypothesis, which asserts that any change in expenditures is led by changes in tax revenues (Friedman, 1978). There is also an inverse relation, implying the spend-and-tax hypothesis (Roberts, 1978), where expenditures are generated earlier to tax gathering. Indeed, this means that the fiscal authority is only generating the revenues necessary to finance the expenditures decided so, fiscal budgets would not be under control, i.e., fiscal sustainability is endangered, and budget deficit reduction can only be achieved through reductions in government expenditures (Afonso and Jalles, 2016). Hereafter, the fiscal synchronization hypothesis determines the simultaneity of the spending and revenue choices (Meltzer and Richard, 1981). Alternatively, if there is not any relation between expenditures and revenues, that is, the absence of a causal relationship between both variables, meaning that both variables are independent behaviour in the decision-making of fiscal authorities, named the institutional separation hypothesis[3] (Wildavsky, 1988; Baghestani and McNown, 1994).

On the one hand, studies analyzing the expenditures – revenues nexus are focused on different countries and periods, evaluating the sustainability of public accounts, the Intertemporal Budget Constraint (IBC, hereinafter) emerges as a topic where vast studies are centred on the possible articulation between the public accounts sustainability and fiscal policy, stating the IBC that a sustainable fiscal policy is that can make the discounted value of the debt go to zero at the limit so that the present value borrowing restraint is maintained, and also involves an intertemporal balance of the government budget, establishing the contemporary value of debt as the discounted sum of expected future surpluses (Berenguer-Rico and Carrion-i-Silvestre, 2011), emerging different

[2] See Sargent and Wallace (1981), Hamilton and Flavin (1986), Trehan and Walsh (1988, 1991) Hakkio and Rush (1991) or Quintos (1995), among others for a deep explanation of the topic.
[3] Hoover and Sheffrin (1992) suggest that the lack of causality between revenue and expenditure could be attributed to a federal state organization.

strands in the literature which treat linearities and nonlinearities in the relationship between both variables[4] and shed light on the effects of the government's budget constraint in the policies carried out by economic authorities, being a basis for the comprehension of the public accounts' sustainability.

Furthermore, the relevance of this research question is clear given the huge number of studies that have addressed the topic, showing mixed results. Among others, we can highlight Koren and Stiassny (1998) who uses a sample of nine countries, obtaining the existence of the spend-and-tax hypothesis for Austria, Italy and France and the opposite, i.e., the tax-and-spend hypothesis fulfilment for the UK, the USA, The Netherlands and Germany and finally, the absence of any causal relationship in the case of Switzerland and Sweden. Attending to the application and assessment of the causal link between both variables for the southern peripheral countries (Portugal, Ireland, Greece and Spain) country group, Kollias and Makrydakis (2000) evidence the fulfilment of the tax-and-spend hypothesis for Spain, the fiscal synchronization hypothesis for Greece and Ireland and the institutional separation hypothesis in the case of Portugal. Moreover, Kollias and Paleologou (2006) analyze the causal link between revenues and expenditures for 15 European Union countries, supporting the fiscal synchronization hypothesis for Denmark, Greece, Ireland, The Netherlands, Portugal and Sweden.

Furthermore, countries such as Austria, Belgium, and Germany follow the institutional separation hypothesis. Regarding the unidirectional causal relationship, when it comes from revenues to expenditures, i.e., the tax-and-spend hypothesis, it occurs for Italy and Spain while the reverse causal link is revealed for Luxembourg. They also show the Buchanan – Wagner hypothesis[5] for Finland, France and the UK. Thus, Afonso and Rault (2009) study the causal link in a sample of 25 European Union countries, finding different patterns in the results. On the one hand, the spend-and-tax hypothesis is followed by Austria, France, Greece, Italy, and Spain. Conversely, the tax-and-spend hypothesis holds for the Czech Republic, Estonia, Germany, Luxembourg, Lithuania, and Poland. Finally, two countries reveal the fiscal synchronization hypothesis: Ireland and Slovakia. Similarly, Vamvoukas (2011) analyses the causal relationship in 15 European countries, exhibiting strong support for the fiscal synchronization hypothesis in the 15 EU member countries for the pre-Maastricht and post-Maastricht periods. More recently, Paleologou (2013) found a bidirectional causality between revenues and expenditures, i.e., the fiscal synchronization hypothesis, in Sweden and Germany and the spend-and-tax hypothesis was confirmed for Greece. Bolat (2015) examined this link for the 10 European countries, verifying the tax-and-spend hypothesis in Germany, Italy, and the Netherlands, and the

[4] This issue has been addressed based on different econometric techniques applied and the countries selected. See Giavazzi et al. (2000), Cipollini (2001), Bajo-Rubio et al. (2010), Afonso et al. (2011), Lusinyan and Thornton (2011), Paleologou (2013), Trachanas and Katrakilidis (2013), Bajo-Rubio et al. (2014), Afonso and Jalles (2014), Camarero et al. (2015), Afonso and Rault (2015), Carrion-i-Silvestre (2016), Paniagua et al. (2017), Irandoust (2018), Beqiraj et al. (2018), Brady and Magazzino (2018, 2019), Piergallini and Postigliola (2020) or Vides et al. (2020), among others.

[5] For our analysis, the Buchanan – Wagner hypothesis holds the same sense as the tax-and-spend hypothesis (Buchanan and Wagner, 1977; Wagner, 1976).

spend-and-tax hypothesis for France and Portugal. Finally, he could not find causality in Belgium, Austria, Finland, Denmark, and the UK, being this latter piece of evidence for the institutional separation hypothesis.

Additionally, Mutascu (2015) analyzed the southern peripheral countries and obtained a unidirectional causality from government revenues to expenditures, being evidence for the tax-and-spend hypothesis, in Greece and Italy; the spend-and-tax hypothesis in Portugal, and the institutional separation hypothesis in Ireland and Spain. Attending to a set of Central and Eastern European countries sample, Bolat and Belke (2015) could not reject the tax-and-spend hypothesis in Slovenia; the spend-and-tax hypothesis in Estonia, Latvia, and Slovakia; the fiscal synchronization hypothesis in Romania and Bulgaria, and the institutional separation hypothesis in the Czech Republic, Hungary, Lithuania, and Poland. In contrast, Mutascu (2016) use the same sample of countries as the previous study, finding a lack of causality in the Baltic states, Poland, and Romania, i.e., the institutional separation hypothesis was validated in these countries; the spend-and-tax hypothesis held in Bulgaria and the tax-and-spend hypothesis was followed in Czech Republic, Hungary, and Slovenia; and the fiscal synchronization hypothesis for Slovakia. Finally, Tashevska et al. (2020) explore the path of causality by using a sample of six Southeastern European transition economies, confirming the tax-and-spend hypothesis in Albania, Bulgaria, Croatia, Serbia, and Slovenia and the fiscal synchronization hypothesis in Macedonia.

The relationship between output and expenditures

Second, we summarize the evidence regarding the link between the output[6] and government expenditures, studied in the literature from two complementary points of view. On the one hand, we find Wagner's law, which establishes that national income growths are the cause of increases in government expenditures, i.e., the direction of Granger-causality is from national income to government expenditures (Arestis et al., 2021). Conversely, the reverse relation is about the Keynesian view of national income growth as the consequence of higher levels of government expenditures. That is, the causal relation would run from government expenditures to output. Indeed, the likely link between public expenditures and output is an issue of fiscal policy sustainability, particularly during the phase of the business cycle wherein the government make a great effort to restrict public spending.

Hitherto, many papers have been steered to confirm the Keynesian view or Wagner's law by employing different models and data from various countries or groups worldwide, evidencing mixed results leading to a lack of consensus regarding the hypothesis tested. Focusing on European countries, we may highlight some studies such as Dritsakis and Adamaopoulos (2004) that test Wagner's Law versus the Keynesian view from a Greek

[6] In the literature, output has been represented either by gross national product or by gross domestic product. Additionally, in our case, we denote growth or economic growth and output as synonyms and both are called in the same way.

perspective between 1960 and 2001, supporting the Wagner's Law by evidencing the causality path from output to government expenditure. For its part, Loizides and Vamvoukas (2005) assess the endorsement of any of both hypotheses previously mentioned for the UK, Ireland, and Greece from 1960 to 1990. Their results confirm the causality from government expenditures to output, i.e., the Keynesian view, in the UK and Ireland and conversely, Wagner's law is supported for Greece. In the case of Greece, Katrakilidis and Tsaliki (2009) find a divergent result from that obtained by Dritsakis and Adamaopoulos (2004). In this sense, they find a bidirectional causality between both variables for a sample from 1958 to 2004. Additionally, Durevall and Henrekson (2011) studied the existence of Wagner's law for Sweden and the UK in a very long-run sample. However, they evidence that there exist some shorter periods where Wagner's law holds, and Kuckuck (2014) also analyzed to verify the authority of Wagner's law for five industrialized EU countries, i.e., the UK, Denmark, Sweden, Finland, and Italy, during the period 1850–2010, showing that a long-run equilibrium between public spending and economic growth may exist. Nevertheless, Wagner's law seems to be more feasible for countries at the early stages of development.

