REM WORKING PAPER SERIES

Fiscal and External Sustainability: a Two-Step Time-varying Granger Causality Assessment

António Afonso, José Alves, José Carlos Coelho, Jamel Saadaoui

REM Working Paper 0369-2025

February 2025

REM – Research in Economics and Mathematics
Rua Miguel Lúpi 20,
1249-078 Lisboa,
Portugal

ISSN 2184-108X

REM – Research in Economics and Mathematics

Rua Miguel Lupi, 20
1249-078 LISBOA
Portugal

Telephone: +351 - 213 925 912
E-mail: rem@iseg.ulisboa.pt

https://rem.rc.iseg.ulisboa.pt/

https://twitter.com/ResearchRem

https://www.linkedin.com/company/researchrem/

https://www.facebook.com/researchrem/

Fiscal and External Sustainability: a Two-Step Time-varying Granger Causality Assessment*

António Afonso[$] José Alves[#] José Carlos Coelho[+] Jamel Saadaoui[±]

February 2025

Abstract

We implement a two-step analysis of fiscal and external causality patterns using a data set covering the 27 EU countries in the period 2002Q1-2023Q4. In the 1st step, we compute fiscal and external sustainability time-varying coefficients, modelling the cointegration relationship between government revenues and government spending, and between exports and imports. In the 2nd step, we use three recursive strategies, combined with Granger causality tests: forward expanding, rolling, and recursive window methods to capture causal relationships. Our results show that: (i) peripheral countries have lower sustainability coefficients, while non-Eurozone countries have higher sustainability coefficients, (ii) after the 2008 global financial crisis, there was an improvement in fiscal and external sustainability for most countries, (iii) during the Eurozone crisis in 2010-2012, in Austria, France, Greece, Ireland, Netherlands, Slovakia and Spain, there was causality between fiscal and external sustainability, (iv) during that period, causality was observed between the external and fiscal sustainability in EMU countries (Austria, Germany, Malta, Netherlands, Slovakia, Slovenia, Spain) and in non-EMU countries.

Keywords: fiscal sustainability; external sustainability; European Union; time-varying causality; lag-augmented vector autoregression

JEL codes: C22; C23; F32; F41; H30; H62

---

* This work was supported by the FCT (*Fundação para a Ciência e a Tecnologia*) [grant number UIDB/05069/2020]. The opinions expressed herein are those of the authors and do not necessarily reflect those of the authors' employers. Any remaining errors are the authors' sole responsibility.

$ ISEG - Lisbon School of Economics & Management, Universidade de Lisboa; REM/UECE. R. Miguel Lupi 20, 1249-078 Lisbon, Portugal. CESifo Research Network Fellow. CESifo (Center for Economic Studies and Ifo Institute); email: aafonso@iseg.ulisboa.pt.

ISEG – School of Economics and Management, Universidade de Lisboa; REM – Research in Economics and Mathematics, UECE – Research Unit on Complexity and Economics. CESifo Research Fellow (Center for Economic Studies and Ifo Institute); email: jalves@iseg.ulisboa.pt.

+ ISEG – School of Economics and Management, Universidade de Lisboa; REM – Research in Economics and Mathematics, UECE – Research Unit on Complexity and Economics. Email: josecoelho@iseg.ulisboa.pt.

± University Paris 8, IEE, LED, France. Email: jamelsaadaoui@gmail.com.

1. Introduction

Fiscal sustainability has been a topical issue in the last years, notably in the context of the European Union (EU), where a common fiscal framework is in place as guidance for the respective Member States' fiscal authorities. This framework, with some additional adjustments, dates back to the Stability and Growth Pact (SGP), and to the start of the 3rd phase of the Economic and Monetary Union, in January 1999. In the context of the SGP, specifically considering the preventive arm and of the corrective arm (notably the Excessive Deficit Procedure), fiscal sustainability has always been a main tenet, both to ensure sound fiscal policies and to provide a stable environment for the implementation of the common monetary policy in the Euro Area countries.[1]

After the Global Financial Crisis (GFC), which impacted adversely EU's public accounts and external positions, particularly prompting international financing programs, notably for Greece, Portugal, and Ireland, the EU put forward in 2011, in addition to the common fiscal surveillance, also a so-called Macroeconomic Imbalance Procedure (MIP). With this surveillance mechanism, Member States intended to identify, prevent and address the emergence of potentially harmful macroeconomic imbalances, and external sustainability issues, in a particular Member State, the Euro Area, or the EU as a whole. Hence. The MIP foresees the possibility of enhanced surveillance for countries identified with excessive imbalances named the Excessive Imbalance Procedure.[2]

Therefore, the questions of fiscal sustainability and external sustainability are paramount, and can also be framed in the Twin Deficit Hypothesis (TDH) where fiscal deficits tend to translate into current account deficits. Indeed, the TDH relationship can be explained in the framework of the Mundell-Fleming Model, stemming from the macro accounting identity for aggregate demand, where the current account balance is defined as the sum of net private saving (net lending position of the private sector) and net public saving (general government balance). Hence, a fiscal shock could drive the current account in the same direction.[3] For instance, a government budget deficit can cause a current account deficit when the government budget is not fully financed by domestic private saving and needs foreign capital inflows as well.

[1] To limit government deficit and debt, EU Member States have agreed reference fiscal thresholds, enshrined in the EU treaties: a 3% deficit ratio and a 60% debt ratio (calculated relative to a Member State's GDP).
[2] One of the Scoreboard Indicators in the MIP is that the 3-year backward moving average of the current account balance as percent of GDP, should be within the thresholds of +6% and -4%.
[3] See Appendix TDH.

Nevertheless, a budget deficit can lead to an increase in the net lending position of the private sector, and then no effect on the current account balance occurs.

More specifically, we are then interested in assessing the relationship between the fiscal sustainability and the external sustainability for EU countries. In other words, in this paper we check four possible scenarios: whether the fiscal sustainability Granger causes the external sustainability, if the external sustainability Granger causes the fiscal sustainability, if there is bi-directional Granger causality, or if there is no relationship between fiscal and external sustainability.

Therefore, we use a data set covering the 27 EU countries during the period 2002Q1-2023Q4 to implement a two-step analysis of fiscal and external causality patterns. In the 1st step, and using Schlicht's (2021) method, we compute the fiscal and external sustainability time-varying coefficients, modelling, on the one hand, the cointegration relationship between government revenues and government spending, and on the other hand, the cointegration relationship between exports and imports. In the 2nd step, we then use a lag-augmented vector autoregression with three recursive strategies, combined with Granger causality tests; the forward expanding window method; the rolling window method; and the recursive evolving window method to capture the potential causal relationships.

Our main results show that: (i) peripheral countries have lower sustainability coefficients, while non-Eurozone countries have higher sustainability coefficients, (ii) after the 2008 global financial crisis, there was an improvement in fiscal and external sustainability for most countries, (iii) during the Eurozone crisis in 2010-2012, in Austria, France, Greece, Ireland, Netherlands, Slovakia and Spain, there was causality between fiscal and external sustainability, (iv) during that period, causality was observed between the external and fiscal sustainability in EMU countries (Austria, Germany, Malta, Netherlands, Slovakia, Slovenia, Spain) and in non-EMU countries. Hence, the patterns of causality between the fiscal and external sustainability have specificities in each country.

The organization of the paper is as follows. Section 2 provides the literature review. Section 3 explains the methodology. Section 4 presents the data, and section 5 carries out the empirical analysis. Section 6 concludes.

2. Literature review

2.1. Fiscal and external sustainability

The literature has addressed fiscal and external sustainability related issues in the past. Hamilton and Flavin (1986), for example, carry out stationarity tests on the budget balance and public debt in a pioneering study applied to the United States. The methodology for studying the properties of public debt became very popular based on this article. The analysis of the cointegration relationship between government revenues and expenditures (Hakkio and Rush, 1991) is another method to examine the sustainability of public finances. According to these authors, if government revenues and expenditures are non-stationary, the existence of cointegration between both variables is a necessary condition for the government to comply with the present value budget constraint (PVBC), and, therefore, to ensure fiscal solvency.

Furthermore, there is the perspective of Bohn (1998) who maintains that fiscal sustainability is ensured if the primary government balance responds positively to increases in the public debt-to-GDP ratio (backward-looking approach). This is consistent with a Ricardian fiscal (or monetary predominance) regime, in which the government has to attain primary government surpluses in order that its budget constraint is consistent with the repayment of the initial stock of real public debt. Canzoneri et al. (2001), along with Bohn (1998), are part of the literature on so-called fiscal reaction functions, being the perspective of Canzoneri et al. (2001) forward-looking. Hence, in a Ricardian regime, a budget surplus results in the reduction of public debt in the future. Earlier, Trehan and Walsh (1991) note that the stationary of the first differences of the stock of real public debt is a sufficient condition for fiscal sustainability.

The empirical literature on fiscal sustainability initially focused on individual countries or small groups of countries and was based on unit root tests and the study of the causality and cointegration relationship between government revenues and expenditures (Haug, 1995; Getzner et al. 2001). Within the scope of the empirical literature on fiscal sustainability, later, studies emerged using a panel data structure from a relatively wide range of countries, employing standard panel techniques as well as examining panel cointegration relationships (Afonso, 2008; Afonso and Rault, 2010). The use of data with an annual frequency is a common view of analysis (Weinchenrieder and Zimmer, 2014; Lee *et al.*, 2018), however, we can find studies that use quarterly data (Afonso and Jalles, 2017; Afonso and Coelho, 2023). In several articles, the empirical scope comprises the European Union or even Euro Area countries (Vanhorebeek and Rompuy, 1995; Afonso, 2005; Brady and Magazzino, 2018; Afonso et al., 2021).

Regarding the topic of external sustainability, we can identify two complementary definitions of external accounts solvency, namely: (i) current net foreign assets must equal the symmetric of the sum of future net exports (the economy will have to achieve future net exports whose present value covers the symmetric of the current value of net foreign assets); and (ii) the present value of current net foreign assets is zero in infinity (in order to ensure a sustainable path for the external position).

The absence of Ponzi games is empirically tested by studying the stationarity of the stock of current net foreign assets in first differences. From a practical point of view, the stationarity of the current account balance is tested. In the same way as in the analysis of fiscal sustainability, the rejection of stationarity does not mean the absence of sustainability (according to Trehan and Walsh, 1991). In addition, external sustainability can be also tested through cointegration tests between exports and imports of goods and services. A current account balance would be sustainable if the series of exports and imports of goods and services are cointegrated (Husted, 1992; Wu, 1996). A sufficient condition for the intertemporal constraint to hold is that there is a negative relationship between net exports and net foreign assets (see Durdu et al., 2013).

Empirically, external sustainability can be analyzed from two perspectives, both of which are related to the intertemporal current account constraint. The first perspective considers the macroeconomic determinants of this restriction to compute the required adjustments (see, for instance, Afonso et al., 2019, based on Milesi-Ferretti and Razin, 1996). The second perspective performs time-series and panel data tests to ascertain the behavior of the current account balance, exports and imports of goods and services over time.

More specifically, Afonso et al. (2019) analyse external sustainability for 22 European Union countries between 1970Q1 and 2015Q4 according to two perspectives. In particular, the authors found evidence of sustainability of the current account balance and cointegration between exports imports of goods and services in just a few countries. In turn, Afonso et al. (2020) examine external sustainability considering the same sample and conclude that the current account balance is non-stationary, although there is a stable long-term relationship between exports and imports of goods and services.

Within the scope of the second perspective of the empirical analysis of the external sustainability, unit root tests of the current account balance are carried out (Raybaudi et al., 2004; Chen, 2011), with cointegration tests between exports and imports (Husted, 1992; Camarero et al., 2013) or both (Wu, 1996; Holmes, 2013). Moreover, there are also nonlinear approaches, which admit structural breaks, regime shifts and threshold values (Apergis et al., 2000; Chen, 2014; Lanzafame, 2014; Camarero et al., 2015; Andre et al., 2018), and the use of error correction models to assess reaction functions of net exports to net foreign assets (Durdu et al., 2013; Bajo-Rubio et al., 2014). These analyzes are applied to individual countries (Raybaudi et al., 2004; Camarero et al., 2013) as well as to panels of countries, namely developed and emerging, OECD and Euro Area (Holmes, 2006; Camarero et al., 2015).

Although there are studies that use a quarterly data frequency (Chen, 2011, 2014), the use of annual data is more usual (Husted, 1992; Bajo-Rubio et al., 2014).

2.2. Interplay between fiscal and external accounts

The literature advances five perspectives to explain the relationship between the government balance and the external balance, namely: (i) the Twin Deficit Hypothesis; (ii) the Ricardian Equivalence Hypothesis; (iii) the Current Account Targeting Hypothesis; (iv) the feedback linkage; and (v) the Twin Divergence Hypothesis.

The Twin Deficit Hypothesis (TDH) states that the fiscal deficit tends to result in a current account deficit. This relationship can be explained in the framework of two perspectives: the Mundell-Fleming Model (Mundell, 1960; Fleming, 1962) and the Keynesian Absorption Theory. From the first perspective, in an economy with a flexible exchange rate regime, a fiscal deficit leads to higher domestic real interest rates, which in turn attracts foreign capital flows and results in an appreciation of exchange rates. A stronger national currency reduces net exports and translates into a loss of the economy's external competitiveness, which in turn creates an external accounts deficit. In a fixed exchange rate regime, an increase in government deficit results in an increase in prices and income, which consequently leads to a real appreciation of the currency, which it turns negatively affects the current account balance. The second perspective suggests that an increasing government deficit can translate in upward pressure on domestic absorption, which results in increased domestic spending, and thus contributes to increased imports, leading to a deterioration in the current account balance.

Abell (1989) and Rosenweig and Tallman (1993), using Vector Auto-Regressive (VAR) models and impulse response functions, corroborate this perspective for the United States. More recently, McFarlane *et al.* (2020) and Kim (2024) confirm this result. Also using quarterly data, Makin and Narayan (2013) for Australia and Janko (2020) for Canada obtain evidence from the TDH, using cointegration tests and an Autoregressive Distributed Lag (ARDL) model. Furthermore, Vamvoukas (1999) for Greece, Daly and Siddiki (2009) for OECD countries, and Trachanas and Katrakilidis (2013) for Greece, Ireland, Italy, Portugal and Spain conclude by verifying the causality between the fiscal balance and the external balance.

The Twin Deficits Hypothesis, in addition to being corroborated by time series studies, which are generally applied to individual countries or to a group of countries with similar characteristics, is also confirmed by studies using panel data. These studies, which are less frequent than the first type, apply the usual econometric panel estimation techniques (e.g., for large panels, Altayligil and Çetrez, 2020; for OECD countries, Piersanti, 2000; for European Union countries, Afonso and Coelho, 2022).

According to the Ricardian Equivalence Hypothesis (REH) (Barro, 1974; 1989), the fiscal balance and the external balance are unrelated, as fiscal changes induce an intertemporal reallocation of savings (with intertemporal substitution between taxes and government deficits), whereas the intertemporal fiscal constraints of private agents, the real interest rate, investment, and the current account balance all remain unchanged. Therefore, fiscal deficits do not result in changes in interest and exchange rates and the effects on the current account are null, and there is no relationship between the budget balance and the external balance. Algieri (2013) reports empirical support for the REH for Greece, Ireland, Italy, Portugal and Spain, through causality tests and using data with a quarterly frequency.

An inverse relationship could also exist which moves in the direction of the external accounts to the public accounts. The underlying idea is that the external position of an economy can deteriorate because of factors that are exogenous to its fiscal position. In this scenario, a government deficit can respond to this deterioration and adjust to stabilise the economy. Adjustment can be made by using automatic stabilisers and/or discretionary fiscal policies. Summers (1988) referred to this inverse relationship as “Current Account Targeting”. In this context, there is an inverse and positive relationship from the current account balance to the government balance. The Current Account Targeting Hypothesis (CATH) has empirical support in Kalou and Paleologou (2012) and Nikiforos *et al.* (2015) for Greece, through cointegration and causality tests and a Vector Error-Correction (VEC) model.