In this respect, as we have seen, economic growth could be linked with government revenues and expenditures, drawing a path in the design of the fiscal policy, and emerging the concept of public finance pro-cyclicality. In this sense, the European Commission (2007) establishes an important aspect of prudent fiscal policy, i.e., by controlling the evolution of public expenditures, to prevent the procyclical influence on economic activity and to contribute to compliance with EU fiscal rules, which were a persistent element in the EU spending in the pre-Great Recession crisis and being a weak link in fiscal policy. In this regard, Balassone et al. (2010) study fiscal issues for 14 EU countries, obtaining asymmetrical effects occurring during the economic cycle and that the primary budget balances were depreciated during recessions but not recovered in the expansion stages and Cronin and McQuinn (2021) revealed that EU governments expect open government expenditure policy to behave pro-cyclically, going against to the spirit and intention of the EU fiscal rules.

The output and inflation linkage

Third, considering the effect of inflation on output or vice versa, we study the feasible causal link between inflation and output, where Pradhan et al. (2015) point out some hypotheses resulting from this link. In this sense, when inflation causes output, it is called the supply-leading hypothesis (SLH). Conversely, when causality runs in the opposite direction, i.e., from output to inflation, it is known as the demand-following hypothesis (DFH). If there is a bi-directional flow causality between inflation and output, it is said that the feedback hypothesis (FBH) appears. Finally, the neutrality hypothesis (NLH) states that there is not any causal link between inflation and output. However, the literature concerning this relationship is limited to European countries.

Nonetheless, there exist several papers that address this issue for different groups of countries. For example, Darrat (1988), Apergis (2004) and Pradhan et al. (2013) find evidence in support of the SLH for Malaysia, Philippines and Thailand, the G7, and BRICS countries, respectively; and Nguyen and Wang (2010), Kim et al. (2013) or Pradhan et al. (2015) support the fulfilment of the DFH for Taiwan, and Korea, respectively. For its part, the FBH is supported in the OECD countries (Andrés and Hernando, 1999; Andrés et al., 2004), Taiwan (Nguyen and Wang, 2010) and MENA countries (Kar et al., 2011), among others. Finally, the NLH is held in Indonesia (Chowdhury, 2002), a group of countries from the Middle East and Central Asia (Billmeier and Massa, 2009) or a set of developed and developing countries (Vaona, 2012).

The inflation and revenues nexus

Fourth, when we explore the nature of the relationship between inflation and public revenues, the concept of fiscal drag explains in some way how inflation influences income. Following Ursprung and Wettstein (1992) it is important to distinguish between real[7] and nominal fiscal drag. The latter type could work as follows:

> *Given a progressive tax system and the lack of a perfect indexation, inflation moves taxpayers into tax brackets with higher marginal tax rates. This so-called 'bracket creep' leads to rising tax–income ratios. Since this relationship holds even in the absence of any real growth with positive nominal growth, the phenomenon can be called 'nominal fiscal drag'* (Heinemann, 2001, p. 528).

In this sense, it seems important the reaching low levels of inflation rates for the development of government revenues. We can find few studies which have treated the concept of fiscal drag within the European Union framework, highlighting Gros and Vandille (1995) where the impact of price stability on tax revenues has been neglected in the EMU. Also, Persson et al. (1998) investigated the Swedish case, showing a considerable impact of inflation on tax revenues. Thus, Heinemann (2001) evidenced that there are EMU countries as France and Italy which show significant fiscal drag, whereas the inverse nexus is obtained for Germany by Immervoll (2005) who addresses the existence of fiscal drag in three European countries as Germany, the Netherlands, and the United Kingdom. The fiscal drag can cause more severe collection, distributive, and allocative impacts than the explicit reforms themselves, which introduced publicized and express regulatory changes. Good examples of the latter for the Spanish case can be found in Maza and Gonzalez-Paramo (1987), Sanz et al. (2004), Sanz and Romero (2007), Fernandez and Sanz (2009), in Creedy and Sanz-Sanz (2010) or, more recently, in Martinez-Lopez (2017).

Otherwise, inflation may cause government expenditures. In this sense, governments would moderate their expenditure levels properly depending on the level of inflation

[7] As Heinemann (2001) states, the real type of fiscal drag does not depend on inflation.

(Ezirim et al., 2008). Unfortunately, although this relation has not been treated deeply in the literature, most of the studies are focused on analyzing whether expenditures would cause inflation and hence, economic growth. However, it is well-known that the automatic adjustment of public policy outputs from inflation (Weaver, 2010). In other words, Gray (1976) states that although indexation insulates the real sector from the effects of monetary shocks, it can exacerbate the real effects of real shocks so, in our multivariate framework, it would be possible to identify how inflation could cause revenues and expenditures jointly. However, this issue has been treated in the labour market literature (see Durant et al. (2012), for a survey; De la Roca (2014), for the Spanish case; or Bokhorst (2022), for Belgium) or pensions (see European Commission (2018a, b); Hohnerlein (2019); De la Fuente et al. (2019); or Ayuso et al. (2021)).

The cost of debt service and expenditures linkage

Finally, our last relationship analyzed is taking into account the causal link between the cost of debt service (measured in our study as interest payments or implicit interest rates) and the rest of the variables, i.e., government expenditures and revenues, and GDP. Although this relationship has not been treated with a similar deepness in the previous literature, some existing studies such as Reinhart and Rogoff (2010) and Bitar et al. (2018), among others, help to illustrate the expected effects of public debt on fiscal variables and growth. However, both variables, i.e., interest payment and implicit interest rates, will be included in our causality system to consider the potential impact of the financial sector in our analysis.

Therefore, we synthesize the empirical evidence about alternative hypotheses in Table A2 in Appendix. However, in Table 1, we have included the linkages of all the hypotheses previously mentioned with their possible impact on fiscal sustainability.

As abovementioned, these variables must be included in an environment, where all of them are interrelated, making a complex dependency network. Indeed, Sims (1972) and Lütkepohl (1982) explained the necessity of incorporating other 'exogenous' variables to conduct an inference with a higher dimension system. i.e., omission of relevant variables can lead to biased results. So, we follow the new approach for testing Granger Causality in panel data in the context of Vector Autoregressive (VAR) models, introduced by Gil-Bermejo et al. (2022). This proposal lets us extend the number of relevant variables (generally limited to two/three). It is based on averaging individual Wald tests statistics of cross-sectional units using Fisher's transformation framework proposed by Dumitrescu and Hurlin (2012) and Emirmahmutoglu and Kose (2011). In this regard, following Shojaie and Fox (2022), it is important to take into consideration all the relevant variables, which may provide relevant information to identify correct causal relations and as Eichler (2012), we try to identify the possible causal relations in a whole. Thus, to the best of our knowledge, this is the first time that such a multivariate causal analysis has been applied to this topic.

Table 1. Linkages between fiscal and monetary variables with fiscal sustainability.

Relation	Hypotheses	Impact on the degree of fiscal sustainability
$EXP \Leftarrow REV$	Tax-and-spend hypothesis	↑
$EXP \Rightarrow REV$	Spend-and-tax hypothesis	↓
$EXP \Leftrightarrow REV$	Fiscal synchronization hypothesis	↑
$EXP \quad REV$	Institutional separation hypothesis	↓ ≈
$EXP \Rightarrow GDP$	Keynesian view	≈ ↑
$EXP \Leftarrow GDP$	Wagner's law	↓
$GDP \Rightarrow EXP$ $GDP \Rightarrow REV$	Full public finances pro-cyclicality	↓
$GDP \Rightarrow INFL$	Demand-following hypothesis (DFH)	↓ ≈
$GDP \Leftarrow INFL$	Supply-leading hypothesis (SLH)	↓ ≈
$GDP \Leftrightarrow INFL$	Feedback hypothesis (FBH)	≈ ↑
$GDP \quad INFL$	Neutrality hypothesis (NLH)	↓ ≈ ↑
$INFL \Rightarrow REV$	Fiscal drag	↑
$INFL \Rightarrow EXP$ $INFL \Rightarrow REV$	Indexation of the economy	↓
$IIR \Rightarrow TR/TE \Rightarrow GDP$	Debt sustainability	↓

Notes: Own elaboration. ↓ indicates negative impact on fiscal sustainability, ≈ indicates no significative impact on fiscal sustainability and ↑ indicates a positive impact on fiscal sustainability. See Table A2 for references related to each hypothesis.

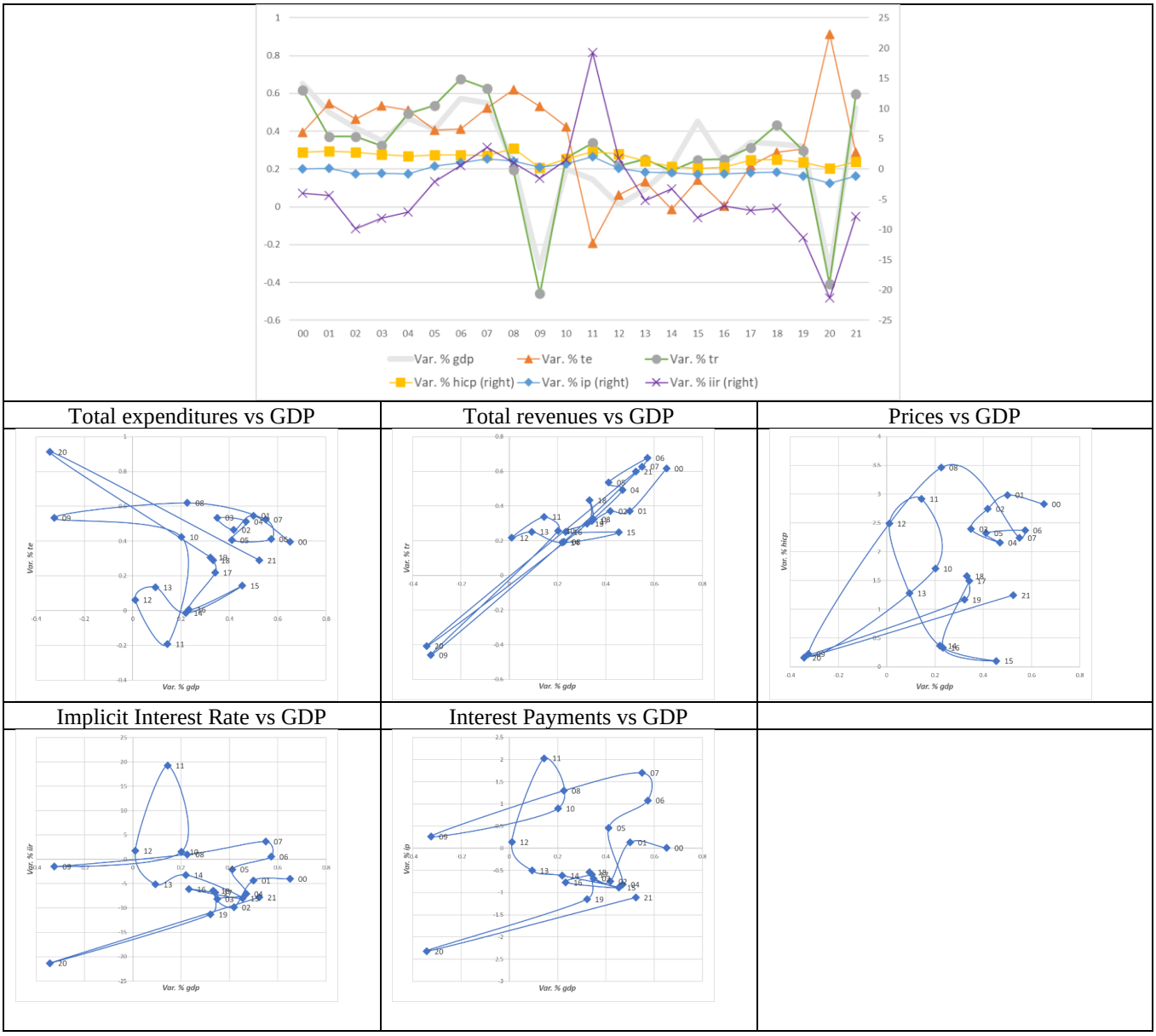
3. Econometric approach

3.1 Data

In our work, we provide a test of the sustainability of the public accounts for a set of twelve euro-area countries' fiscal policies over the period that covers, quarterly, from 1999Q1 to 2019Q4, amounting to 84 observations for each national time series. In our view, having a comprehensive understanding of the transmission channels during this period, before the emergence of COVID-19, is a prerequisite for successfully addressing the current challenges. Particularly, those faced by fiscal and monetary policy in promoting a more sustainable growth path in the short, medium, and long term. We extracted the full dataset from Eurostat.

The selected euro-area countries are Austria, Belgium, Germany, Luxembourg, Greece, Spain, Ireland, Italy, Finland, France, Netherlands and Portugal. Our empirical model is composed of the following variables: (i) Total Expenditures (TE) and Total Revenues (TR), as a proxy of the fiscal policy stand, (ii) Gross Domestic Product (GDP) to proxy the economic activity, (iii) the Interest Payments (IP) and Implicit Interest Rates (IIR) as a proxy for the cost of debt service and (iv) and Harmonized Index of Price Consumer (HIPC), as a monetary policy indicator (the central aim of Euro Area monetary policy). As we know, in the EMU there is no common fiscal policy so, panel analysis is relevant in the context of countries seeking to pursue sound fiscal policies within the framework of the Stability and Growth Pact.

Following Afonso and Coelho (2023), the analysis for the Eurozone as a whole is



Source: Eurostat.

justified because there exists a single, common monetary policy among the country members; a common fiscal framework; a financial market integration, which provides net welfare improvements and improves the macro-economic coherence of the monetary union (Lane, 2008); and the existence of feedback and spillover effects among the members.

Figure 1: Recent developments of Baseline model variables, 2000-2021.

Figure 1 shows the annual rate of variables included in our model throughout our sample period (2000-2021). Even though our dataset is quarterly, for the sake of clarity, we draw the annual average rate. The top panel includes the whole set of variables together whereas bivariate panels are included below to focus on their correlations with

the economic situation (GDP growth in our model). All of them together provide very interesting insights regarding their reactions to very significant structural shocks such as the Great Recession (2009 in the chart) and the COVID-19 crisis (2020). On the one hand, it can be observed how fiscal policy indicators (TE and TR) react differently. Thus, in the case of the public revenues behaves as procyclical whereas TE seems to react in a more countercyclical way. On the other hand, monetary policy indicators (HICP and IP) show also more in line with economic activity. Interestingly, the bottom panels show how the reactions of IP and IIR to the Great Recession and COVID-19 crisis are very different. One potential explanation is the different measures adopted by the European Central Bank in terms of public finances sustainability, having a more proactive role in the latter, ensuring that Euro area countries can afford the emission of higher levels of public debt to face the increasing demand for public expenditures.

3.2 Methodology

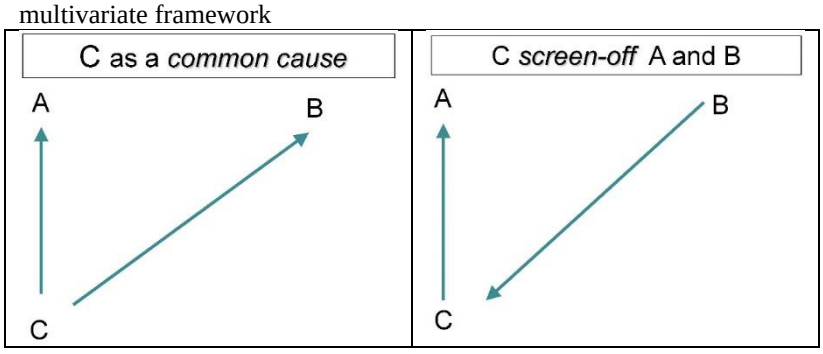
This subsection proposes the method to assess the *ultimate* causality path amongst the variables included in a panel VAR model based on Gil-Bermejo et al. (2022). Firstly, considering the panel VAR (τ_i) model with *p* variables:

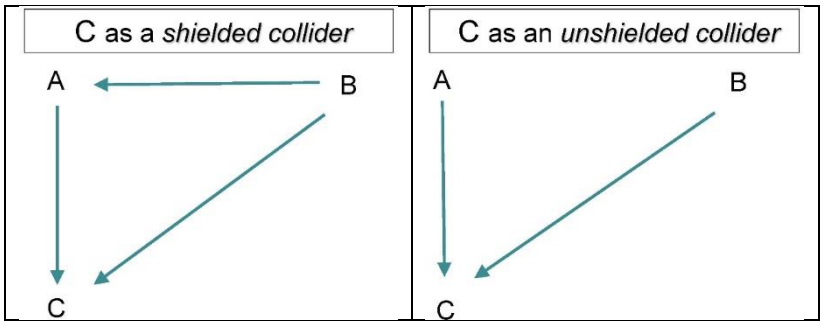
$$y_{i,t} = \mu_i + \sum_{\tau=1}^{\tau_i} \Phi_{i(\tau)} y_{i,t-\tau} + u_{i,t} \qquad i=1,\ldots,N;\ t=1,\ldots,T \tag{1}$$

The index *i* indicates each cross-sectional unit, and *t* represents the time periods. μ_i is a $(p \times 1)$ fixed effects vector and$\Phi_{i,1}, \ldots, \Phi_{i,\tau_i}$ are $(p \times p)$ matrices of parameters. $u_{i,t}$ is $(p \times 1)$ of error terms, which are iid and, τ_i is the order of the autoregressive process.

Emirmahmutoglu and Kose (2011) and Dumitrescu and Hurlin (2012) have driven a developing process for causality tests in a multivariate structure. Likewise, it is worth highlighting studies to link the abovementioned developments to those developed in the graph-theoretic method and theory of causal discovery (see Spirtes et al. (2000) for a deep description). Gil-Bermejo et al. (2022) combine both pieces of literature to help to identify the underlining factors/indicators shaping the causal network dependencies within a multivariate framework (see Demiralp and Hoover (2003) for an extended explanation).