Feldstein and Horioka (1980), for 21 OECD countries, between 1960 and 1974, and using a Simultaneous Equations Model (SEM), point that savings and investment are highly correlated and thus this linkage translates into bi-directional relationship between the fiscal balance and the current account balance, with both variables moving together. As the relationship between variables occurs in both directions, this result may support both the TDH and CATH. Using quarterly data between 1960 and 1984 for the United States, Darrat (1988) concludes that there is a bi-directional relationship between the budget balance and the trade balance.

Lastly, Kim and Roubini (2008) assess the existence of endogenous movements of the fiscal deficit and the current account deficit, for the United States. They suggest that “twin divergence” is also likely, i.e., the current account deficit can improve when the government deficit worsens. This result, induced by an increase of the real interest rate (due to an expansionary fiscal policy), is attributed to two factors, namely, a partial Ricardian movement of private savings and a crowding out effect on investment.

3. Methodology

3.1. Time-varying fiscal and external sustainability

In the first step, and in order to measure fiscal and external sustainability, we follow notably Afonso (2005) and Afonso et al. (2019) approaches, respectively. Specifically, and regarding the fiscal sustainability, we rely on the cointegration relationship method between government revenues (R) and government expenditures (G), while for the external sustainability we look for the cointegration between exports (X) and imports (M). However, as we intend to use the time-varying sustainability coefficients and not an average value for a given time period, we rely on the Schlicht's (2021) method, we compute the fiscal and external sustainability coefficients through equations (1) and (2), respectively:

$$R_t = \alpha_{0,i,t} + \beta_{i,t}.G_{i,t} + u_t \quad (1)$$

$$X_t = \alpha_{0,i,t} + \gamma_{i,t}.M_{i,t} + \varepsilon_t \quad (2)$$

where $\beta_{i,t}$ and $\gamma_{i,t}$ are the fiscal and external sustainability coefficients to be estimated for each quarter t and for each country i, respectively The closer are β and γ to unity, the higher are the fiscal and external sustainability. As mentioned above, equations (1) and (2) are estimated resorting to Schlicht's (2021) methodology, which assumes that β and γ changes "slowly and unsystematically over time":

$$\beta_t = \beta_{t-1} + \nu_t \quad (3)$$

$$\gamma_t = \gamma_{t-1} + \epsilon_t \quad (4)$$

where $\nu_t \sim N(0, r^2)$ and $\epsilon_t \sim N(0, r^2)$.

Building on Schlicht (2021), equations (1) and (3), along with equations (2) and (4), should be estimated simultaneously. The authors propose a method that extends the linear model by allowing the independent variables to vary gradually over time, unlike the static assumption of the linear model. The expected value of the fiscal (external) response coefficient at time t is assumed to be the same as its value at time $t-1$, following a random walk process. The variation in the coefficients, represented by ν_t (or ϵ_t, for external sustainability), is assumed to follow a normal distribution with a mean of zero and a variance of r^2. These variances r^2 are estimated using a method of moments estimator, which coincides with the maximum-likelihood estimator for large samples but is more efficient and transparent for small samples. Thus, the standard regression model is a special case where r^2 approaches zero, resulting in $\beta_t = \beta_{t-1}$ (or $\gamma_t = \gamma_{t-1}$, for external sustainability). By allowing r^2 to be small but non-zero, the coefficients are permitted to evolve slowly over time, starting from the previous year's coefficients and incorporating any changes or deviations that occurred during that year.

Furthermore, we have assessed the presence of unit roots in each series for each country, as presented in Table A1, in the Appendix, concluding that those series are mostly stationary at first differences. Therefore, and as previously allured, we have computed the time-varying fiscal, β, and external coefficients, γ, resorting to the Schlicht's (2021) approach, in order to assess the time-varying Granger causality between fiscal and external sustainability.

3.2. Time-varying Granger causality

Following Shi et al. (2020), we rely on the lag-augmented vector autoregression (LA-VAR) approach (Toda and Yamamoto, 1995; Dolado and Lütkepohl, 1996) for testing time-varying causality between fiscal sustainability (external sustainability coefficient series) and external sustainability (fiscal sustainability coefficient series). This approach does not require any choices concerning the detrending or differencing of the series. Besides, it explicitly allows for unknown changing points in the causal relationships. This approach relies on a series of non-Granger causality tests (i.e., the null is the absence of Granger-causality between the variables). These tests are robust to structural breaks, large-scale events that produces regime changes. The LA-VAR model is expressed as follows for an *n*-dimensional vector y_t,

$$y_t = \gamma_0 + \gamma_1 t + \sum_{i=1}^{k} J_i y_{t-i} + \sum_{j=k+1}^{k+d} J_j y_{t-j} + \varepsilon_t \tag{5}$$

where t is a time trend, k is the lag order of the original VAR model, d denotes the maximum order of integration of the variables in y_t, and ε_t is the error term. The regression can also be written as follows:

$$y_t = \mathbf{\Gamma}\tau_t + \mathbf{\Phi}x_t + \mathbf{\Psi}z_t + \varepsilon_t, \tag{6}$$

where

$\mathbf{\Gamma} = (\gamma_0, \gamma_1)_{n\times 2}$, $\tau_t = (1, t)'_{2\times 1}$, $x_t = (y'_{t-1}, \dots, y'_{t-k})'_{nk\times 1}$, $z_t = (y'_{t-k-1}, \dots, y'_{t-k-d})'_{nd\times 1}$,

$\mathbf{\Phi} = (J_1, \dots, J_k)_{n\times nk}$, and $\mathbf{\Psi} = (J_{k+1}, \dots, J_{k+d})_{n\times nd}$.

The **null hypothesis of Granger non-causality** is given by the restrictions:

$$H_0: \boldsymbol{R}\phi = 0 \tag{7}$$

where $\phi = vec(\mathbf{\Phi})$ using row vectorization, and $\boldsymbol{R}$ is a $m\times n^2k$ matrix. The elements of the coefficient matrix $\mathbf{\Psi}$ of the final d lagged vectors are taken to be zero. Then, equation (5) can be extended to a more compact form as:

$$Y = \tau\mathbf{\Gamma}' + X\mathbf{\Phi}' + Z\mathbf{\Psi}' + \varepsilon \tag{8}$$

where $Y = (y_1, y_2 \dots, y_T)'_{T\times n}$, $\tau = (\tau_1, \dots, \tau_T)'_{T\times 2}$, $X = (x_1, \dots, x_T)'_{T\times nk}$, $Z = (z_1, \dots, z_T)'_{T\times nd}$, and $\varepsilon = (\varepsilon_1, \dots, \varepsilon_T)'_{T\times n}$. Let $Q_\tau = I_T - \tau(\tau'\tau)^{-1}\tau'$ and $Q = Q_\tau - Q_\tau Z(Z'Q_\tau Z)^{-1}Z'Q_\tau$.

The OLS estimator is:

$$\widehat{\mathbf{\Phi}} = Y'QX(X'QX)^{-1}. \tag{9}$$

The standard Wald statistic $\mathcal{W}$ to test the hypothesis H_0 is:

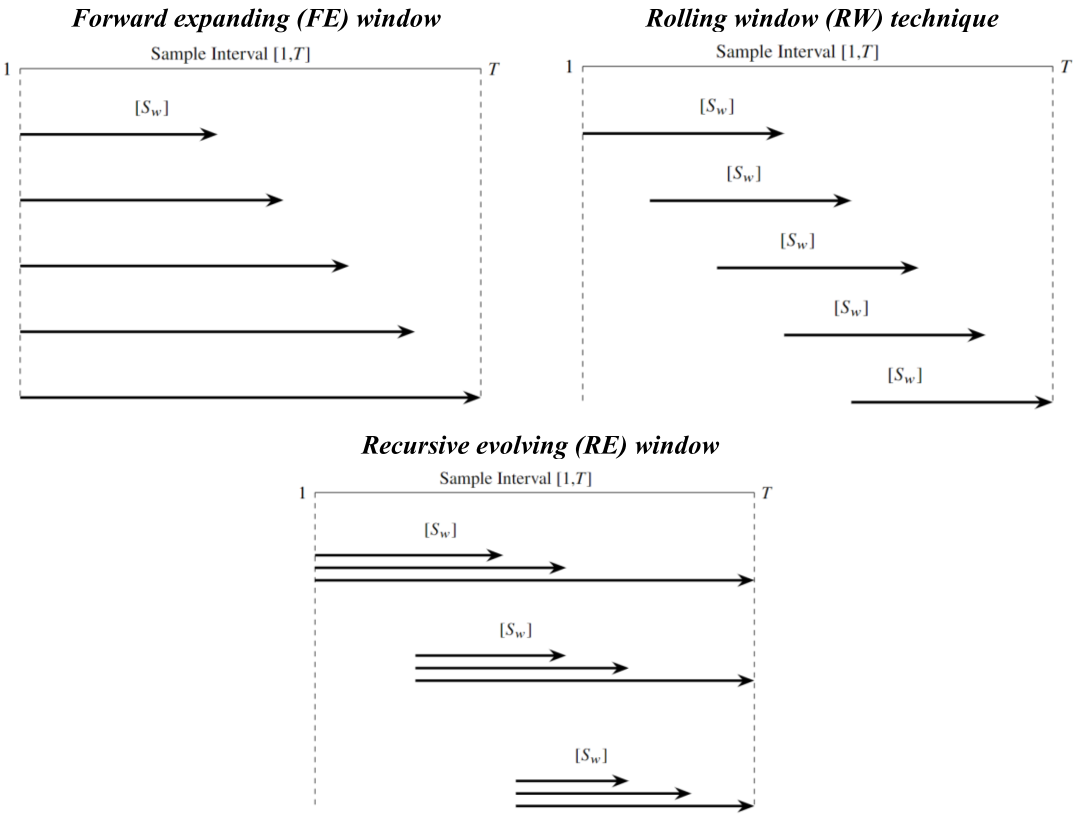
$$\mathcal{W} = (\boldsymbol{R}\hat{\phi})'\left[\boldsymbol{R}\left\{\hat{\Sigma}_\varepsilon \otimes (X'QX)^{-1}\right\}\boldsymbol{R}'\right]^{-1}\boldsymbol{R}\hat{\phi}, \tag{10}$$

where $\hat{\phi} = \mathrm{vec}(\widehat{\mathbf{\Phi}})$, $\hat{\Sigma}_\varepsilon = \frac{1}{T}\hat{\varepsilon}'\hat{\varepsilon}$, and $\otimes$ denotes the Kronecker product.

Three recursive strategies, combined with Granger causality tests, can be used: (i) the forward expanding (FE) window method; (ii) the rolling window (RW) method; and (iii) the recursive evolving (RE) window method. According to the simulations by Shi et al. (2020), the RE window algorithm provides the most reliable results, followed by the RW method.[4]

[4] In their simulations, Shi et al. (2020) considered different cases for the order of integration in a bivariate VAR model: both variables are stationary (case 1), one variable is I(1) and the other one is stationary (cases 2 and 3), and both are non-stationary (case 4). All the tests are very close to the nominal size of 5 percent and the RE method shows power improvements when (a) the causal strength is moderate (0.8), (b) the sample size is large (T=200, T=300), and (c) the minimum window size is below 24% of the observations.

Figure 1. Forward expanding, rolling, and recursive evolving windows schemes



Source: Adapted from Baum et al. (2021, 2022).

Specifically, the FE window method fixes the starting point at the first observation and moves the ending points from S_w to T (see Figure 1). Next, the RW technique moves the starting and ending points together with a constant distance S_w. The window size is thus kept constant across the time variation. Regarding the RE window method, the ending point S_2 varies across the range $[S_w, T]$. However, the starting point changes from 1 to $(S_2 - S_w) + 1$.

Thanks to the aforementioned recursive strategies, we can obtain a series of Wald statistics[5] $\{\mathcal{W}_{S_1,S_2}\}_{S_2 \geq S_w}^{S_1 \in [1,(S_2-S_w)+1]}$. To test for the Granger non-causality hypothesis, Shi et al. (2020) propose a sup-Wald statistic when recursive evolving window technique is utilized:

$$Sup - \mathcal{W}_{Sw} = \sup_{S_2 \geq S_w, S_1 \in [1,(S_2-S_w)+1]} \{\mathcal{W}_{S_1,S_2}\}. \quad (11)$$

Alternatively, Shi et al. (2020) construct a sub-sample Wald test statistic with heteroskedastic

[5] When S_w is equal to S_2, then S_1 is equal to 1 and the window size can expand until reaching S_2, as can be seen in the upper part of Figure 3. When S_w is equal to $(1/2)S_2$, then S_1 is equal to 1/2 and the window size can expand until reaching S_2, as can be seen in the lower part of Figure 3.

errors:

$$\mathcal{W}^* = T_w\left(\mathbf{R}\hat{\phi}\right)'\left[\mathbf{R}\{\hat{V}^{-1}\hat{\Sigma}\hat{V}^{-1}\}\mathbf{R}'\right]^{-1}\mathbf{R}\hat{\phi}, \tag{12}$$

where $\hat{\phi} = \text{vec}\left(\hat{\mathbf{\Phi}}\right)$ and $\hat{\mathbf{\Phi}}$ is the OLS estimate for the sub-sample running from S_1 to S_2. Besides:

$$\begin{aligned} &\hat{V} = I_n \otimes \hat{Q} \text{ with } \hat{Q} = \frac{1}{T_w}\sum x_t x_t', \\ &\hat{\Sigma} = \frac{1}{T_w}\sum \hat{\xi}_t\hat{\xi}_t' \text{ with } \hat{\xi}_t = \hat{\varepsilon}_t \otimes x_t. \end{aligned} \tag{13}$$

Therefore, the heteroskedastic-consistent sup-Wald test statistic can be expressed as:

$$\mathcal{S}up - \mathcal{W}_{SW}^* = \sup_{S_2 \geq S_w, S_1 \in [1,(S_2 - S_w)+1]} \{\mathcal{W}_{S_1,S_2}^*\}. \tag{14}$$

The main advantage of this methodology, fully described in Shi et al. (2020), is that the null of absence of causality is not constrained to be fulfilled over the whole sample. In this sense, the approach that we use in the paper is more general. Thus, these tests are more dependable and have more economic underpinnings than standard Granger causality tests. Three outcomes are possible with these tests: (i) absence of causality over the full period; (ii) causality over specific periods; and (iii) causality over the whole sample. In the first case, the causality between fiscal and external sustainability is absent. In the second case, the causality between fiscal and external sustainability is observed over specific subperiods and can support the "twin deficit" channel and/or the "international spillover" channel. In the third case, the causality is observed over the full sample period as in the standard Granger causality tests.

4. Data

Our study comprises 27 European countries, namely, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, covering the 2002Q1-2023Q4 period.