Figure 2: Theoretical illustration of conditional dependency within a multivariate framework

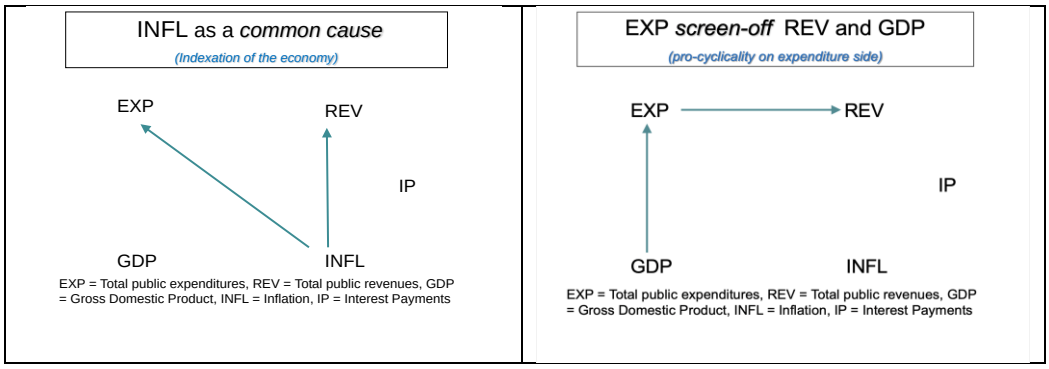


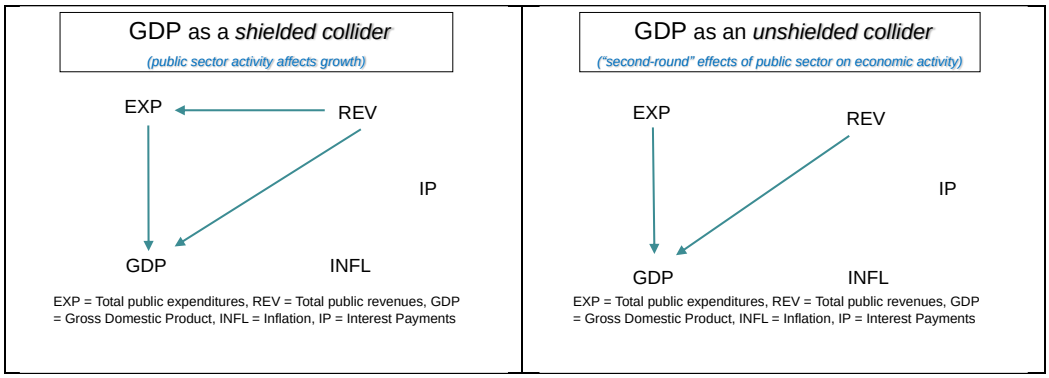


Source: Gil-Bermejo et al., (2022).
Note: C may be just one variable or a more complex structure of indirect links between a set of third variables.

To clarify the underlying intuition, Figure 2 shows some theoretical illustrations. To do so, we consider a trivariate vector Y=[A, B, C], where C may be either a third variable of the final result of a more complex network of indirect links between the remaining list of variables included in the complete model. As we illustrate, a variety of basic dependencies might emerge among them. First, looking at the top-left panel, it could be the case that C is a common cause shaping the relationship between A and B. Under these circumstances, omitting or including this information in our procedure will determine the final output and, thus, the conclusions we may reach from them. In our empirical application, this could be the case when price indexation is complete then, public finance is connected by reacting to price changes (see Figure 2, top-right panel). Second, an alternative scenario is included in the top-right panel, where the *third* variable also plays an important role. A and B could be dependent even if there is no direct link among them, and always we identify a variable (C) connecting them through an indirect link. In our application, this is the case when a procyclical spending policy is implemented. Third, in the bottom panels, we present two different scenarios in which variable C is a collider in the sense that the arrowhead comes to this point, no matter if A and B are directly connected (bottom-left) or not (bottom-right) when we condition on C. In the following Figure 3, one can identify a similar scheme for some of the variables that we have selected, as one potential causal graph indicating the impact of public sector activity on economic growth.

Figure 3. An example of conditional dependency.





Source: Own elaboration from Demiralp and Hoover (2003).

Next, we briefly describe the steps of our empirical strategy. First, we conduct the standard causality Wald test for every country and alternative model -built by considering different combinations/subsets of indicators-, which assesses the significance of the matrix of linear parameters $A_{i,s}$. In the case of Granger non-causality, the null hypothesis for the *i-th* individual is defined as:

$$H_0 : \Phi_{i,\tau} = 0 \text{ for all } I \tag{2}$$

The following step is to perform the Fisher transform to obtain the common measure for the entire panel (along with any significant subset of units). Fisher (1932) proposes the following transformation of the individual p values (p_i).

$$\lambda = -2 \sum \ln p_i \tag{3}$$

where p_i is the p-value corresponding to the *i-th* individual cross-section. This test has a chi-square distribution with *2N* degrees of freedom.

Next, following David (1949) estimates a global measure of the dominant correlation of the cross-sectional individuals. This tells us about the direction and intensity of the link. In this sense, using Fisher transformation to normalize the distribution and stabilize the variance of the correlation coefficients is proposed to make them suitable for combination. Once the coefficients are transformed, they could be averaged as habitual. Finally, the transformation is unfinished to get the correlation coefficient that condenses the information contained in the combined correlation coefficients[8]. A short description of this procedure is:

- Step 1: Being $r_1, \ldots, r_N$ all the correlation coefficients we desire to combine into a common metric (R)[9] we need first the Fisher transformation of each r_i, which is defined by:

$$z_i = \ln \frac{(1 + r_i)}{(1 - r_i)} \tag{4}$$

[8] This process reduces the skew of the distribution.
[9] Proxy to population Correlation.

each z_i is approximately normally distributed with variance $\frac{1}{T_i}$ where T_i is the sample size used to calculate r_i.

- Step 2: By using these transformations, the summary coefficient *(Z)* of the correlations could be computed as the sample mean:

$$Z = \sum \frac{z_i}{N} \tag{5}$$

This expression is then approximately normally distributed with variance $\frac{1}{\sum_{i=1}^{N} T_i}$.

- Step 3: Once Z is calculated, we can undo the transformation to summarize the dominant correlation coefficient.

$$R = \frac{e^{2Z}-1}{e^{2Z}+1} \tag{6}$$

The second step of our empirical work is to depurate and identify the ultimate causal path. In this respect, Gil-Bermejo et al. (2022) proposed the use of the PC algorithm in its stable version (following Colombo and Maathuis, 2014)[10], being an iterative algorithm based on qualitative information about if a particular local conditional independence constraint holds (see Demiralp and Hoover (2003) for the algorithm performance). To keep things simple, there is an edge between them whenever a robust causal relationship exists between a pair of variables at the final stage of the process.[11] This edge shows the existence of the relationship, the sense of the link (the variable leading), and the intensity of the connection (measured in our case as the dominant crossed correlation function).

4. Empirical results

In this section, we show the main results obtained by using the empirical approach previously detailed[12]. As we could initially expect, various channels may play an important role in shaping the fiscal sustainability path. For example, total expenditures can lead to inappropriate public sector performance in terms of fiscal policies stability and budget imbalances, provoking a lack of confidence, rising public debt levels or problems with the deficit, being necessary to understand the linkages among different macroeconomic variables, such as economic growth, total revenues, inflation, implicit interest rates and interest payments. Consequently, the resulting path could be of key interest to the fiscal policy design. Furthermore, we consider a representative sample of

[10] The main difference between the original version and the stable version is that the stable version of the algorithm keeps the sets of adjacent nodes unchanged at each particular level. Thus, the output is independent of the order of the variables.

[11] The above procedure is also valid for any relationship, although we have focused on causality in this paper.

[12] The median value of Schwarz, Hannan-Quinn and Akaike criteria is used to determine the lag length to be used in the VAR. Moreover, following Toda and Yamamoto (1995), we assume that a VAR in levels can be used to test general restrictions even in the presence of integrated or cointegrated series.

euro countries which may contribute to obtaining a common pattern shaping this relationship. This common pattern could be an important clue for the European Union as long as the design of common policies is concerned.

First, our estimation displays heterogeneity in the results. In Table 2, we show the correlation matrix amongst the variables used. As we can see, the values of the correlation corresponding to the possible relation between each variable, corresponding to the baseline model where all the variables and countries are included. Furthermore, we could see the values for each country regarding a given relationship between variables and for all the countries considered, our benchmark scenario. In this sense, a degree scale (in absolute terms) may be considered. Thus, the first range covers values from 0 to 0.2, evidencing a weak correlation. Second, a medium correlation is ranged between 0.2 and 0.5. Third, a strong correlation would be established in the range between 0.5 and 0.8; and finally, we could talk about a very strong correlation for values above 0.8. More importantly, it is worth noticing that although there may be a low correlation between variables, a causal relationship may continue to exist. According to this scale, we identify a very strong correlation among Total Expenditures, Total Revenues, GDP, Inflation and Implicit Interest Rates (with estimates above 0.9). However, the correlation between Interest Payments and other variables is less significant and heterogeneous across countries.

Table 2. Cross-Correlation amongst fiscal, monetary and growth variables

Country	TE, TR	TE, GDP	TE, HICP	TE, IIR	TE, IP	TR, GDP	TR, HICP	TR, IIR	TR, IP	GDP, HICP	GDP, IIR	GDP, IP	HICP, IIR	HICP, IP	IIR, IP
Austria	0.98	0.98	0.97	-0.88	-0.33	0.99	0.99	-0.90	-0.42	0.99	-0.89	-0.39	-0.91	-0.43	0.71
Belgium	0.99	0.98	0.99	-0.98	-0.89	0.99	0.99	-0.97	-0.92	0.99	-0.98	-0.94	-0.96	-0.92	0.93
Finland	0.98	0.98	0.99	-0.94	-0.81	0.99	0.97	-0.92	-0.81	0.96	-0.95	-0.85	-0.90	-0.78	0.93
France	0.99	0.99	0.99	-0.89	-0.23	0.99	0.99	-0.92	-0.28	0.99	-0.90	-0.24	-0.92	-0.29	0.58
Germany	0.98	0.97	0.96	-0.97	-0.91	0.99	0.98	-0.96	-0.91	0.98	-0.95	-0.90	-0.91	-0.83	0.97
Ireland	0.61	0.53	0.83	0.52	0.75	0.93	0.83	0.36	0.48	0.86	0.41	0.53	0.59	0.80	0.91
Italy	0.98	0.99	0.97	-0.90	-0.27	0.97	0.98	-0.88	-0.27	0.94	-0.93	-0.35	-0.86	-0.28	0.65
Luxembourg	0.99	0.99	0.99	0.66	0.90	0.99	0.99	0.65	0.90	0.99	0.66	0.92	0.72	0.93	0.89
Netherlands	0.97	0.98	0.97	-0.96	-0.78	0.99	0.97	-0.96	-0.88	0.98	-0.97	-0.89	-0.98	-0.89	0.89
Portugal	0.91	0.92	0.92	0.46	0.81	0.98	0.97	0.47	0.82	0.94	0.32	0.34	0.59	0.91	0.83
Spain	0.95	0.99	0.97	-0.52	0.59	0.99	0.91	-0.55	0.40	0.94	-0.57	0.44	-0.27	0.72	0.58
Greece	0.85	0.92	0.70	-0.38	0.25	0.81	0.89	-0.64	-0.12	0.51	-0.39	0.34	-0.64	-0.29	0.79
ALL	**0.97**	**0.97**	**0.97**	**-0.74**	**-0.12**	**0.99**	**0.98**	**-0.75**	**-0.26**	**0.97**	**-0.77**	**-0.24**	**-0.70**	**-0.12**	**0.85**

Notes: ALL denotes the aggregate level of the data used.

Second, we show the p-values of our causality path in Tables 3a and 3b, sequenced by levels, i.e., according to the iterative process -PC algorithm- attending to all possible links amongst the variables selected. In this sense, this procedure starts with a bivariate analysis of all the possible connections (level 1). Then, those causal links which are not significant, i.e., those relationships with a p-value above 0.1 for all the alternatives subsets, are excluded from the following level. Later, in level 2, those causal relationships which have survived the first filter are tested by adding the rest of the variables. For example, in the case of $TE \Rightarrow TR$, we have to check all the possible relations conditioning the rest of the variables, such as $TE_{GDP} \Rightarrow TR$, $TE_{HICP} \Rightarrow TR$, $TE_{IIR} \Rightarrow TR$, and $TE_{IP} \Rightarrow TR$, our procedure tests the possibility of an endogenous causality link which runs from TE to TR but with another system variable as a part of the trivariate causality test. Again, those links which are not significant, will not pass to the next level. The same occurs for the following levels, by adding variables to the endogenous system until reaching the final

level, which corresponds to the number of variables in the proposed system. In our case, the final step would be level 5. This level shows a debugging process which delimits the ultimate causality path for the variables selected. In this regard, we suggest the estimates for those relationships that have survived the iterative algorithm after debugging all the possible links.

Table 3a. PC algorithm results.

Level	Causality from	TR	GDP	HICP	IIR	IP	Causality from	TE	GDP	HICP	IIR	IP	Causality from	TE	TR	HICP	IIR	IP
1	TE →	0.001	0.000	***0.316***	***0.296***	***0.230***	TR→	0.013	0.000	0.057	***0.190***	***0.373***	GDP →	0.038	***0.136***	***0.214***	0.014	0.003
2	TE_{TR} →	-----	0.000				TR_{TE} →	-----	0.000	0.079			GDP_{TE} →	-----			0.004	0.000
	TE_{GDP} →	***0.152***	-----				TR_{GDP} →	0.004	-----	0.000			GDP_{TR} →	0.020	-----		0.000	0.000
	TE_{HICP} →	0.000	0.000	-----			TR_{HICP} →	0.014	0.000	-----			GDP_{HICP} →	0.010		-----	0.000	0.000
	TE_{IIR}→	0.002	0.000		-----		TR_{IIR}→	0.009	0.000	0.000	-----		GDP_{IIR}→	0.014			-----	0.002
	TE_{IP}→	0.000	0.000			-----	TR_{IP}→	0.004	0.000	0.000		-----	GDP_{IP}→	0.005			0.007	-----
3	$TE_{TR,GDP}$ →	-----	-----				$TR_{TE,GDP}$ →	-----	-----	0.000			$GDP_{TE,TR}$ →	-----	-----		0.000	0.000
	$TE_{TR,HICP}$ →	-----	0.000	-----			$TR_{TE,HICP}$ →	-----	0.000	-----			$GDP_{TE,HICP}$ →	-----		-----	0.000	0.000
	$TE_{TR,IIR}$ →	-----	0.000		-----		$TR_{TE,IIR}$ →	-----	0.000	0.000	-----		$GDP_{TE,IIR}$ →	-----			-----	0.018
	$TE_{TR,IP}$ →	-----	0.000			-----	$TR_{TE,IP}$ →	-----	0.000	0.000		-----	$GDP_{TE,IP}$ →	-----			***0.132***	-----
	$TE_{GDP,HICP}$ →	0.001	-----	-----			$TR_{GDP,HICP}$ →	0.019	-----	-----			$GDP_{TR,HICP}$ →	0.014	-----	-----	0.000	0.000
	$TE_{GDP,IIR}$ →	0.033	-----		-----		$TR_{GDP,IIR}$ →	0.000	-----	0.000	-----		$GDP_{TR,IIR}$ →	0.016	-----		-----	0.002
	$TE_{GDP,IP}$ →	0.059	-----			-----	$TR_{GDP,IP}$ →	0.001	-----	0.000		-----	$GDP_{TR,IP}$ →	0.021	-----		0.016	-----
	$TE_{HICP,IIR}$ →	0.023	0.000	-----	-----		$TR_{HICP,IIR}$ →	0.008	0.000	-----	-----		$GDP_{HICP,IIR}$ →	0.029		-----	-----	0.005
	$TE_{HICP,IP}$ →	0.016	0.000	-----		-----	$TR_{HICP,IP}$ →	0.003	0.000	-----		-----	$GDP_{HICP,IP}$ →	0.025			0.017	-----
	$TE_{IIR,IP}$ →	0.000	0.000		-----	-----	$TR_{IIR,IP}$ →	0.024	0.000	0.000	-----	-----	$GDP_{IIR,IP}$ →	***0.140***			-----	-----
4	$TE_{TR,GDP,HICP}$ →	-----	-----	-----			$TR_{TE,GDP,HICP}$ →	-----	-----	-----			$GDP_{TE,TR,HICP}$ →	-----	-----	-----	0.000	0.000
	$TE_{TR,GDP,IIR}$ →	-----	-----		-----		$TR_{TE,GDP,IIR}$ →	-----	-----	0.001	-----		$GDP_{TE,TR,IIR}$ →	-----	-----		-----	0.026
	$TE_{TR,GDP,IP}$ →	-----	-----			-----	$TR_{TE,GDP,IP}$ →	-----	-----	0.000		-----	$GDP_{TE,TR,IP}$ →	-----	-----		***0.132***	-----
	$TE_{TR,HICP,IIR}$ →	-----	0.000	-----	-----		$TR_{TE,HICP,IIR}$ →	-----	0.000	-----	-----		$GDP_{TE,HICP,IIR}$ →	-----		-----	-----	0.068
	$TE_{TR,HICP,IP}$ →	-----	0.000	-----		-----	$TR_{TE,HICP,IP}$ →	-----	0.000	-----		-----	$GDP_{TE,HICP,IP}$ →	-----		-----	***0.182***	-----
	$TE_{TR,IIR,IP}$ →	-----	0.000		-----	-----	$TR_{TE,IIR,IP}$ →	-----	0.000	0.000	-----	-----	$GDP_{TE,IIR,IP}$ →	-----			-----	-----
	$TE_{GDP,HICP,IIR}$ →	0.009	-----	-----	-----		$TR_{GDP,HICP,IIR}$ →	0.040	-----	-----	-----		$GDP_{TR,HICP,IIR}$ →	0.026	-----	-----	-----	0.005
	$TE_{GDP,HICP,IP}$ →	0.013	-----	-----		-----	$TR_{GDP,HICP,IP}$ →	0.037	-----	-----		-----	$GDP_{TR,HICP,IP}$ →	0.032	-----	-----	0.015	-----
	$TE_{GDP,IIR,IP}$ →	0.009	-----		-----	-----	$TR_{GDP,IIR,IP}$ →	0.000	-----	0.000	-----	-----	$GDP_{TR,IIR,IP}$ →	***0.192***	-----		-----	-----
	$TE_{HICP,IIR,IP}$ →	0.011	0.000	-----	-----	-----	$TR_{HICP,IIR,IP}$ →	**0.213**	0.000	-----	-----	-----	$GDP_{HICP,IIR,IP}$ →	***0.414***		-----	-----	-----
5	$TE_{TR,GDP,HICP,IIR}$ →	-----	-----	-----	-----		$TR_{TE,GDP,HICP,IIR}$ →	-----	-----	-----	-----		$GDP_{TE,TR,HICP,IIR}$ →	-----	-----	-----	-----	0.057
	$TE_{TR,GDP,HICP,IP}$ →	-----	-----	-----		-----	$TR_{TE,GDP,HICP,IP}$ →	-----	-----	-----		-----	$GDP_{TE,TR,HICP,IP}$ →	-----	-----	-----	***0.209***	-----
	$TE_{TR,GDP,IIR,IP}$ →	-----	-----		-----	-----	$TR_{TE,GDP,IIR,IP}$ →	-----	-----	0.000	-----	-----	$GDP_{TE,TR,IIR,IP}$ →	-----	-----		-----	-----
	$TE_{TR,HICP,IIR,IP}$ →	-----	0.000	-----	-----	-----	$TR_{TE,HICP,IIR,IP}$ →	-----	0.000	-----	-----	-----	$GDP_{TE,HICP,IIR,IP}$ →	-----		-----	-----	-----
	$TE_{GDP,HICP,IIR,IP}$ →	0.030	-----	-----	-----	-----	$TR_{GDP,HICP,IIR,IP}$ →	***0.141***	-----	-----	-----	-----	$GDP_{TR,HICP,IIR,IP}$ →	***0.481***	-----	-----	-----	-----