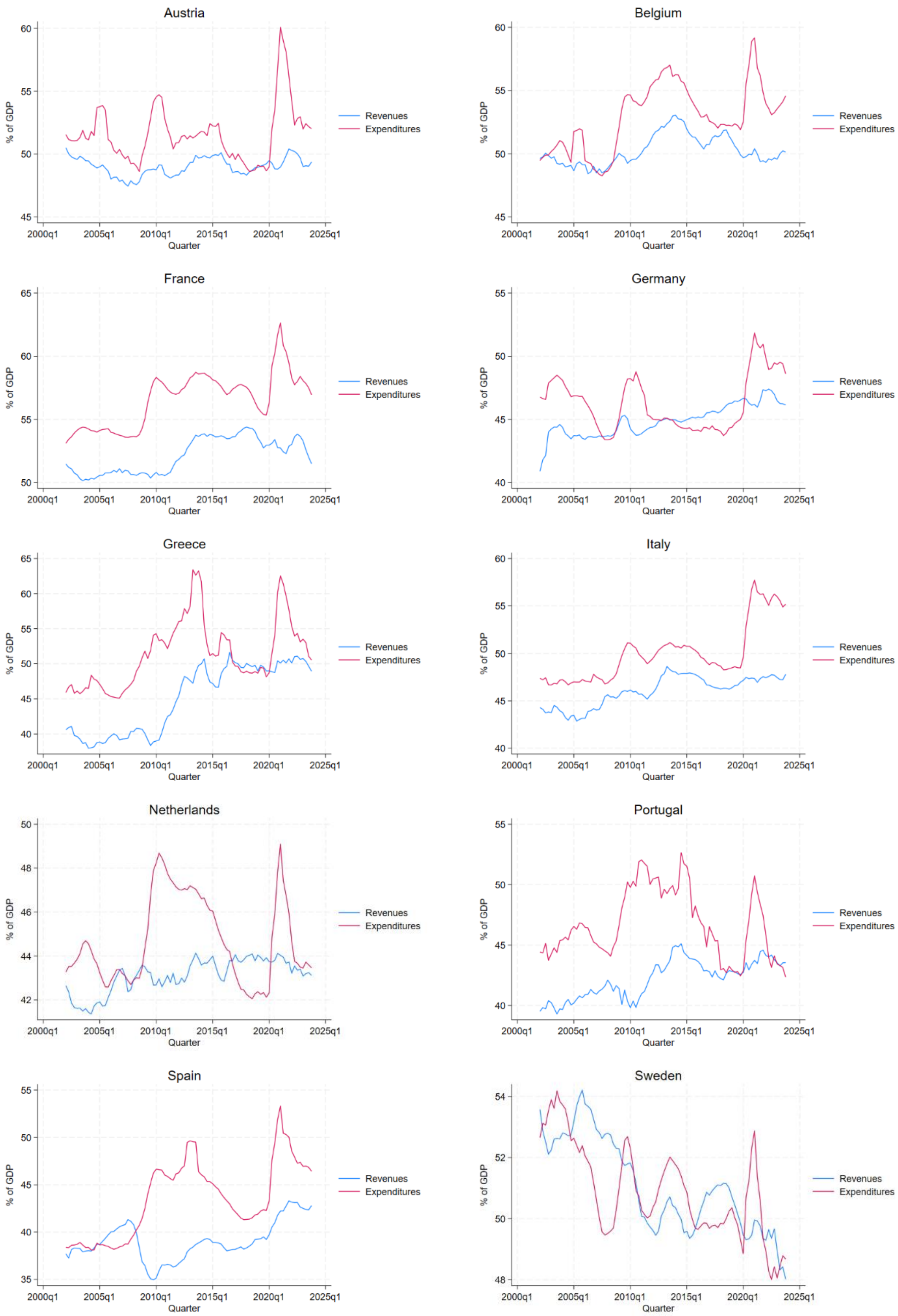
The data on government revenues and expenditures to compute the time-varying fiscal sustainability as well as the data on exports and imports to obtain the time-varying external sustainability coefficients were retrieved from the Eurostat database. Regarding the government revenues and expenditures dynamics as well as exports and imports evolution though time, in Figures 2 and 3, we have highlighted such dynamics for some selected countries. Generally, while there is an overall co-movement between exports and imports, translating a more balanced external sector, the dynamics between government revenues and expenditures follow sometimes opposite directions, emphasizing some periods of fiscal imbalances.

These perceptions are somehow corroborated by the descriptive statistics for the full sample, presented in Table 1. As can be observed, the average time-varying external sustainability coefficient (γ = 0.744) is five times larger than the average time-varying fiscal sustainability coefficient (β = 0.140), highlighting the dissociation between the two sustainability coefficients. Additionally, in Table 2, we present the average time-varying fiscal and external sustainability per country, further illustration the higher magnitude of the external sustainability estimated coefficients. In Figure 4, a temporal dynamics of these coefficients is depicted for some selected EU economies where some co-movement is visible.

Table 3 reports the averages of the time-varying coefficients of fiscal and external sustainability for several groups of EU countries: core, periphery, Baltic, Central and Eastern, Euro Area and non-Euro Area.[6] We consider this distinction between Euro Area and non-Euro Area since the loss of the exchange rate policy may lead some economies to suffer from recurrent external imbalances that forced some financial and fiscal international program interventions, namely the peripheral Euro Area economies. The distinction between Euro Area and non-Euro Area countries may further elucidates the impact of monetary union on fiscal and external sustainability.

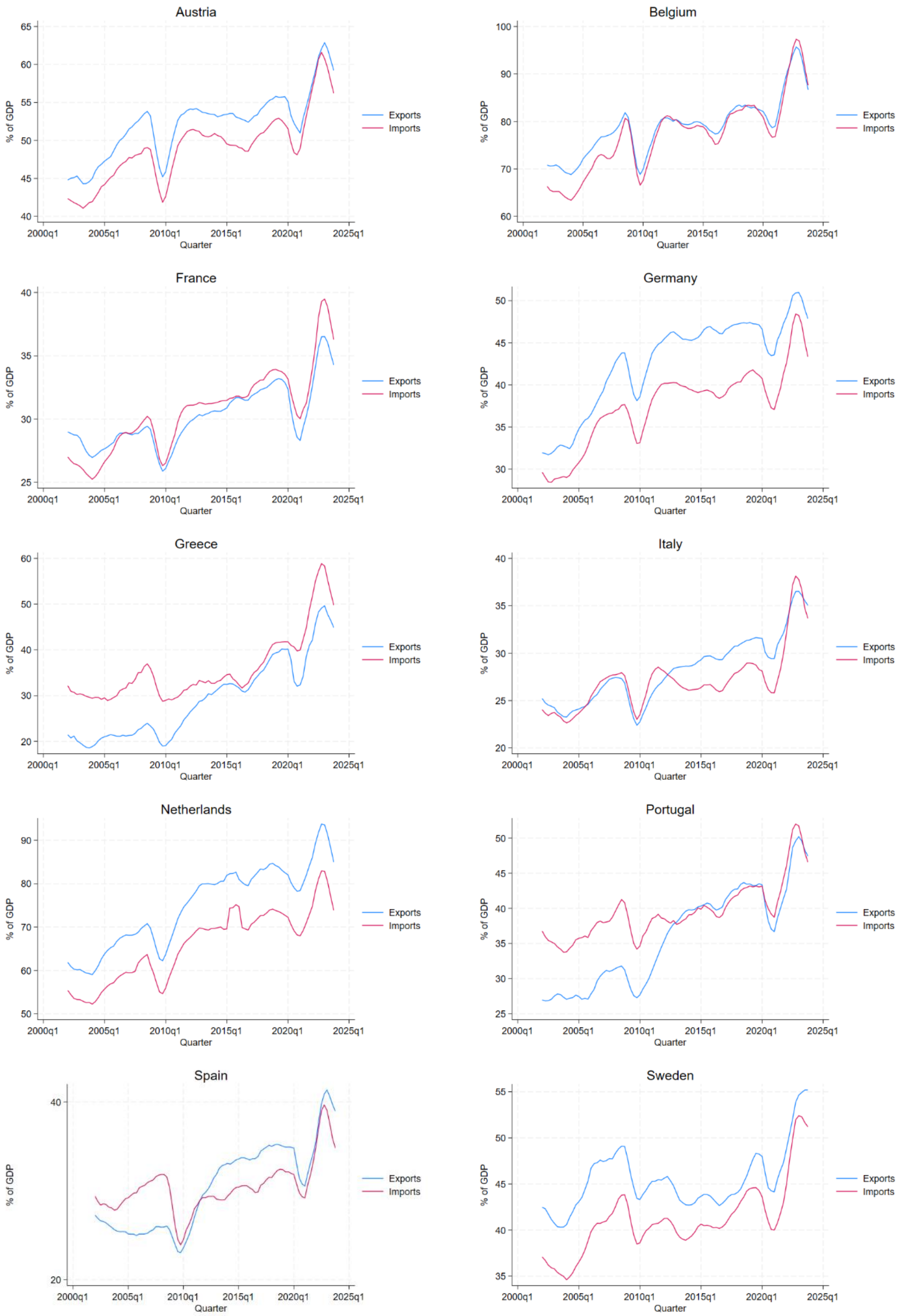
[6] The core EU countries' group is composed by Austria, Belgium, Denmark, Finland, France, Germany, Luxembourg, the Netherlands, and Sweden. In the peripheral EU countries' group, we consider Cyprus, Greece, Ireland, Italy, Malta, Portugal and Spain. Estonia, Latvia and Lithuania belong to the Baltic EU countries' group. The Central and Eastern EU countries' group integrates Bulgaria, Croatia, Czechia, Hungary, Poland, Romania, Slovakia, and Slovenia. The Euro Area countries are: Austria, Belgium, Croatia, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain. In turn, the non-Euro Area countries are: Bulgaria, Czechia, Denmark, Hungary, Poland, Romania, and Sweden.

Figure 2. Relationship between government revenues and government expenditures for selected countries, 2002Q1-2023Q4



Source: EUROSTAT database.

Figure 3. Relationship between exports and imports for selected countries, 2002Q1-2023Q4



Source: EUROSTAT database.

In particular, Table 3 shows that the average of the time-varying coefficients of fiscal sustainability for the core countries is lower when considering all the countries. However, the average time-varying coefficients of external sustainability are higher. In turn, peripheral countries exhibit lower averages in relation to core countries and the full sample for both fiscal and external sustainability coefficients. For the Baltic countries, the average fiscal sustainability coefficients are higher compared to the full sample; in the case of external sustainability coefficients, the average is lower. Central and Eastern countries exhibit higher averages relative to the full sample. Comparing countries that belong to the Eurozone and those that do not belong to the Eurozone, the average values of the time-varying coefficients of fiscal and external sustainability are lower for countries that are part of the Eurozone.

Table 1. Descriptive Statistics, full sample

Variable	*Mean*	*Std. Dev.*	*Max.*	*Min.*	*Obs.*
Revenues	42.475	6.436	56.362	21.939	2376
Expenditures	45.101	6.816	64.894	21.198	2376
Exports	63.001	35.710	213.501	18.545	2376
Imports	60.732	30.011	181.690	22.651	2376
$\boldsymbol{\beta}$	0.140	0.124	0.502	-0.154	2376
$\boldsymbol{\gamma}$	0.744	0.222	1.065	-0.393	2376

Source: Authors' calculations.

Table 2. Average time-varying fiscal and external sustainability coefficients, 2002Q1-2023Q4

	Fiscal	*External*		*Fiscal*	*External*
Austria	0.016	0.928	**Italy**	0.125	0.664
Belgium	0.063	0.815	**Latvia**	0.157	0.528
Bulgaria	0.199	0.722	**Lithuania**	0.097	0.713
Croatia	0.133	0.684	**Luxembourg**	0.282	0.954
Cyprus	-0.008	0.391	**Netherlands**	0.189	0.840
Czechia	0.300	0.975	**Malta**	0.027	0.792
Denmark	0.441	0.975	**Poland**	0.165	0.706
Estonia	0.239	0.692	**Portugal**	0.019	0.781
Finland	-0.046	0.813	**Romania**	0.209	0.636
France	0.030	0.858	**Slovakia**	0.032	0.801
Germany	0.113	0.828	**Slovenia**	0.386	0.849
Greece	0.121	0.737	**Spain**	0.037	0.729
Hungary	0.159	0.820	**Sweden**	0.132	0.881
Ireland	0.154	-0.033			

Source: Authors' calculations.

Table 3. Average time-varying fiscal and external sustainability coefficients by country groups, 2002Q1-2023Q4

Sample	*Fiscal*	*External*
Full Sample	0.140	0.744
Core countries	0.135	0.877
Periphery countries	0.068	0.580
Baltic countries	0.164	0.644
Central and Eastern countries	0.198	0.774
Euro Area countries	0.105	0.719
non Euro Area countries	0.229	0.816

Source: Authors' calculations.

Given the effects of 2008 Global and Financial Crisis (GFC) on EU countries, and the subsequent Eurozone crisis in 2010-2012, we distinguish between the periods prior and after the GFC, i.e., the pre-GFC and the post-GFC periods refers to the timespan before and after 2009 (inclusive), respectively. Thus, based on Table 4, we can see that after the 2008 GFC, there was an improvement in fiscal and external sustainability for most European Union countries as well as for the European Union as a whole, especially with regard to external sustainability. This evidence is due to the fiscal and external adjustments that occurred in these countries after 2009 and also following the Eurozone crisis in 2010-2012, which resulted in the correction of the fiscal and external imbalances that had accumulated until then.

Furthermore, Table 5 points that the fiscal/external sustainability and external/fiscal sustainability causal relationships became stronger after the outbreak of the 2008 global financial crisis for the several groups of countries included in the analysis.

Nonetheless, despite the descriptive statistics and the average time-varying fiscal and external coefficients per country and groups of countries, we compute the correlation between such variables, as illustrated in the heatmap of Figure 5. We can clearly see a higher correlation between expenditures and revenues, suggesting that there may be higher fiscal sustainability levels, which is contradicted by the average value of the time-varying fiscal sustainability coefficients, presented in Table 1. At the same time, we find low correlation values between fiscal and external time-varying sustainability coefficients. Moreover, taking into account the different time-varying sustainability coefficients of each economy, and given the different development patterns and features of the EU economies we are considering in this study, we calculated the correlation matrix along different country groups, presented in Table 6.

Regarding the correlations in Table 6, we can conclude that in core EU countries, the correlation between fiscal and external sustainability coefficients is moderate (0.626), indicating a nuanced relationship where fiscal policies and external balances influence each other being relatively interdependent. This suggests that core countries may possess more robust mechanisms to manage fiscal and external imbalances independently. Conversely, in peripheral EU countries, the correlation is negative and close to zero, highlighting a weaker interdependence between fiscal and external sustainability. This could imply that peripheral countries are more vulnerable to external shocks, which can significantly impact their fiscal stability.

Euro Area countries exhibit a lower correlation between fiscal and external variables, particularly pre-GFC, suggesting that the shared fiscal and monetary policy framework may not amplify the interdependence between these two aspects of sustainability. Non-Euro Area countries, on the other hand, show a more varied pattern, with some exhibiting strong correlations while others do not, reflecting the diverse fiscal and external dynamics outside the Eurozone.

The temporal analysis, comparing pre- and post-GFC periods, reveals significant shifts in the relationships between fiscal and external sustainability. In the pre-GFC period, the correlations are generally lower, indicating a more stable and less interdependent relationship. However, post-GFC, the correlations increase, particularly in Euro Area countries, suggesting that the crisis has heightened the sensitivity of fiscal sustainability to external factors. This shift underscores the importance of external balances in maintaining fiscal health in the aftermath of economic shocks.

Table 4. Average time-varying fiscal and external sustainability coefficients by countries, pre and post-GFC, 2002Q1-2023Q4

	Fiscal		*External*	
	PRE-GFC	**POST-GFC**	**PRE-GFC**	**POST-GFC**
Austria	0.011	0.018	0.928	0.927
Belgium	0.045	0.071	0.830	0.808
Bulgaria	0.238	0.180	0.545	0.805
Croatia	0.132	0.133	0.581	0.733
Cyprus	-0.047	0.011	0.317	0.426
Czechia	0.281	0.309	0.924	0.999
Denmark	0.464	0.430	0.950	0.986
Estonia	0.201	0.257	0.574	0.746
Finland	-0.063	-0.038	0.919	0.763
France	0.005	0.041	0.888	0.844
Germany	0.085	0.126	0.760	0.859
Greece	0.020	0.169	0.593	0.804
Hungary	0.127	0.173	0.738	0.859
Ireland	0.284	0.094	-0.331	0.106
Italy	0.092	0.141	0.603	0.692
Latvia	0.106	0.181	0.334	0.619
Lithuania	0.074	0.107	0.575	0.777
Luxembourg	0.280	0.283	0.912	0.974
Netherlands	0.190	0.188	0.735	0.890
Malta	0.009	0.035	0.740	0.817
Poland	0.167	0.165	0.583	0.763
Portugal	-0.015	0.035	0.652	0.841
Romania	0.232	0.198	0.482	0.707
Slovakia	0.030	0.032	0.711	0.843
Slovenia	0.355	0.401	0.794	0.875
Spain	0.043	0.034	0.594	0.793
Sweden	0.166	0.116	0.915	0.865
Mean	0.130	0.144	0.661	0.782

Source: Authors’ calculations.