Notes:

1) HICP = Harmonized Index of Consumer Price, GDP = Gross Domestic Product, TE= Total Expenditures, TR= Total Revenues, IIR = Implicit Interest Rates, IP = Interest Payments.

2) Bold and italics denote non-significance at 10% level.

Table 3b. PC algorithm results.

Level	Causality from	TE	TR	GDP	IIR	IP	Causality from	TE	TR	GDP	HICP	IP	Causality from	TE	TR	GDP	HICP	IIR
1	HICP →	0.068	0.037	0.022	***0.528***	***0.254***	IIR→	0.000	0.012	0.000	0.000	0.000	IP →	0.012	***0.128***	0.003	0.007	0.007
2	$HICP_{TE}$ →	-----	***0.149***	0.064			IIR_{TE} →	-----	0.000	0.000	0.000	0.005	IP_{TE} →	-----		0.000	0.000	0.014
	$HICP_{TR}$ →	0.099	-----	0.059			IIR_{TR} →	0.000	-----	0.000	0.006	0.000	IP_{TR} →	0.000	-----	0.000	0.000	0.000
	$HICP_{GDP}$ →	***0.316***	***0.562***	-----			IIR_{GDP} →	0.000	0.034	-----	0.006	0.000	IP_{GDP} →	0.000		-----	0.004	0.000
	$HICP_{IIR}$→	0.002	0.027	0.002	-----		IIR_{HICP}→	0.000	0.027	0.001	-----	0.000	IP_{HICP}→	0.000		0.001	-----	0.000
	$HICP_{IP}$→	0.004	0.021	0.001		-----	IIR_{IP}→	0.000	0.000	0.000	0.000	-----	IP_{IIR}→	0.001		0.000	0.000	-----
3	$HICP_{TE,TR}$ →	-----	-----	0.066			$IIR_{TE,TR}$ →	-----	-----	0.000	0.016	0.002	$IP_{TE,TR}$ →	-----	-----	0.000	0.002	0.031
	$HICP_{TE,GDP}$ →	-----	***0.423***	-----			$IIR_{TE,GDP}$ →	-----	0.004	-----	0.003	0.000	$IP_{TE,GDP}$ →	-----		-----	0.019	0.040
	$HICP_{TE,IIR}$ →	-----	0.039	0.004	-----		$IIR_{TE,HICP}$ →	-----	***0.156***	0.003	-----	0.000	$IP_{TE,HICP}$ →	-----		0.006	-----	0.022
	$HICP_{TE,IP}$ →	-----	0.029	0.005		-----	$IIR_{TE,IP}$ →	-----	0.000	0.000	0.000	-----	$IP_{TE,IIR}$ →	-----		0.000	0.000	-----
	$HICP_{TR,GDP}$ →	***0.225***	-----	-----			$IIR_{TR,GDP}$ →	0.000	-----	-----	0.011	0.000	$IP_{TR,GDP}$ →	0.004	-----	-----	0.003	0.000
	$HICP_{TR,IIR}$ →	0.000	-----	0.010	-----		$IIR_{TR,HICP}$ →	0.000	-----	0.000	-----	0.000	$IP_{TR,HICP}$ →	0.007	-----	0.000	-----	0.002
	$HICP_{TR,IP}$ →	0.012	-----	0.000		-----	$IIR_{TR,IP}$ →	0.028	-----	0.000	0.034	-----	$IP_{TR,IIR}$ →	0.055	-----	0.002	0.008	-----
	$HICP_{GDP,IIR}$ →	0.005	***0.288***	-----	-----		$IIR_{GDP,HICP}$ →	0.000	***0.165***	-----	-----	0.000	$IP_{GDP,HICP}$ →	0.006		-----	-----	0.000
	$HICP_{GDP,IP}$ →	0.055	0.071	-----		-----	$IIR_{GDP,IP}$ →	0.019	0.000	-----	0.024	-----	$IP_{GDP,IIR}$ →	0.036		-----	0.010	-----
	$HICP_{IIR,IP}$ →	0.022	0.048	0.007	-----	-----	$IIR_{HICP,IP}$ →	0.000	0.042	0.002	-----	-----	$IP_{HICP,IIR}$ →	0.014		0.000	-----	-----
4	$HICP_{TE,TR,GDP}$ →	-----	-----	-----			$IIR_{TE,TR,GDP}$ →	-----	-----	-----	0.060	0.000	$IP_{TE,TR,GDP}$ →	-----	-----	-----	0.011	0.065
	$HICP_{TE,TR,IIR}$ →	-----	-----	0.001	-----		$IIR_{TE,TR,HICP}$ →	-----	-----	0.001	-----	0.000	$IP_{TE,TR,HICP}$ →	-----	-----	0.003	-----	0.011
	$HICP_{TE,TR,IP}$ →	-----	-----	0.000		-----	$IIR_{TE,TR,IP}$ →	-----	-----	0.000	0.001	-----	$IP_{TE,TR,IIR}$ →	-----	-----	0.001	0.000	-----
	$HICP_{TE,GDP,IIR}$ →	-----	***0.191***	-----	-----		$IIR_{TE,GDP,HICP}$ →	-----	***0.213***	-----	-----	0.000	$IP_{TE,GDP,HICP}$ →	-----		-----	-----	0.078
	$HICP_{TE,GDP,IP}$ →	-----	***0.122***	-----		-----	$IIR_{TE,GDP,IP}$ →	-----	0.006	-----	0.001	-----	$IP_{TE,GDP,IIR}$ →	-----		-----	0.019	-----
	$HICP_{TE,IIR,IP}$ →	-----	0.010	0.000	-----	-----	$IIR_{TE,HCIP,IP}$ →	-----	0.051	0.003	-----	-----	$IP_{TE,HICP,IIR}$ →	-----		0.012	-----	-----
	$HICP_{TR,GDP,IIR}$ →	0.000	-----	-----	-----		$IIR_{TR,GDP,HICP}$ →	0.000	-----	-----	-----	0.000	$IP_{TR,GDP,HICP}$ →	0.007	-----	-----	-----	0.009
	$HICP_{TR,GDP,IP}$ →	0.013	-----	-----		-----	$IIR_{TR,GDP,IP}$ →	0.041	-----	-----	***0.251***	-----	$IP_{TR,GDP,IIR}$ →	**0.107**	-----	-----	0.027	-----
	$HICP_{TR,IIR,IP}$ →	0.000	0.010	0.001	-----	-----	$IIR_{TR,HICP,IP}$ →	0.005	-----	0.000	-----	-----	$IP_{TR,HICP,IIR}$ →	0.017	-----	0.003	-----	-----
	$HICP_{GDP,IIR,IP}$ →	0.000	-----	-----		-----	$IIR_{GDP,HICP,IP}$ →	0.000	***0.105***	-----	-----	-----	$IP_{GDP,HICP,IIR}$ →	0.070		-----	-----	-----
5	$HICP_{TE,TR,GDP,IIR}$ →	-----	-----	-----	-----		$IIR_{TE,TR,GDP,HICP}$ →	-----	-----	-----	-----	0.000	$IP_{TE,TR,GDP,HICP}$ →	-----	-----	-----	-----	***0.167***
	$HICP_{TE,TR,GDP,IP}$ →	-----	-----	-----		-----	$IIR_{TE,TR,GDP,IP}$ →	-----	-----	-----	0.007	-----	$IP_{TE,TR,GDP,IIR}$ →	-----	-----	-----	0.030	-----
	$HICP_{TE,TR,IIR,IP}$ →	-----	-----	0.002	-----	-----	$IIR_{TE,TR,HICP,IP}$ →	-----	-----	0.000	-----	-----	$IP_{TE,TR,HICP,IIR}$ →	-----	-----	***0.035***	-----	-----
	$HICP_{TE,GDP,IIR,IP}$ →	-----	**0.111**	-----	-----	-----	$IIR_{TE,GDP,HICP,IP}$ →	-----	0.052	-----	-----	-----	$IP_{TE,GDP,HICP,IIR}$ →	-----		-----	-----	-----
	$HICP_{TR,GDP,IIR,IP}$ →	0.000	-----	-----	-----	-----	$IIR_{TR,GDP,HICP,IP}$ →	0.003	-----	-----	-----	-----	$IP_{TR,GDP,HICP,IIR}$ →	***0.174***	-----	-----	-----	-----

Notes:

1) HICP = Harmonized Index of Consumer Price, GDP = Gross Domestic Product, TE= Total Expenditures, TR= Total Revenues, IIR = Implicit Interest Rates, IP = Interest Payments.

2) Bold and italics denote non-significance at 10% level.

The PC algorithm results help to synthesise the direction of surviving relationships, whereas the dominant correlation measures between variables inform us about the intensity of the link. Both estimates are integrated into a causal map as shown in Figure 4. Thus, this figure shows the results in the case of the whole set of European countries for the final level obtained by using the PC algorithm. In this sense, we could highlight some interesting findings.

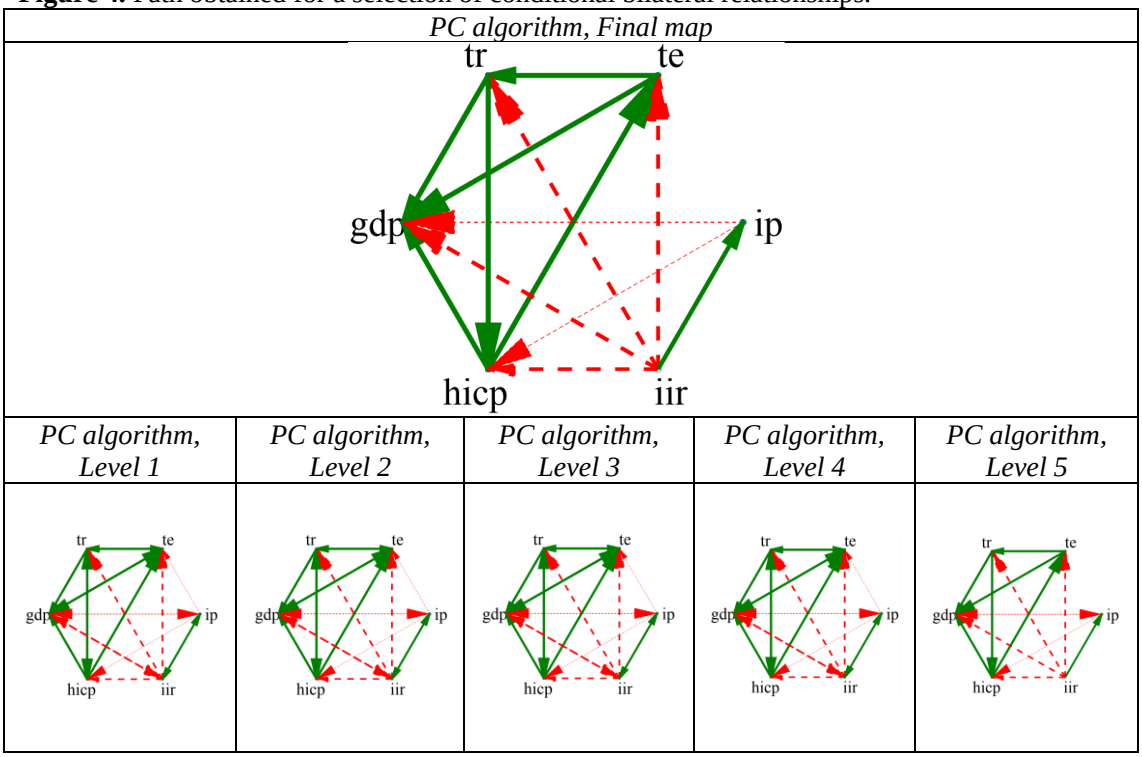
From a bird's eye view, we can see that there is a catalyst that could be the monetary policy indicators: interest rates and prices; and, to a lesser extent, Total Expenditures. On the other hand, the results show how GDP is sensitive to all indicators. Indeed, we could see that TE leadership could lead to some important implications in sustainability terms. The leading role of TE may be seen as twofold. On the one hand, we find evidence supporting the Keynesian view. On the other, it indicates a "warning" in fiscal sustainability as these increases in spending will result in pressures to increase public revenues. These movements are limited to keep a sound maximum tax burden and, therefore, may lead to the implementation of more restrictive spending policies in subsequent periods, potentially damaging the future evolution of other indicators (GDP, among others). Additionally, the gap in expenditure and revenue should be financed by debt and then rising debt increases debt servicing costs, thereby interest payments. The interest payment is being affected by the interest rate as well as inflation, both variables being the monetary policy indicators.

Besides, the link between TE and GDP could be explained by an "underground movement" ($TE \Rightarrow TR$ -spend-and-tax hypothesis- and $TR \Rightarrow GDP$) that conditions the primary relationship and provides added value and economic significance to the primary connection, and that ends up modelling in a larger and more complex system. Interestingly, as explained in the methodology section, GDP could act as a shielded collider, meaning how the public sector globally affects economic growth. Furthermore, as an example, the supply-leading hypothesis (SLH) appears when HICP causes GDP. Thus, we can observe that this fiscal sustainability is affected by HICP positively and IIR inversely. So, from a fiscal policy point of view, monetary indicators also play an important role in the design of policies. Importantly, the current institutional framework within the EMU shows the relevance of considering potential divergences of country-specific monetary policy impacts over time.

From a monetary point of view, one can see how an increase in HICP could be translated into a rise in TE and an increment in TR (for example, Spain and Germany have a growth of 19% and 7.9% of the tax revenues due to inflationary pressure in the first half of 2022, respectively) and being able to lead to an increase in GDP due to the force that inflation has subjected to the level of expenses and revenues. The relation HICP – IP concerns monetary policy -prices stability- and financial tools, indicating the more difficult access to financial resources when episodes with higher price volatility. Definitively, we can observe that HICP acts as a common cause, indicating an indexation of the economy. Furthermore, according to economic theory, one of the measures to struggle with inflation is the raising of interest rates. In this sense, the European Central

Bank raised rates at the beginning of September 2022 to tackle record inflation. This can be observed in the inverse relation between IIR and HICP. However, the impact of IIR on the rest of the indicators is latent. As we can see, if IIR is subject to a positive shock, it would be transmitted inversely to TE, TR and GDP. This inverse relation lets us think about the relevance of monetary policy in the goal of sustainability of public accounts. Finally, IP negatively affects GDP and HICP. The first relation (IP – GDP) would suggest that higher payment of interest would imply a minor level of Growth due to the restriction of having to pay debts or focus on the guide of an expense or investment policy. This can be applied to the rest of the indicators which are negatively affected by IP (HICP).

Figure 4. Path obtained for a selection of conditional bilateral relationships.



Source: Own elaboration using Causality Map Toolbox.

Notes:

1) HICP = Harmonized Index of Consumer Price, GDP = Gross Domestic Product, TE= Total Expenditures, TR= Total Revenues, IIR = Implicit Interest Rates, IP = Interest Payments.

2) Granger's Causality test obtained at 10% of significance level for 1999/q1-2019/q4. Variables are expressed as growth rates so that we ensure their stationarity. The solid (dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider the line, the higher this value.

Moreover, in Figure A1 in Appendix, we have included two new estimations to check the robustness of our econometric approach. They confirm the robustness of our estimates as our main findings hold[13]. These new estimates correspond to a model with five variables, swapping between IP and IIR and a new system with IP and IIR, respectively.

[13]In the Robustness check in Figure A1, we have modelled five variables and swapped Implicit Interest Rates (IIR) and Interest Payments (IP), obtaining that the main conclusions remain. We consider the (implicit) interest rate that governments pay on their debt, and maybe this IIR could explain in a better way the degree of uncertainty. Furthermore, in Figure A2 in Appendix, we have included estimates considering

In sum, it seems clear that fiscal variables (TE and TR) possess effects on growth (GDP) and these fiscal variables are affected by the monetary indicator (HICP). This latter link warns us about the dominance and importance of the monetary policy in this context, being important the synchronization between fiscal rules and monetary policies. Finally, the variables which represent the cost of debt service (IIR and IP) recognize the negative effect that debt holds on growth and fiscal sustainability.

5. Concluding remarks

In this paper, we have addressed the alternative interdependencies between indicators of fiscal sustainability, monetary policy, and economic growth. In our view, having a comprehensive understanding of the transmission channels during this period, before the emergence of COVID-19, is a prerequisite for successfully addressing the current challenges. This will also aid in properly analyzing the significant impact of the COVID-19 period in future studies with better data availability, considering the potential structural changes that current shocks may introduce in the Eurozone economy.

Previous analyses have been studied so far separately using bivariate/trivariate systems, testing only some of the potential relationships. Therefore, they have leaven out some potential explaining factors and missing relevant pieces of the economic drivers.