Table 5. Normalized means of test statistics of causality tests by groups of countries, pre and post-GFC, 2006Q4-2023Q4

Sample	Fiscal causes External	External causes Fiscal
Core	0.300	0.189
Peripheral	0.205	0.322
Baltic	0.299	0.275
CEEC	0.245	0.218
pre-GFC	0.134	0.169
post-GFC	0.278	0.252
Core pre-GFC	0.195	0.161
Peripheral pre-GFC	0.072	0.162
Baltic pre-GFC	0.100	0.150
CEEC pre-GFC	0.132	0.193
Core post-GFC	0.316	0.193
Peripheral post-GFC	0.224	0.346
Baltic post-GFC	0.328	0.294
CEEC post-GFC	0.262	0.221

Source: Authors' calculations.

The study also highlights regional variations within the Euro Area, distinguishing between peripheral and non-peripheral countries. Peripheral Euro Area countries exhibit higher correlations and interdependency between fiscal and external sustainability post-crisis, indicating a heightened vulnerability to external shocks. Non-peripheral Euro Area countries, while also showing increased correlations post-crisis, maintain a relatively lower level of interdependence compared to their peripheral counterparts. This suggests that non-peripheral countries may have more resilient fiscal frameworks that can better absorb external shocks.

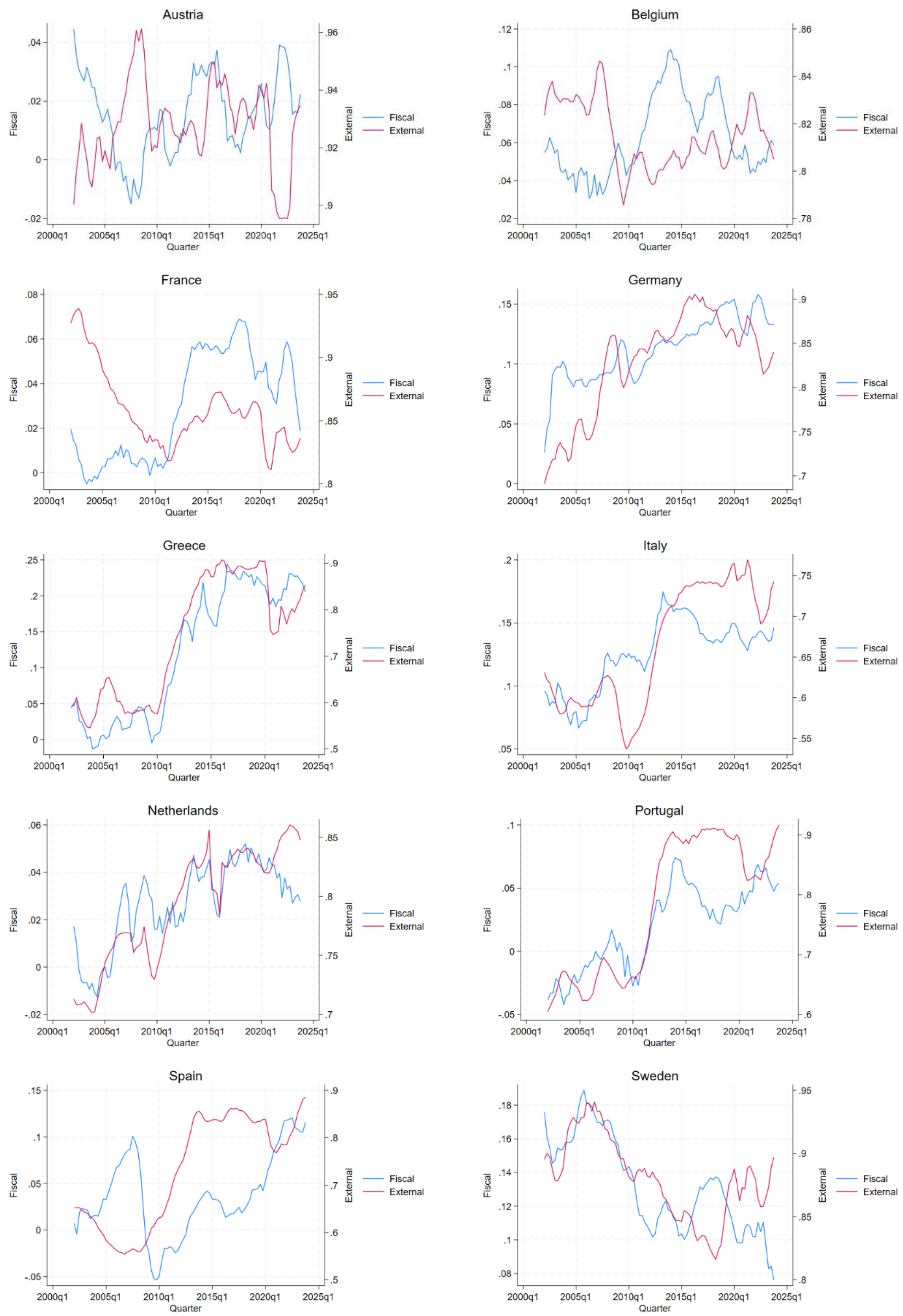
In summary, the correlation matrices underscore the complex and dynamic relationship between fiscal and external sustainability across different EU regions and time periods. The findings highlight the varying degrees of interdependence between fiscal policies and external balances, influenced by regional characteristics, monetary union membership, and economic shocks. These insights are crucial for policymakers aiming to enhance fiscal and external sustainability, particularly in the context of economic integration and global financial volatility.

Table 6. Correlation Matrix by countries' groups and periods

	Core European Countries					*Peripheral European Countries*				
	Revenues	*Expenditures*	*Exports*	*Imports*	*Fiscal*	*Revenues*	*Expenditures*	*Exports*	*Imports*	*Fiscal*
Expenditures	0.841					0.808				
Exports	-0.576	-0.616				-0.589	-0.574			
Imports	-0.546	-0.570	0.995			-0.519	-0.513	0.981		
Fiscal	0.062	-0.188	0.385	0.352		0.252	0.109	0.357	0.355	
External	0.106	-0.152	0.344	0.301	0.626	0.562	0.452	-0.134	-0.068	-0.088
	Euro area countries					***Non-Euro area countries***				
Expenditures	0.851					0.896				
Exports	-0.385	-0.486				0.185	0.218			
Imports	-0.383	-0.470	0.986			-0.053	0.001	0.937		
Fiscal	-0.274	-0.319	0.517	0.531		0.403	0.219	0.113	0.001	
External	0.537	0.380	0.050	0.060	-0.012	0.607	0.525	0.616	0.341	0.473
	Baltic countries					***CEEC countries***				
Expenditures	0.613					0.830				
Exports	0.498	0.198				0.391	0.274			
Imports	0.370	0.020	0.916			0.334	0.217	0.969		
Fiscal	0.947	0.405	0.477	0.412		-0.337	-0.402	0.298	0.349	
External	0.407	0.252	0.917	0.722	0.308	0.271	0.168	0.791	0.661	0.330
	Pre-GFC					***Post-GFC***				
Expenditures	0.874					0.863				
Exports	-0.102	-0.195				-0.308	-0.421			
Imports	-0.261	-0.316	0.958			-0.326	-0.423	0.985		
Fiscal	-0.096	-0.214	0.341	0.353		-0.046	-0.171	0.296	0.303	
External	0.644	0.628	0.075	0.004	-0.037	0.495	0.276	0.052	0.048	0.308
	Pre-GFC & Euro area					***Post-GFC & Euro area***				
Expenditures	0.835					0.861				
Exports	-0.153	-0.395				-0.434	-0.531			
Imports	-0.199	-0.396	0.984			-0.421	-0.513	0.986		
Fiscal	-0.516	-0.622	0.706	0.682		-0.215	-0.276	0.450	0.475	
External	0.746	0.699	-0.018	-0.027	-0.524	0.511	0.286	0.038	0.052	0.180
	Pre-GFC & non-Euro area					***Post-GFC & non-Euro area***				
Expenditures	0.883					0.890				
Exports	-0.081	0.015				0.104	0.027			
Imports	-0.295	-0.206	0.945			-0.090	-0.113	0.961		
Fiscal	0.364	0.208	0.038	-0.023		0.428	0.257	0.234	0.092	
External	0.669	0.651	0.324	0.086	0.598	0.570	0.345	0.529	0.312	0.646
	Pre-GFC & Euro area & Peripheral					***Post-GFC & Euro area & Peripheral***				
Expenditures	0.809					0.814				
Exports	-0.644	-0.638				-0.639	-0.664			
Imports	-0.570	-0.520	0.967			-0.562	-0.601	0.984		
Fiscal	-0.526	-0.666	0.797	0.665		0.410	0.284	0.254	0.277	
External	0.750	0.780	-0.667	-0.519	-0.861	0.597	0.347	-0.181	-0.118	0.201
	Pre-GFC & Euro area & non-Peripheral					***Post-GFC & Euro area & non-Peripheral***				
Expenditures	0.811					0.924				
Exports	-0.535	-0.701				-0.375	-0.453			
Imports	-0.527	-0.678	0.995			-0.411	-0.470	0.990		
Fiscal	-0.606	-0.590	0.844	0.827		-0.643	-0.624	0.566	0.608	
External	0.531	0.237	0.183	0.145	0.080	0.153	0.063	0.486	0.419	0.173

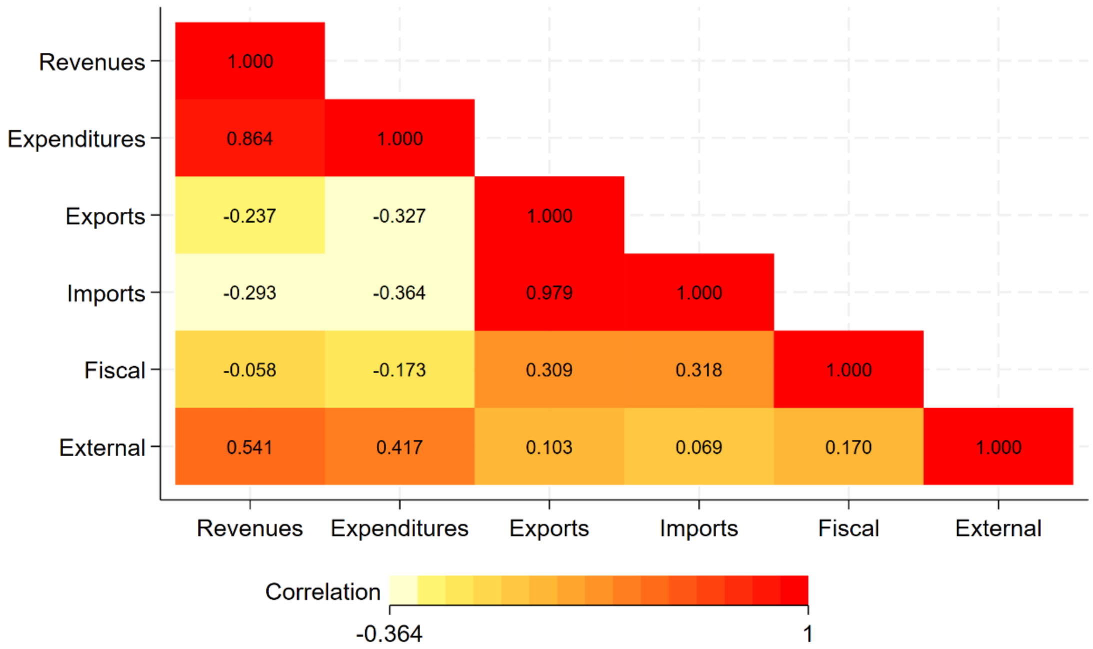
Source: Authors' calculations. We have also considered the Euro Area group combining all the countries that have introduced the euro as currency. We set a country that belongs to the Euro Area when the euro currency begins to circulate in a respective period.

Figure 4. Time-varying fiscal and external sustainability coefficients, 2002Q1-2023Q4



Source: Authors' calculations.

Figure 5. Heatmap of correlation matrix, full sample



Source: Authors' calculations.

5. Empirical Analysis

5.1. Fiscal sustainability causes external sustainability?

In this sub-section we now use the time-varying sustainability coefficients obtained in the 1st step analysis, to compute the causality patterns between fiscal sustainability and external sustainability.

Based on Figure 6, where we plot the recursive time-varying granger causality tests, the null hypothesis of non-causality is rejected in several cases (forward and rolling window results are reported in the Appendix). Hence, we can draw some conclusions about the evidence of causality between fiscal sustainability coefficients and external sustainability coefficients for the 27 European Union countries in the period between 2006Q4 and 2023Q4.

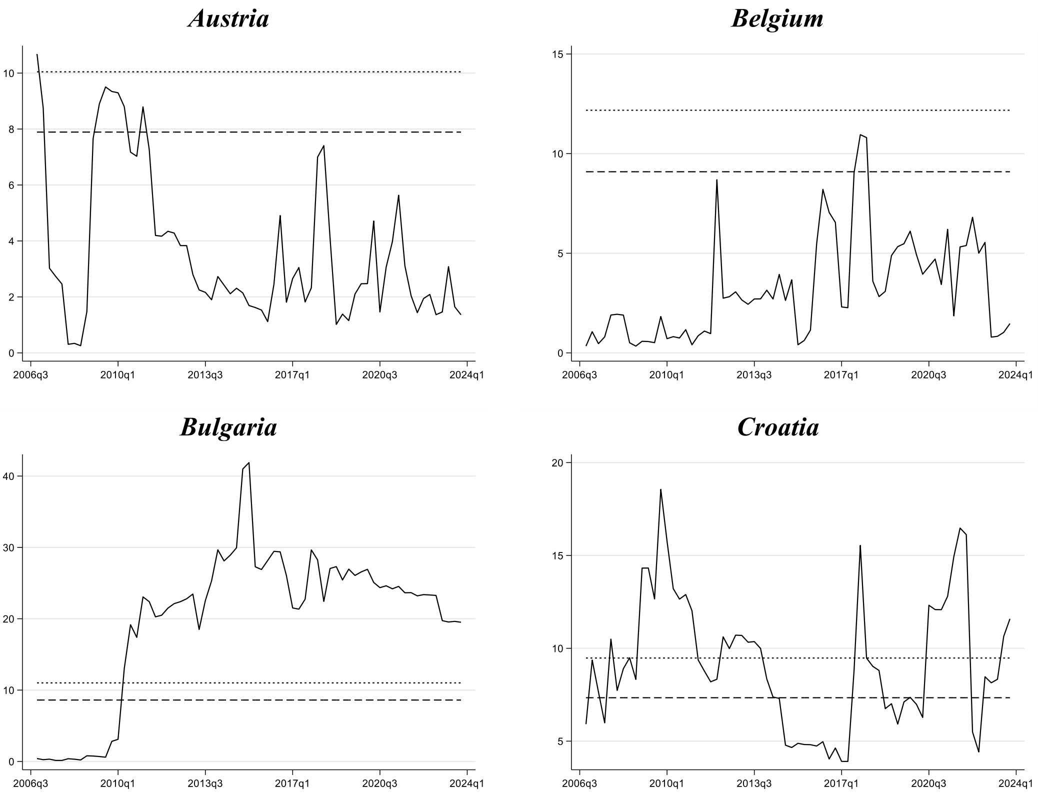
When the 2008 global financial crisis occurred, in some countries that fiscal sustainability Granger causes external sustainability, namely in Austria, Croatia, Czechia, Germany, Ireland, Netherlands, Slovakia, Spain, and Sweden (where the null hypothesis of no-Granger causality is rejected, and with the test statistic surpassing the confidence bands).

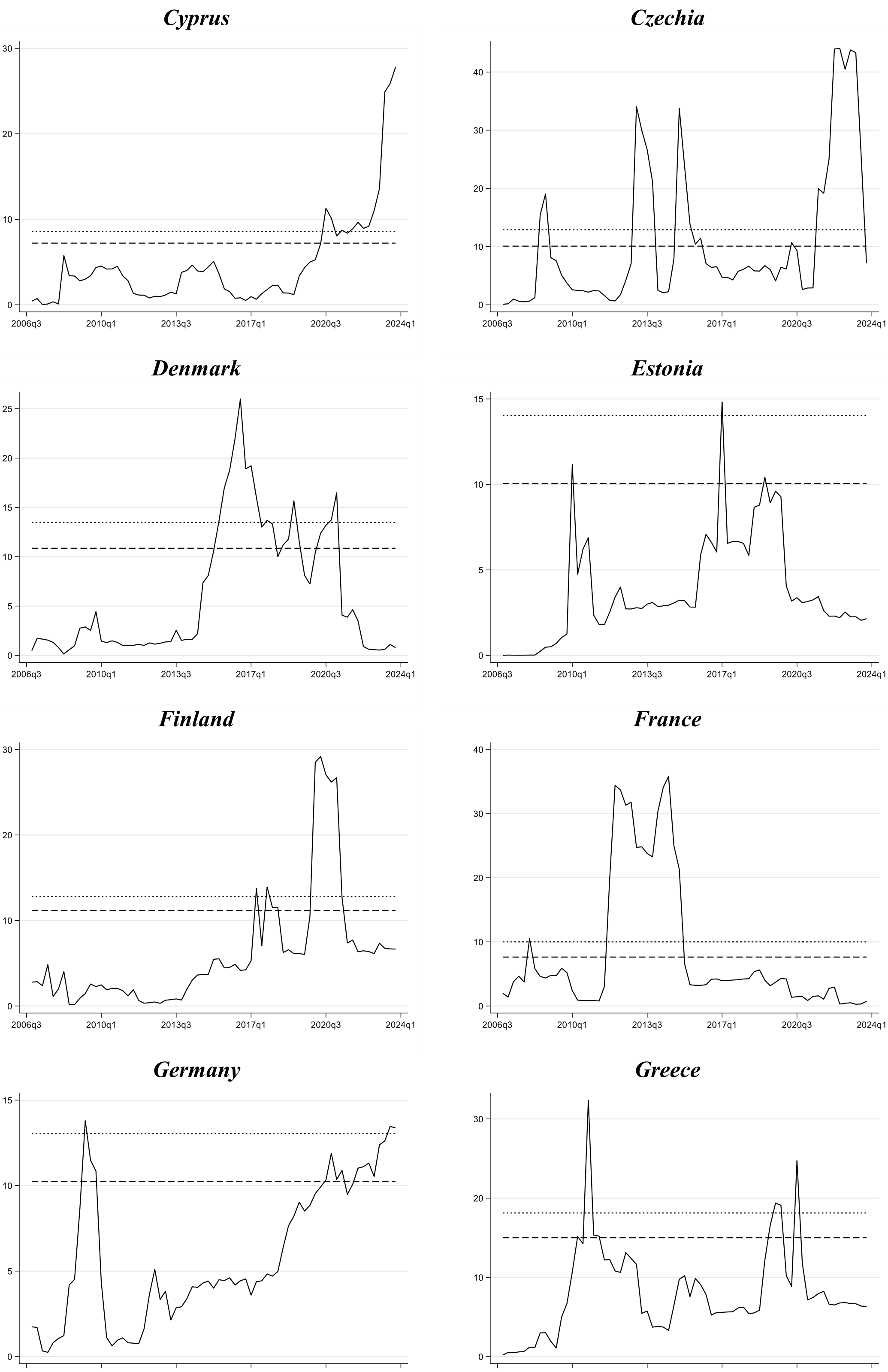
During the period of the Eurozone crisis in 2010-2012, in Austria, France, Greece, Ireland, Netherlands, Slovakia and Spain, there was a causality between fiscal sustainability and external sustainability. In some countries that are not part of the Euro Area, this pattern of causality is also observed, namely Croatia, Romania and Sweden.

Throughout the great confinement crisis associated with the SARS-CoV-2 pandemic (2020-2022), we obtained empirical support for the causality between fiscal sustainability and external sustainability in countries such as Croatia, Cyprus, Czechia, Denmark, Finland, Germany, Greece, Ireland, Italy, Malta, Poland, Portugal, Romania, Slovakia, Slovenia, and Spain.

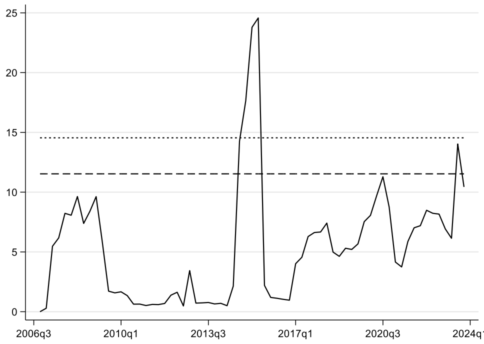
Furthermore, for Bulgaria, there is a pattern of causality between fiscal sustainability and external sustainability as of 2010Q2; for Cyprus, from 2020Q3; Czechia, from 2021Q3; Malta, from 2020Q2; Portugal, from 2018Q4; Slovakia, from 2021Q1; and Spain, from 2014Q2. In Latvia, there is no causality between the fiscal and external sustainability coefficients in the period under analysis.

Figure 6. Recursive evolving (RE) window approach time-varying granger causality, fiscal causes external sustainability

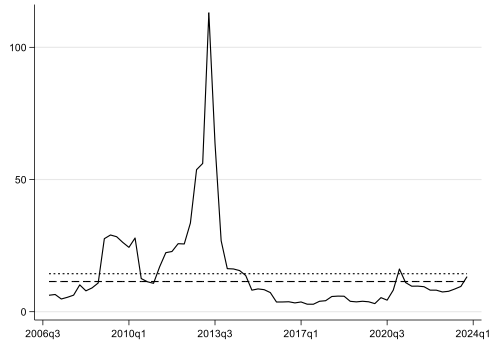



Cyprus
Czechia
Denmark
Estonia
Finland
France
Germany
Greece
2006q3
2010q1
2013q3
2017q1
2020q3
2024q1

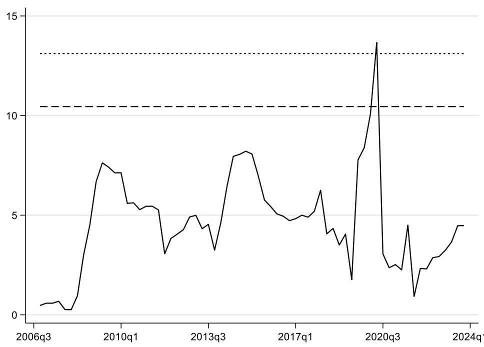
Hungary



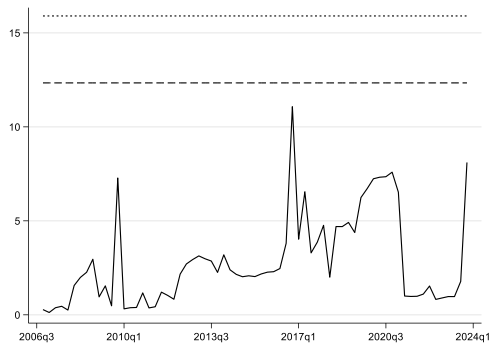
Ireland



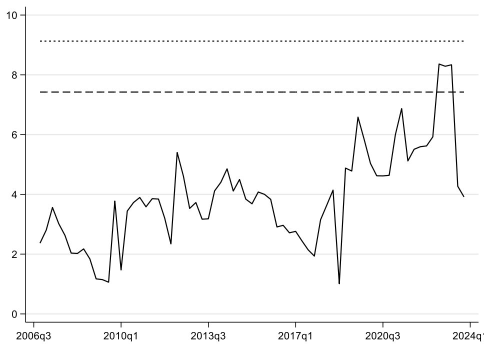
Italy



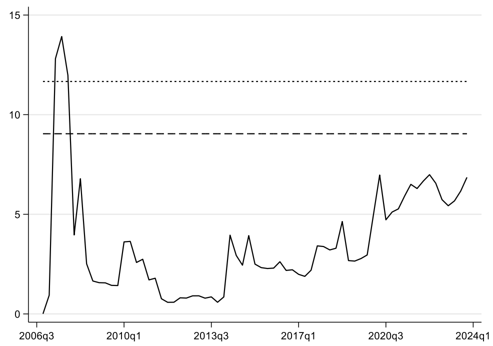
Latvia



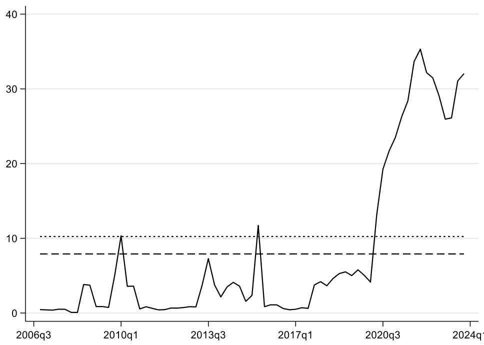
Lithuania



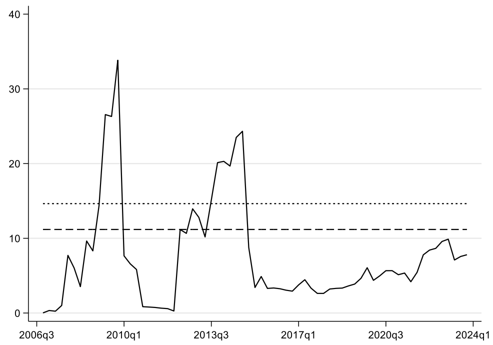
Luxembourg



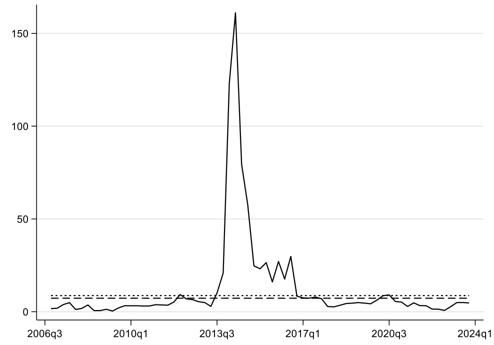
Malta



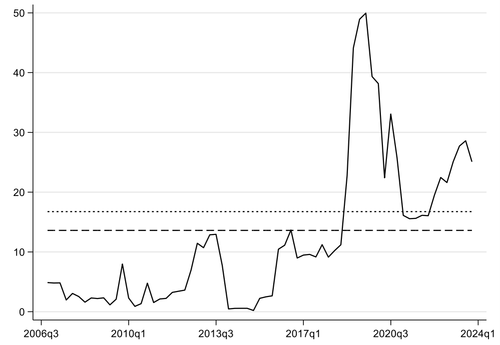
Netherlands



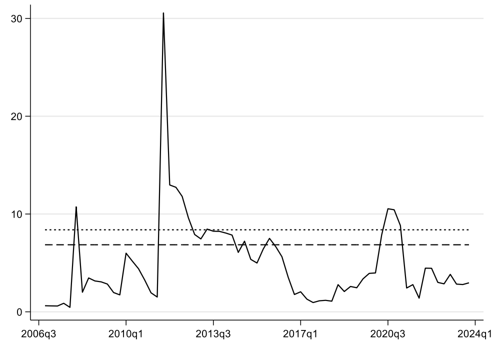
Poland



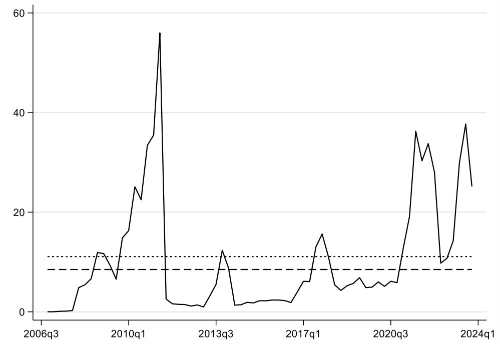
Portugal



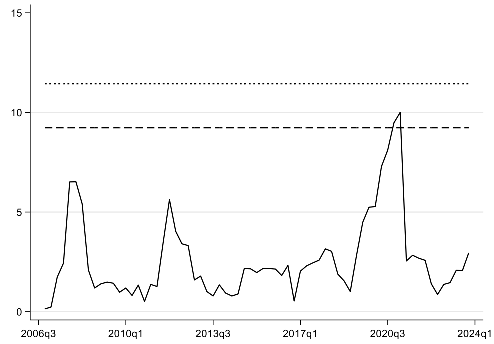
Romania



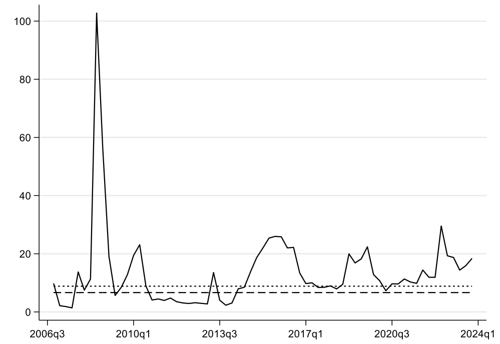
Slovakia



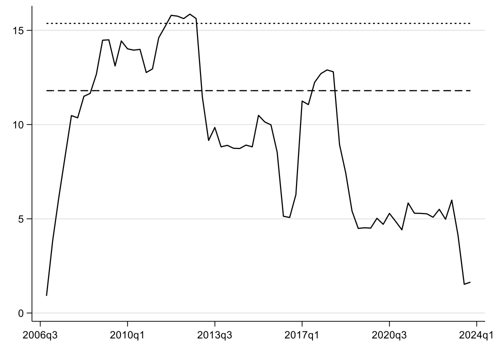
Slovenia



Spain



Sweden



Notes: We select a minimum window size of 20 quarters. We include a trend in the underlying VAR model. The size of the tests is controlled during 10 quarters. These statistics are robust to heteroskedasticity. The dotted line indicates the 90*th* (lower line) and 95*th* (upper line) percentile of test statistics, where 499 bootstrap replications have been used. We present the results of the recursive window at the 5 and 10% levels for readability purposes. Source: Authors' calculations.

5.2. External sustainability causes fiscal sustainability?

Moreover, we now use the time-varying sustainability coefficients obtained in the 1st step analysis, to compute the causality patterns between external sustainability and fiscal sustainability.

Analyzing Figure 7, we can conclude that, during the occurrence of the 2008 GFC, the pattern of causality between external sustainability and external sustainability was not significant in the European Union countries, with the exceptions of Czechia, Poland, Romania and Slovakia.

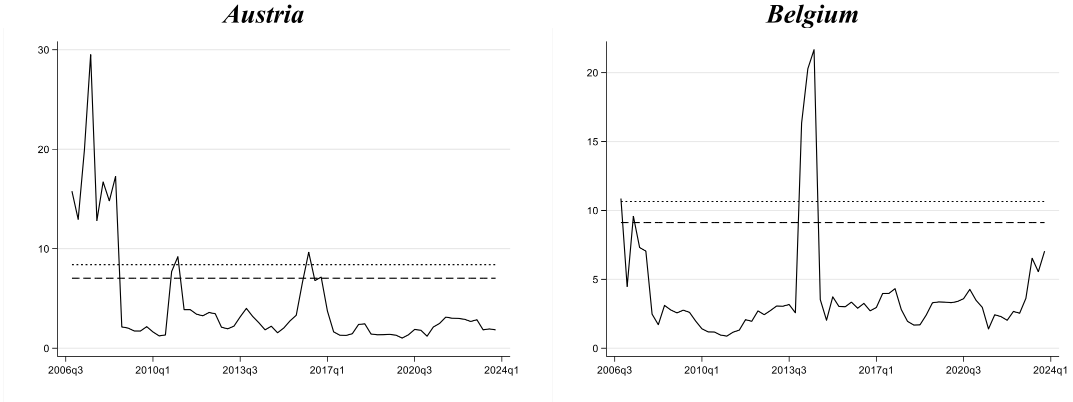
During the Euro Area crisis, causality was observed between the external and fiscal sustainability coefficients in countries that are part of the Economic and Monetary Union - Austria, Germany, Malta, Netherlands, Slovakia, Slovenia and Spain - as well as in countries that did not adopt the single currency - Bulgaria, Denmark, Hungary and Poland.