We have taken advantage of a novel approach for testing Granger causality in a multivariate panel data environment, as well as for determining one ultimate "causality path" excluding any redundant relationships (Gil-Bermejo et al., 2022). We have carried out a complete decomposition/integration of the different hypotheses that have been checked in the previous literature separately. In this sense, this methodology lets us analyse them jointly, contributing to expanding and improving the existing empirical evidence. In other words, compared to previous studies, we consider the full system (Shojaie and Fox, 2022) highlighting the need to consider more variables when designing more effective and impactful fiscal/monetary policies over time.

It is well-known that countries belonging to the EMU have considerable differences in terms of politics and economic structure. One of them is the difference regarding the design and application of fiscal policy, where each fiscal measure does not necessarily accompany those monetary policies applied by the ECB, generating greater pressure on the fiscal policy.

Thus, our results state that fiscal policy variables (public expenditure, in particular) seem to drive the force of revenues and GDP, whereas monetary variables are the catalysts in the whole causal map, conditioning the fiscal indicators. Additionally, prices become

Primary Expenditure (PE) instead of Total Expenditure (TE). As can be observed, the resulting causal maps are coincident.

an important indicator because it affects the fiscal variables and GDP. The key role of monetary policy on economic growth and public finance sustainability within the euro area countries reinforces the need of adopting reforms facilitating that monetary and fiscal policy could work together to engage their complementary effects. One promising step forward may be the issuance of mutualized debt by the ECB. Given the heterogeneity of the European countries, the monetary policy seems to hold a clear effect on an aggregate level.

Furthermore, our results evidence the need to clarify and value how different measures affect economic growth, taking care of the needed balance between expenditures and revenues, essential features for sound prospects of economic development. Indeed, it seems that public expenditures are the catalyst in both fiscal and growth sides, giving implications for policymakers in sustainability terms but with some cautions, indicating the need to take into consideration prudent policies due to increases in expenditures would cause rises in pressure to increase fiscal revenues. In other words, policymakers would need to attend to how much they will spend, and then make variations on revenue measures. Moreover, increases in expenditure could benefit other indicators such as GDP. However, this positive linkage is driven by a positive relationship with Total revenues. In this regard, policymakers would have to pay special attention to determining spending policies and combine them with adequate tax policies to ensure sustainable growth. All in all, European countries must consider the effect of inflation on fiscal policies to avoid adverse effects on public finance sustainability and macroeconomic stability. Finally, it would be desirable a mixed policy design that involves both fiscal and monetary policy measures to achieve a sound fiscal discipline.

All in all, our findings aim to identify the channels of the transmission mechanism during the first two decades of EMU and the need for coordinating fiscal–monetary policies. Thus, it seems to be important that, the latest steps taken towards fiscal policy synchronization and harmonization appear to be consistent with the results. Consequently, our results might contribute importantly to the design and evaluation of policies.

Our results are also strongly related to some of the major policy actions taken during our sample period. First, our findings show that EMU implementation and the higher price stability registered for most of the countries (compared to the nineties, for instance) contributed positively not only to aggregated economic activity but also to the relationship with fiscal policy indicators (TE and TR).

Finally, in the aftermath of the Great Recession, our findings prove that increases in the cost of the public debt service (IIR) may have been undermining the prospects of macro and fiscal indicators during the period, also indicating the major impact of adopting non-conventional measures of monetary policies, starting with Draghi's statement "whatever it takes" (26 July 2012), as mentioned above (Wanke, 2017).

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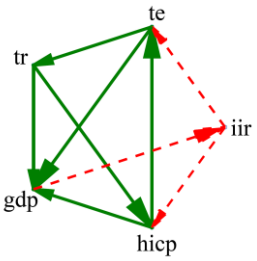
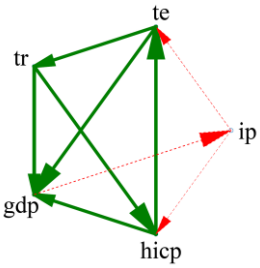
Appendix

Figure A1: Robustness check swapping IIR and IP.

PC algorithm, 5-VAR model with IIR	*PC algorithm, 5-VAR model with IP*
	

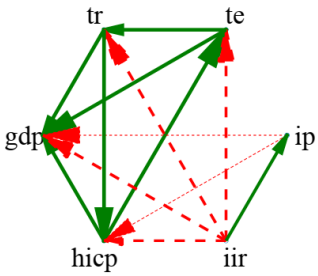
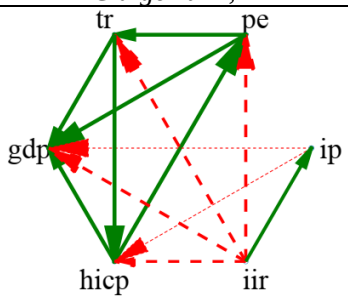
Source: Own elaboration using Causality Map Toolbox.

Notes:

1) HICP = Harmonized Index of Consumer Price, GDP = Gross Domestic Product, TE= Total Expenditures, TR= Total Revenues, IIR = Implicit Interest Rates, IP = Interest Payments.

2) Granger's Causality test obtained at 10% of significance level for 1999/Q1-2019/Q4. Variables are expressed as growth rates so that we ensure their stationarity. The solid (dashed) line indicates that the crossed-correlation between each pair of nodes is positive (negative). Finally, the wider is the line, the higher is this value.

Figure A2: Robustness check swapping TE and PE.

PC algorithm, TE	*PC algorithm, PE*
	

Source: Own elaboration using Causality Map Toolbox.

Notes:

1) HICP = Harmonized Index of Consumer Price, GDP = Gross Domestic Product, PE= Primary Expenditures, TR= Total Revenues, IIR = Implicit Interest Rates, IP = Interest Payments.

2) Granger's Causality test obtained at 10% of significance level for 1999/Q1-2019/Q4. Variables are expressed as growth rates so that we ensure their stationarity. The solid (dashed) line indicates that the crossed-correlation between each pair of nodes is positive (negative). Finally, the wider is the line, the higher this value.

Table A2. Summary of hypotheses under pairwise estimation

Relation	Hypotheses	Source
$EXP \Leftarrow REV$	Tax-and-spend hypothesis	Friedman (1978) Koren and Stiassny (1998) Kollias and Makrydakis (2000) Kollias and Paleologou (2006) Afonso and Rault (2009) Bolat (2014) Mutascu (2015, 2016) Bolat and Belke (2015) Tashevska (2020)
$EXP \Rightarrow REV$	Spend-and-tax hypothesis	Roberts (1978) Koren and Stiassny (1998) Kollias and Paleologou (2006) Afonso and Rault (2009) Paleologou (2013) Bolat (2014) Mutascu (2015, 2016) Bolat and Belke (2015)
$EXP \Leftrightarrow REV$	Fiscal synchronization hypothesis	Meltzer and Richard (1981) Kollias and Makrydakis (2000) Kollias and Paleologou (2006) Afonso and Rault (2009) Vamvoukas (2011) Paleologou (2013) Bolat and Belke (2015) Mutascu (2016) Tashevska (2020)
$EXP \quad REV$	Institutional separation hypothesis	Wildavsky (1988) Baghestani and McNown (1994) Kollias and Makrydakis (2000) Kollias and Paleologou (2006) Bolat (2014) Mutascu (2015, 2016) Bolat and Belke (2015)
$EXP \Rightarrow GDP$	Keynesian view	Loizides and Vamvoukas (2005) Kuckuck (2014)
$EXP \Leftarrow GDP$	Wagner's law	Dritsakis and Adamaopolos (2004) Loizides and Vamvoukas (2005) Durevall and Henrekson (2011)
$GDP \Rightarrow EXP$ $GDP \Rightarrow REV$	Full public finances pro-cyclicality	Balassone et al. (2010) Cronin and McQuinn (2021)
$GDP \Rightarrow INFL$	Demand-following hypothesis (DFH)	Nguyen and Wang (2010) Kim et al. (2013) Pradhan et al. (2015)
$GDP \Leftarrow INFL$	Supply-leading hypothesis (SLH)	Darrat (1988) Apergis (2004) Pradhan et al. (2013)
$GDP \Leftrightarrow INFL$	Feedback hypothesis (FBH)	Andrés and Hernando (1999) Andrés et al. (2004) Nguyen and Wang (2010) Kar et al. (2011)
$GDP \quad INFL$	Neutrality hypothesis (NLH)	Chowdhury (2002) Billmeier and Massa (2009) Vaona (2012)
$INFL \Rightarrow REV$	Fiscal drag	Ursprung and Wettstein (1992)

		Gros and Vandille (1995) Persson et al. (1998) Heinemann (2001) Immervoll (2005) Maza and Gonzalez-Paramo (1987) Sanz et al. (2004) Sanz and Romero (2007) Onrubia and Sanz (2009) Creedy and Sanz (2010) Martinez-Lopez (2017)
$INFL \Rightarrow EXP$ $INFL \Rightarrow REV$	Indexation of the economy	Gray (1976) Weaver (2010) De la Roca (2014) European Commission (2018a,b) Hohnerlein (2019) De la Fuente et al. (2019) Ayuso et al. (2021)
$IIR \Rightarrow EXP$ $IIR \Rightarrow REV$ $IIR \Rightarrow GDP$	Debt sustainability	Reinhart and Rogoff (2010), Bitar et al. (2018)

Notes: Own elaboration.