In countries such as Bulgaria, Croatia, Denmark, Finland, France, Germany, Hungary, Lithuania, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia and Sweden, during the great confinement crisis, we may observe this pattern of causality.

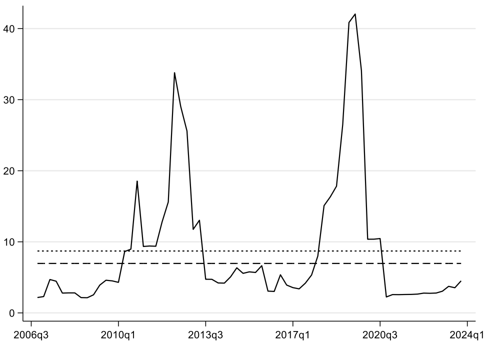
In Italy, from 2013Q4, and in Romania, from 2012Q4, external sustainability Granger causes fiscal sustainability. In Lithuania, this causality pattern between 2015Q2 and 2022Q2 is observed. In Cyprus and Portugal, there was no causality between the external and fiscal sustainability coefficients for the majority of the period under analysis.

Figure 7. Recursive evolving (RE) window approach time-varying granger causality, external causes fiscal sustainability

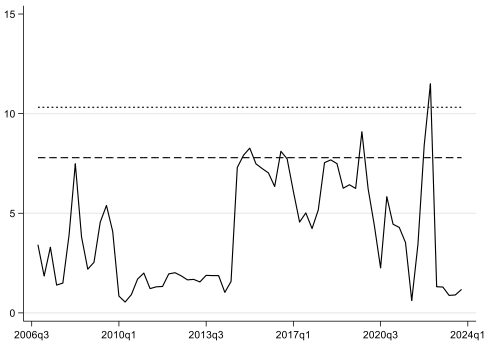
Austria *Belgium*



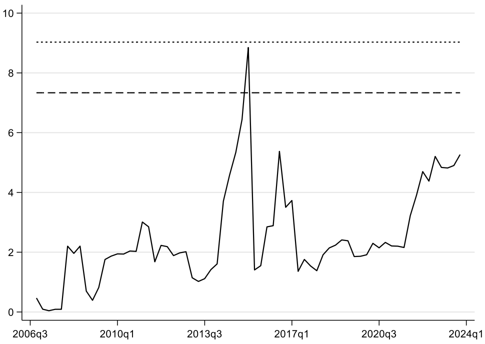
Bulgaria



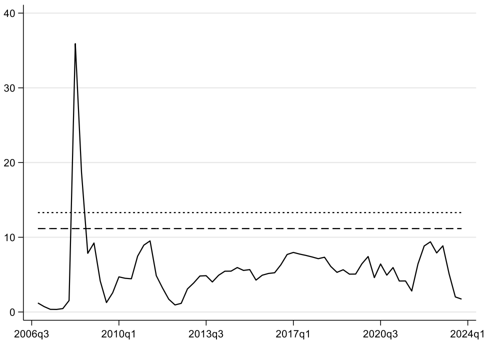
Croatia



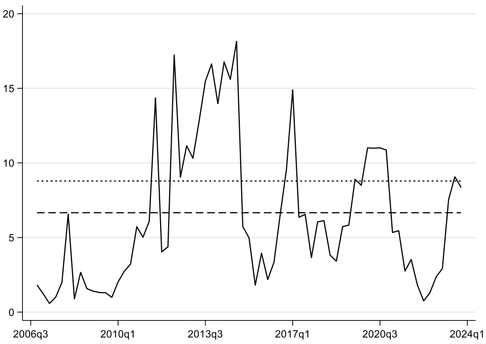
Cyprus



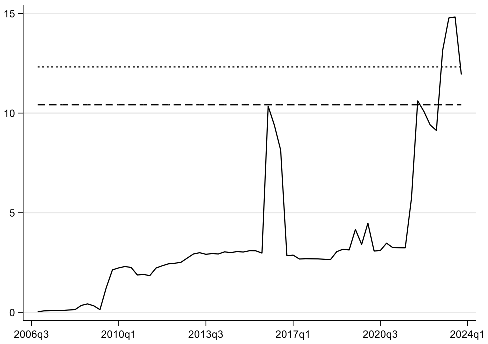
Czechia



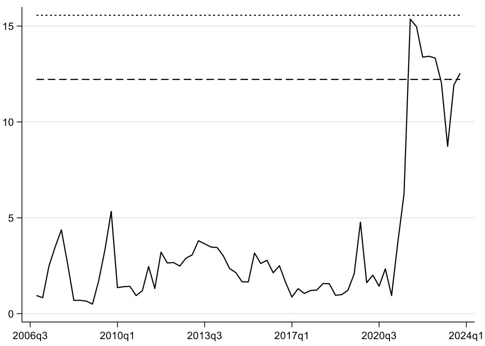
Denmark



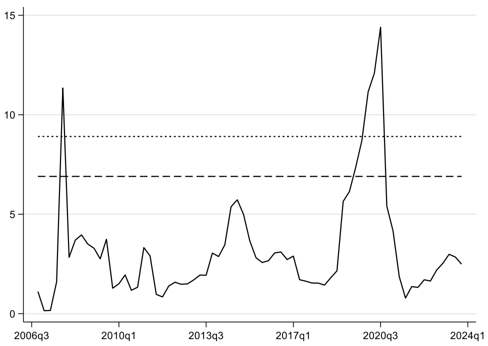
Estonia



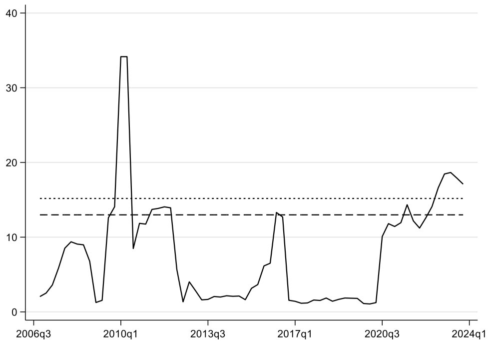
Finland



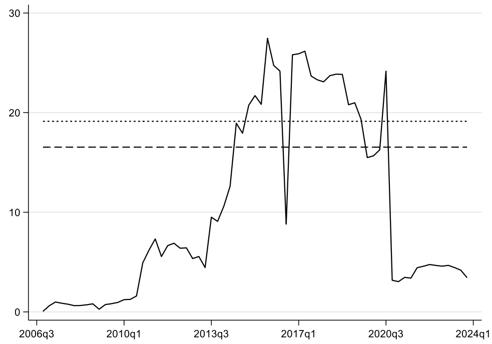
France



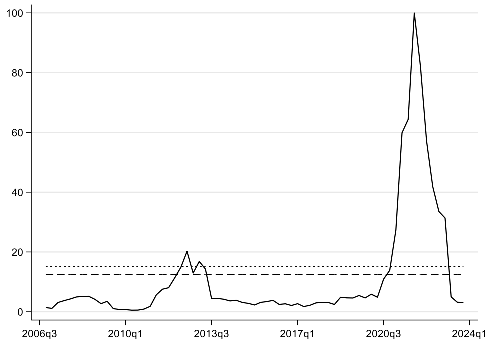
Germany



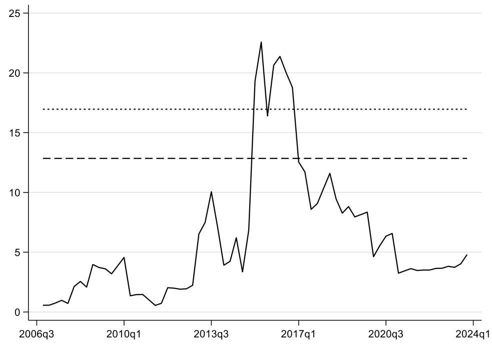
Greece



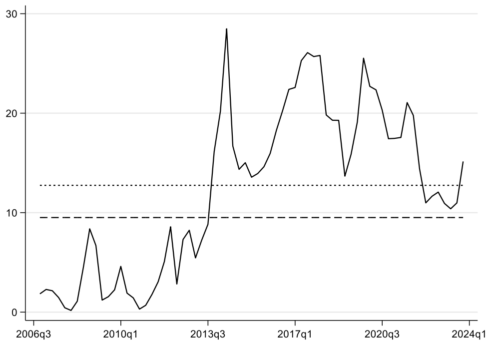
Hungary



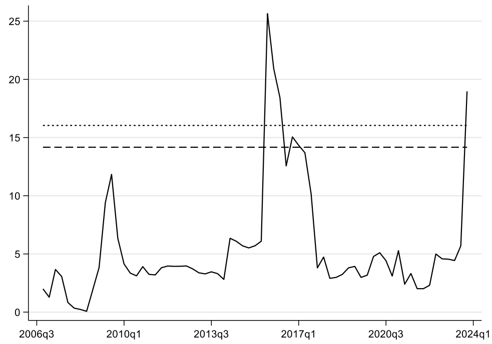
Ireland



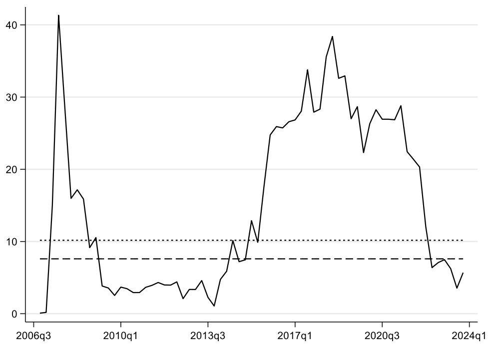
Italy



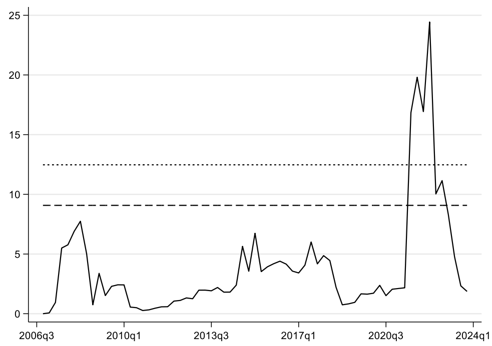
Latvia



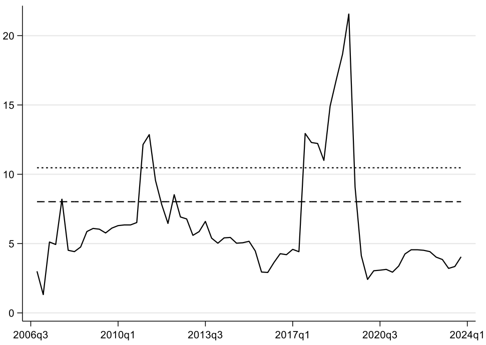
Lithuania



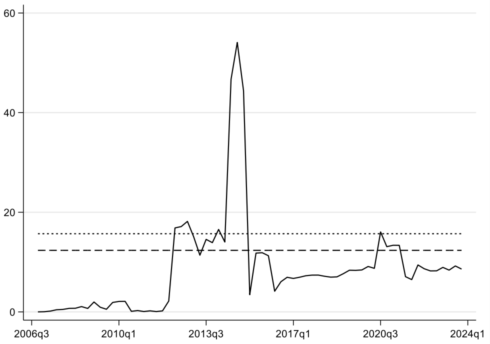
Luxembourg



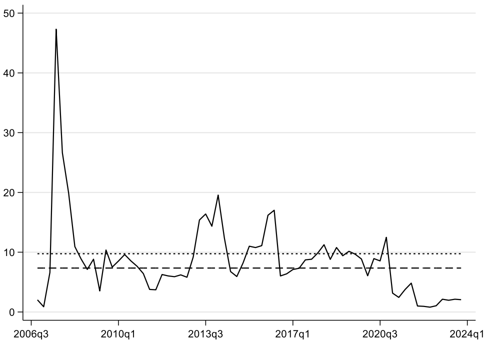
Malta



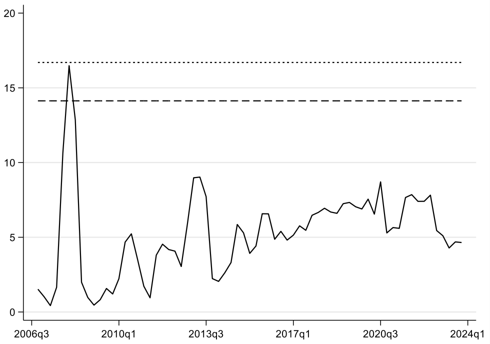
Netherlands



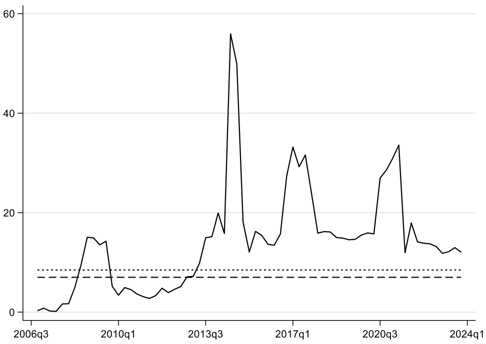
Poland



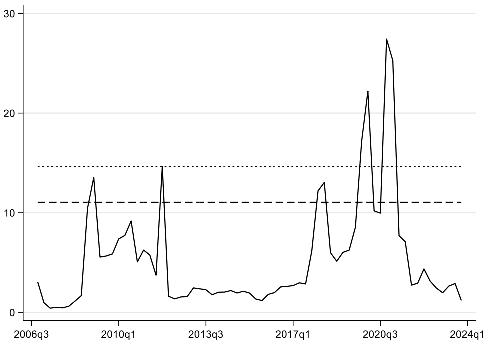
Portugal



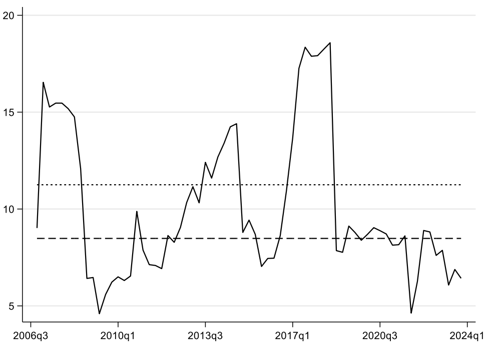
Romania



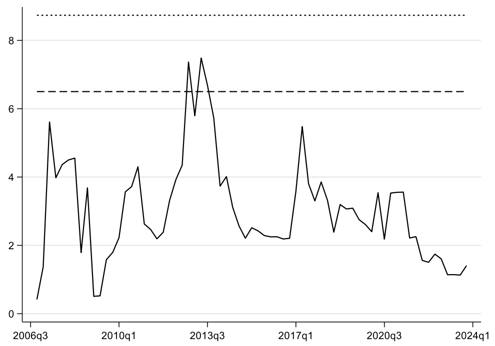
Slovakia



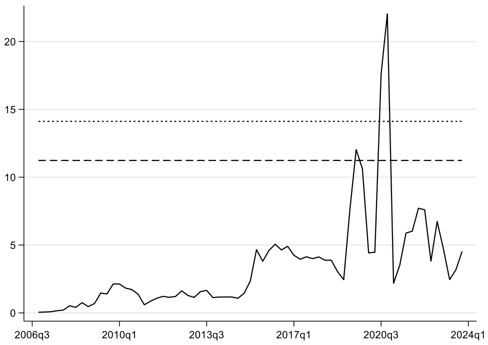
Slovenia



Spain



Sweden



Notes: We select a minimum window size of 20 quarters. We include a trend in the underlying VAR model. The size of the tests is controlled during 10 quarters. These statistics are robust to heteroskedasticity. The dotted line indicates the 90*th* (lower line) and 95*th* (upper line) percentile of test statistics, where 499 bootstrap replications have been used. We present the results of the recursive window at the 5 and 10% levels for readability purposes. Source: Source: Authors' calculations.

6. Conclusion

In this paper, we have performed a two-step time-varying analysis in order to identify causality patterns between fiscal and external sustainability for 27 EU countries during the period 2002Q1-2023Q4.

The first step of the empirical analysis consists of computing the time-varying coefficients of fiscal and external sustainability, based on the cointegration relationships between government revenues and expenditures as well as between exports and imports, using Schlicht' (2021) method. Next, we follow three recursive strategies, namely forward expanding window, rolling window technique and recursive evolving window, to implement Granger causality tests, aiming to capture causal relationships between fiscal and external sustainability.

An important conclusion of our article is related to the existing heterogeneity of the so-called fiscal and external sustainability coefficients of EU countries taken individually as well as between groups of countries. More specifically, peripheral countries have lower sustainability coefficients, while Central and Eastern countries exhibit higher coefficients. Furthermore, non-Eurozone countries have higher sustainability coefficients relative to Eurozone countries. After the 2008 global financial crisis, there was an improvement in fiscal and external sustainability for most EU countries as well as for the EU as a whole, especially with regard to external sustainability.

In addition, the patterns of causality between fiscal and external sustainability of the several EU countries have specificities in each country. Nevertheless, the crises that occurred during the period under analysis, namely the 2008 GFC, the Eurozone crisis in 2010-2012 and the great confinement crisis in 2020-2022, provide a useful framework and explanations.

Finally, following our work, one topic that could be studied in future research is the examination of the determinants of fiscal and external sustainability and the interdependence between both sustainability coefficients. This analysis could be conducted for a specific EU country and/or for the broad panel of EU countries.

References

1. Abell, J. D. (1990). Twin Deficits the 1980s: An Empirical Investigation. *Journal of Macroeconomics*, *12*(1), 81-96. https://doi.org/10.1016/0164-0704(90)90057-H.
2. Afonso, A. (2005). Fiscal Sustainability: The Unpleasant European Case. *FinanzArchiv/Public Finance Analysis*, *61*(1), 19-44. https://doi.org/10.1628/0015221053722532.
3. Afonso, A. (2008). Ricardian fiscal regimes in the European Union. *Empirica*, *35*, 313-334. https://doi.org/10.1007/s10663-008-9066-3.
4. Afonso, A., & Rault, C. (2010). What do we really know about fiscal sustainability in the EU? A panel data diagnostic. *Review of World Economics*, *145*, 731-755. https://doi.org/10.1007/s10290-009-0034-1.
5. Afonso, A., & Coelho, J. C. (2022). The Role of Fiscal Policies for External Imbalances: Evidence from the European Union. *Economic Systems*, *46*(2), 100985. https://doi.org/10.1016/j.ecosys.2022.100985.
6. Afonso, A., & Coelho, J. C. (2023). Public finances solvency in the Euro Area. *Economic Analysis and Policy*, *77*, 642-657. https://doi.org/10.1016/j.eap.2022.12.027.
7. Afonso, A., & Jalles, J. T. (2017). Euro area time-varying fiscal sustainability. *International Journal of Finance and Economics*, *22*(3), 244-254. https://doi.org/10.1002/ijfe.1582.
8. Afonso, A., Huart, F., Jalles, J. T., & Stanek, P. (2019). Assessing the sustainability of external imbalances in the European Union. *The World Economy*, *42*(2), 320-348. https://doi.org/10.1111/twec.12709.
9. Afonso, A., Huart, F., Jalles, J. T., & Stanek, P. (2020). Long-run relationship between exports and imports: current account sustainability tests for the EU. *Portuguese Economic Journal*, *19*(2), 155-170. https://doi.org/10.1007/s10258-019-00168-x.
10. Afonso, A., Alves, J., & Jalles, J. T. (2021). Fiscal Reaction Functions in the EU: A Tale of “r-g” and Whether it Matters. *Revue française d'économie*, *XXXVI*, 65-101. https://doi.org/10.3917/rfe.213.0065.

11. Algieri, B. (2013). An empirical analysis of the nexus between external balance and government budget balance: The case of the GIIPS countries. *Economic Systems*, *37*(2), 233-253. https://doi.org/10.1016/j.ecosys.2012.11.002.

12. Altayligil. Y. B., & Çetrez, M. (2020). Macroeconomic, institutional and financial determinants of current account balances: a panel data assessment. *Journal of Economic Structures*, *9*(49). https://doi.org/10.1186/s40008-020-00225-1.

13. Andre, C., Balcilar, M., Chang, T., Gil-Alana, L. A., & Gupta, R. (2018). Current account sustainability in G7 and BRICS: evidence from a long-memory model with structural breaks. *The Journal of International Trade & Economic Development*, *27*(6), 638-654. https://doi.org/10.1080/09638199.2017.1410853.

14. Apergis, N., Katrakilidis, K. P., & Tabakis, N. M. (2000). Current account deficit sustainability: The case of Greece. *Applied Economics Letters*, *7*(9), 599-603.

15. Bajo-Rubio, O., Díaz-Roldán, C. & Esteve, V. (2014). Sustainability of external imbalances in the OECD countries. *Applied Economics*, *46*(4), 441-449. https://doi.org/10.1080/00036846.2013.851779.

16. Barro, R. J. (1974). Are Government Bonds Net Wealth? *Journal of Political Economy*, *82*(6), 1095-1117. https://doi.org/10.1086/260266.

17. Barro, R. J. (1989). The Ricardian Approach to Budget Deficits. *Journal of Economic Perspectives*, *3*(2), 37-54. https://doi.org/10.1257/jep.3.2.37.

18. Baum, C. F., Hurn, S., & Otero, J. (2021). The dynamics of US industrial production: A time-varying Granger causality perspective. *Econometrics and Statistics*. https://doi.org/10.1016/j.ecosta.2021.10.012.

19. Baum, C. F., Hurn, S., & Otero, J. (2022). Testing for time-varying Granger causality. *The Stata Journal*, *22*(2), 355-378. https://doi.org/10.1177/1536867X221106403.

20. Bohn, H. (1998). The Behavior of U.S. Public Debt and Deficits. *The Quarterly Journal of Economics*, *113*(3), 949-963. https://doi.org/10.1162/003355398555793.

21. Brady, G. L., & Magazzino, C. (2018). Fiscal Sustainability in the EU. *Atlantic Economic Journal*, *46*, 297-311. https://doi.org/10.1007/s11293-018-9588-4.

22. Camarero, M., Carrion-i-Silvestre, J. L., & Tamarit, C. (2013). Global imbalances and the intertemporal external budget constraint: A multicointegration approach. *Journal of Banking & Finance*, *37*(12), 5357-5372. https://doi.org/10.1016/j.jbankfin.2013.01.008.

23. Camarero, M., Carrion-i-Silvestre, J. L., & Tamarit, C. (2015). Testing for external sustainability under a monetary integration process. Does the Lawson doctrine apply to Europe? *Economic Modelling*, *44*, 343-349. https://doi.org/10.1016/j.econmod.2014.06.010.

24. Canzoneri, M. B., Cumby, R. E., & Diba, B. T. (2001). Is the Price Level Determined by the Needs of Fiscal Solvency? *American Economic Review*, *91*(5), 1221-1238. https://doi.org/10.1257/aer.91.5.1221.

25. Chen, S.-W. (2011). Current account deficits and sustainability: Evidence from the OECD countries. *Economic Modelling*, *28*(4), 1455-1464. https://doi.org/10.1016/j.econmod.2011.01.011.

26. Chen, S.-W. (2014). Smooth transition, non-linearity and current account sustainability: Evidence from the European countries. *Economic Modelling*, *38*, 541-554. https://doi.org/10.1016/j.econmod.2014.02.003.

27. Daly, V., & Siddiki, J. U. (2009). The twin deficits in OECD countries: cointegration analysis with regime shifts. *Applied Economic Letters*, *16*(11), 1155-1164. https://doi.org/10.1080/13504850701349179.

28. Darrat, A. (1988). Have Large Budget Deficits Caused Rising Trade Deficits? *Southern Economic Journal*, *54*(4), 879-887. https://doi.org/10.1007/BF02298478.

29. Dolado, J. J., & Lütkepohl, H. (1996). Making Wald tests work for cointegrated VAR systems. *Econometric reviews*, *15*(4), 369-386. https://doi.org/10.1080/07474939608800362.

30. Durdu, C. B., Mendoza, E. G., & Terrones, M. E. (2013). On the solvency of nations: Cross-country evidence on the dynamics of external adjustment. *Journal of International Money and Finance*, *32*, 762-780. https://doi.org/10.1016/j.jimonfin.2012.07.002.

31. Feldstein, M., & Horioka, C. (1980). Domestic Saving and International Capital Flows. *The Economic Journal*, *90*(358), 314-329. https://doi.org/10.2307/2231790.

32. Fleming, J. M. (1962). Domestic Financial Policies under Fixed and under Floating Exchange Rates. *Staff Papers - International Monetary Fund*, *9*, November, 369-379. https://doi.org/10.5089/9781451968873.024.

33. Getzner, M., Glatzer, E., & Neck, R. (2001). On the sustainability of Austrian budgetary policies. *Empirica*, *28*, 21-40. https://doi.org/10.1023/A:1010927632670.

34. Hakkio, C. S., & Rush, M. (1991). Is the Budget Deficit "Too Large?". *Economic Inquiry*, *29*(3), 429-445. https://doi.org/10.1111/j.1465-7295.1991.tb00837.x.

35. Hamilton, J. D., & Flavin, M. A. (1986). On the Limitations of Government Borrowing: A Framework for Empirical Testing. *The American Economic Review*, *76*(4), 808-819. https://www.jstor.org/stable/1806077.

36. Haug, A. A. (1995). Has federal budget deficit policy changed in recent years? *Economic Inquiry*, *33*(1), 104-118. https://doi.org/10.1111/j.1465-7295.1995.tb01849.x.

37. Holmes, M. J. (2006). How sustainable are OECD current account balances in the long run? *The Manchester School*, *74*(5), 626-643. https://doi.org/10.1111/j.1467-9957.2006.00514.x.

38. Husted, S. (1992). The Emerging U.S. Current Account Deficit in the 1980s: A Cointegration Analysis. *The Review of Economics and Statistics*, *74*(1), 159-166.

39. Janko, S. (2020). On the relationship between the current account and the fiscal balance: The case of Canada. *North American Journal of Economics and Finance*, *54*(November), 101241. https://doi.org/10.1016/j.najef.2020.101241.

40. Kalou, S., & Paleologou, S.-M. (2012). The twin deficits hypothesis: Revisiting an EMU country. *Journal of Policy Modelling*, *34*(2), 230-241. https://doi.org/10.1016/j.jpolmod.2011.06.002.

41. Kim, S., & Roubini, N. (2008). Twin deficit or twin divergence? Fiscal policy, current account, and real exchange rate in the U.S. *Journal of International Economics*, *74*(2), 362-383. https://doi.org/10.1016/j.jinteco.2007.05.012.

42. Kim, W. (2024). Fiscal policy and the twin deficits: structural changes matter. *Macroeconomic Dynamics*, *28*(3), 517-545. https://doi.org/10.1017/S1365100523000147.

43. Lanzafame, M. (2014). Current account sustainability in advanced economies. *The Journal of International Trade & Economic Development*, *23*(7), 1000-1017. https://doi.org/10.1080/09638199.2013.821152.

44. Lee, K., Kim, J.-H., & Sung, T. (2018). A test of fiscal sustainability in the EU countries. *International Tax and Public Finance*, *25*, 1170-1196. https://doi.org/10.1007/s10797-018-9488-1.

45. Makin, A. J., & Narayan, P. K. (2013). Re-examining the "twin deficits" hypothesis: evidence from Australia. *Empirical Economics*, *45*(2), 817-829. https://doi.org/10.1007/s00181-012-0628-7.

46. McFarlane, A., Jung, Y. C., & Das, A. (2020). The dynamics among domestic saving, investment, and the current account balance in the USA: a long run perspective. *Empirical Economics*, *58*(4), 1659-1680. https://doi.org/10.1007/s00181-018-1566-9.

47. Milesi-Ferretti, G. M., & Razin, A. (1996). *Current-account sustainability*. NBER Working Paper 81. Available at: http://www.nber.org/papers/w5791.

48. Mundell, R. A. (1960). The Monetary Dynamics of International Adjustment under Fixed and Flexible Exchange Rates. *The Quarterly Journal of Economics*, *74*, 227-257. https://doi.org/10.2307/1884252.

49. Nikiforos, M., Carvalho, L., & Schoder, C. (2015). "Twin deficits" in Greece: in search of causality. *Journal of Post Keynesian Economics*, *38*(2), 302-330. https://doi.org/10.1080/01603477.2015.1065675.

50. Piersanti, G. (2000). Current account dynamics and expected budget deficits: some international evidence. *Journal of International Money and Finance*, *19*(2), 255-271. https://doi.org/10.1016/S0261-5606(00)00004-8.

51. Raybaudi, M., Sola, M., & Spagnolo, F. (2004). Red signals: current account deficits and sustainability. *Economics Letters*, *84*(2), 217-223. https://doi.org/10.1016/j.econlet.2004.02.005.

52. Rosenweig, J. A., & Tallman, E. W. (1993). Fiscal Policy and Trade Adjustment: are the deficits really twins? *Economic Inquiry*, *31*(4), 580-594. https://doi.org/10.1111/j.1465-7295.1993.tb00892.x.

53. Shi, S., Hurn, S., & Phillips, P. C. (2020). Causal change detection in possibly integrated systems: Revisiting the money–income relationship. *Journal of Financial Econometrics*, *18*(1), 158-180. https://doi.org/10.1093/jjfinec/nbz004.

54. Summers, L. H. (1988). Tax Policy and International Competitiveness. *International Aspects of Fiscal Policies*, J. Frankel (ed.), Chicago University Press.

55. Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics*, *66*(1-2), 225-250. https://doi.org/10.1016/0304-4076(94)01616-8.

56. Trachanas, E., & Katrakilidis, C. (2013). The dynamic linkages of fiscal and current account deficits: New evidence from five highly indebted European countries accounting for regime shifts and asymmetries. *Economic Modelling*, *31*(1), 502-510. https://doi.org/10.1016/j.econmod.2012.12.026.

57. Trehan, B., & Walsh, C. E. (1991). Testing Intertemporal Budget Constraints: Theory and Applications to U. S. Federal Budget and Current Account Deficits. *Journal of Money, Credit and Banking*, *23*(2), 206-223. https://doi.org/10.2307/1992777.

58. Vamvoukas, G. A. (1999). The twin deficits phenomenon: evidence from Greece. *Applied Economics*, *31*(9), 1093-1100. https://doi.org/10.1080/000368499323571.

59. Vanhorebeek, F., & Van Rompuy, P. (1995). Solvency and sustainability of fiscal policies in the EU. *De Economist*, *143*, 457-473. https://doi.org/10.1007/BF01384910.

60. Weichenrieder, A. J., & Zimmer, J. (2014). Euro membership and fiscal reaction functions. *International Tax Public Finance*, *21*, 598-613. https://doi.org/10.1007/s10797-013-9299-3.

61. Wu, J. L., Fountas, S., & Chen, S. L. (1996). Testing for the sustainability of the current account deficit in two industrial countries. *Economics Letters*, *52*(2), 193-198. https://doi.org/10.1016/S0165-1765(96)06860-7.

Appendix TDH

The link between the current account balance (*CA*) and the government budget balance (*GB*) stems from the standard macro identity:

$$Y \equiv C + I + G + X - M \qquad \text{(A1)}$$

where *Y* is domestic output, *C* is private consumption expenditure, *I* is private investment, *G* is government consumption, *X* are exports of goods and services, and *M* are imports of goods and services. Using the definition of national income (*R*) and net factor income (*NFI*) from the rest of the world we have:

$$R \equiv Y + NFI. \qquad \text{(A2)}$$

Therefore, disposable income ($R - T$) is consumed or saved:

$$R \equiv C + S + T \qquad \text{(A3)}$$

where S denotes private saving and *T* taxes and the *CA* is the sum of the trade balance ($X - M$) and *NFI*:

$$CA \equiv (X - M) + NFI. \qquad \text{(A4)}$$

From the previous relationships, the CA is defined as the sum of net private saving (net lending position of the private sector) and net public saving, the general government balance, ($GB = T - G$):[7]

$$CA \equiv (S - I) + (T - G). \qquad \text{(A5)}$$

Hence, fiscal shocks could drive the current account in the same direction. In particular, a government budget deficit ($T - G < 0$) would imply a current account deficit ($CA < 0$).

[7] For simplicity, we assume that the budget balance results from the difference between total taxes and public consumption.

Appendix

Table A1. Augmented Dickey-Fuller Stationarity Tests for the General Government Revenues and Expenditures, and Exports and Imports as percentage of GDP

	Revenues				Expenditures				Exports				Imports			
	Levels	*Obs.*	*F.D.*	*Obs.*	*Levels*	*Obs.*	*F.D.*	*Obs.*	*Levels*	*Obs.*	*F.D.*	*Obs.*	*Levels*	*Obs.*	F.D.	Obs.
Austria	-2.419	86	-5.436***	85	-3.344**	86	-4.265***	85	-3.353**	86	-4.198***	85	-3.675***	86	-4.285***	85
Belgium	-1.418	86	-5.015***	85	-2.283	86	-4.579***	85	-4.334***	86	-5.580***	85	-4.309***	86	-5.685***	85
Bulgaria	-2.260	86	-5.434***	85	-2.629*	86	-5.306***	85	-2.398	86	-4.010***	85	-4.263***	86	-3.661***	85
Croatia	-1.230	86	-4.668***	85	-3.848***	86	-4.187***	85	-0.756	86	-6.168***	85	-3.074**	86	-3.771***	85
Cyprus	-1.458	86	-5.325***	85	-3.496**	86	-5.656***	85	0.212	86	-3.843***	85	0.685	86	-4.439***	85
Czechia	-3.254**	86	-6.648***	85	-2.027	86	-4.862***	85	-2.512	86	-3.878***	85	-3.156**	86	-3.720***	85
Denmark	-2.593*	86	-4.135***	85	-2.524	86	-3.221***	85	-1.585	86	-5.070***	85	-1.869	86	-3.999***	85
Estonia	-2.612*	86	-5.076***	85	-2.684*	86	-3.648***	85	-2.273	86	-3.328***	85	-2.947**	86	-3.884***	85
Finland	-1.129	86	-5.519***	85	-1.973	86	-3.393**	85	-4.310***	86	-3.943***	85	-4.458***	86	-4.241***	85
France	-1.341	86	-3.295**	85	-2.585	86	-4.091***	85	-4.031***	86	-4.438***	85	-3.948***	86	-4.458***	85
Germany	-2.37	86	-4.511***	85	-2.248	86	-3.957***	85	-2.533	86	-4.225***	85	-3.556***	86	-4.568***	85
Greece	-0.895	86	-5.000***	85	-2.492	86	-4.957***	85	-1.397	86	-4.112***	85	-2.505	86	-2.898***	85
Hungary	-1.578	86	-4.972***	85	-3.348**	86	-5.494***	85	-2.392	86	-3.756***	85	-4.003***	86	-4.197***	85
Ireland	-0.666	86	-4.574***	85	-0.720	86	-5.354***	85	-0.285	86	-3.070**	85	-1.708	86	-4.941***	85
Italy	-1.173	86	-5.335***	85	-1.507	86	-4.56***	85	-1.819	86	-3.787***	85	-4.458***	86	-4.564***	85
Latvia	-1.750	86	-5.912***	85	-1.872	86	-4.285***	85	-2.188	86	-2.529***	85	-3.721***	86	-2.876*	85
Lithuania	-0.580	86	-4.581***	85	-2.335	86	-4.529***	85	-2.020	86	-3.786***	85	-3.629***	86	-4.018***	85
Luxembourg	-1.688	86	-4.522***	85	-2.473	86	-3.877***	85	-1.263	86	-3.771***	85	-0.919	86	-4.522***	85
Netherlands	-0.914	86	-5.901***	85	-2.271	86	-5.384***	85	-1.349	86	-3.612***	85	-2.123	86	-4.173***	85
Malta	-1.973	86	-6.263***	85	-2.709	86	-3.968***	85	-2.782*	86	-3.615***	85	-2.081	86	-3.688***	85
Poland	-1.841	86	-4.745***	85	-2.789**	86	-5.107***	85	-1.764	86	-2.814*	85	-2.945**	86	-2.879*	85
Portugal	-1.548	86	-6.967***	85	-1.725	86	-4.979***	85	-1.705	86	-4.297***	85	-2.990**	86	-3.998***	85
Romania	-2.732*	86	-4.846***	85	-1.839	86	-6.035***	85	-1.628	86	-3.352**	85	-2.849*	86	-3.498**	85
Slovakia	-0.720	86	-4.195***	85	-2.133	86	-2.865*	85	-2.727*	86	-3.150**	85	-2.911**	86	-3.184**	85
Slovenia	-2.138	86	-5.896***	85	-2.208	86	-5.488***	85	-2.469	86	-3.545***	85	-4.123***	86	-3.916***	85
Spain	-1.496	86	-3.745***	85	-1.821	86	-4.326***	85	-2.009	86	-3.983***	85	-4.536***	86	-4.470***	85
Sweden	-0.503	86	-4.669***	85	-2.443	86	-4.162***	85	-2.630*	86	-3.959***	85	-3.598***	86	-4.581***	85

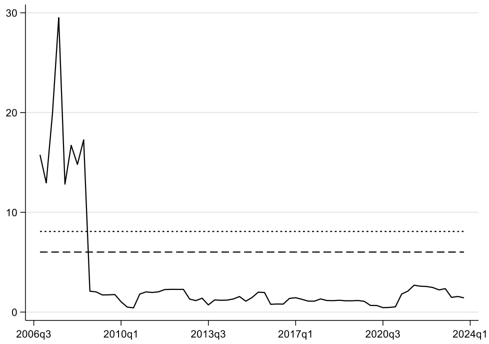
Notes: *, **, and *** denote statistically significance at the 10%, 5%, and 1% level respectively. Unit-root tests were carried out with one-lag, with constant and no trend.

A.1. Forward-Window

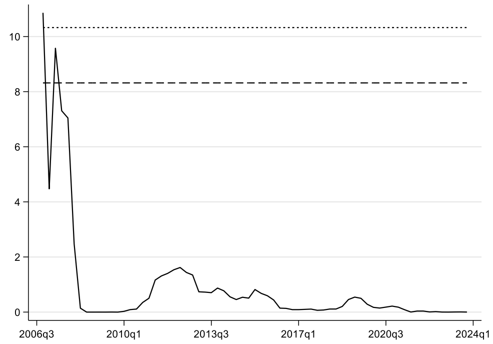
A.1.1. External causes fiscal sustainability

Figure A1. Forward expanding (FE) window time-varying granger causality, external causes fiscal sustainability

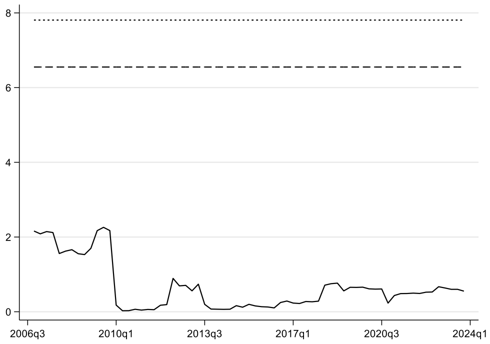
Austria



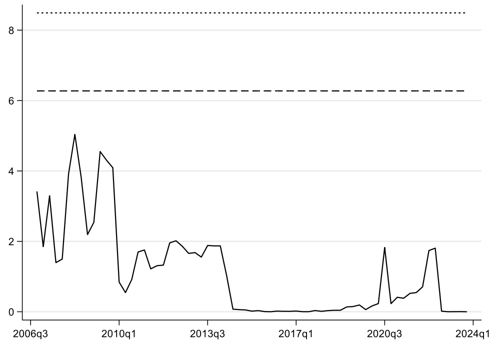
Belgium



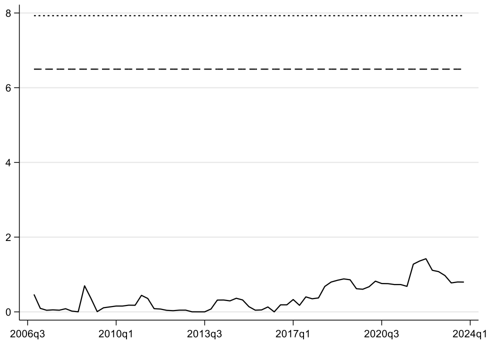
Bulgaria



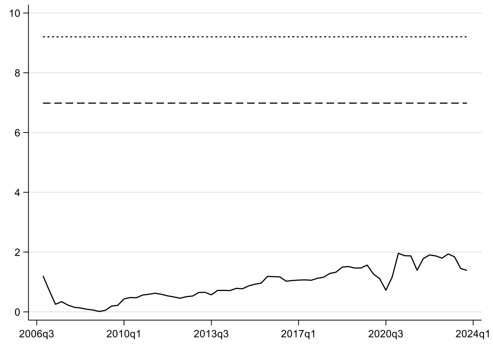
Croatia



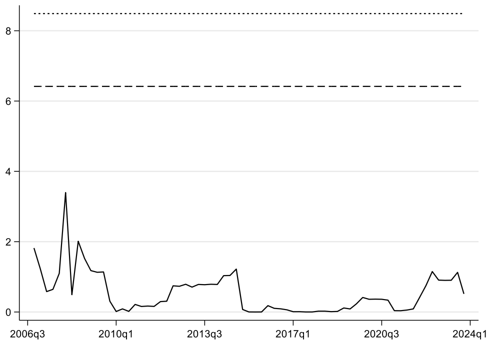
Cyprus



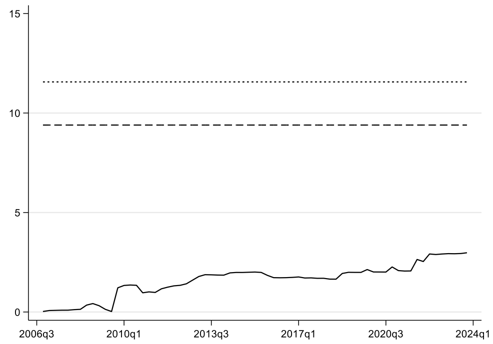
Czechia



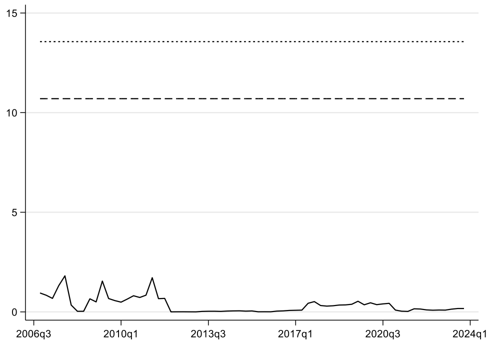
Denmark



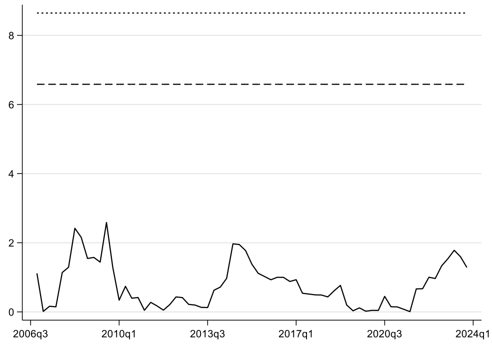
Estonia



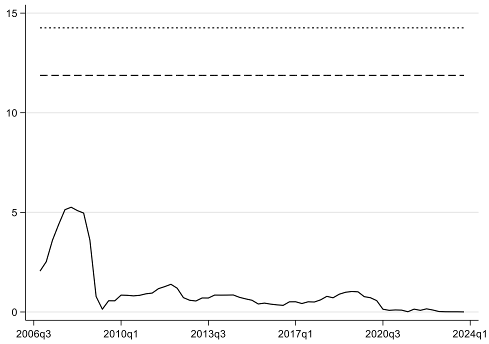
Finland



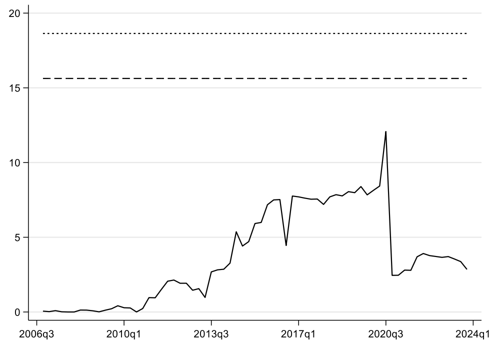
France



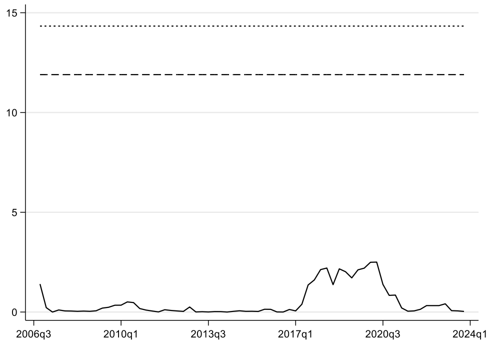
Germany



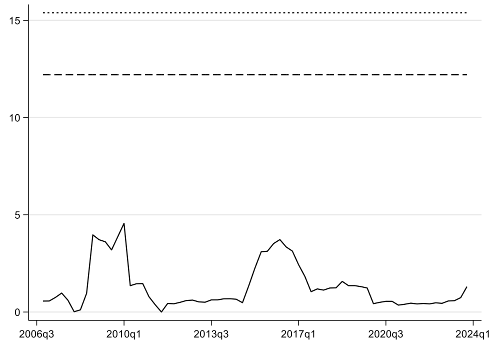
Greece



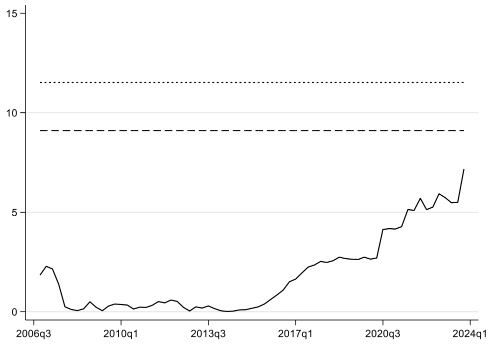
Hungary



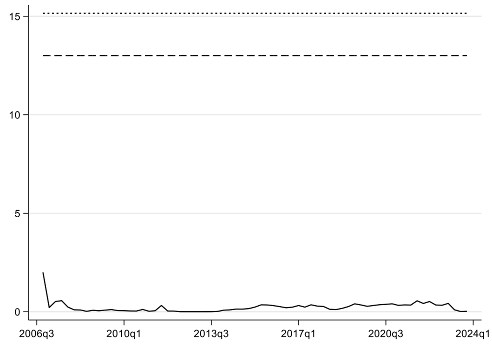
Ireland



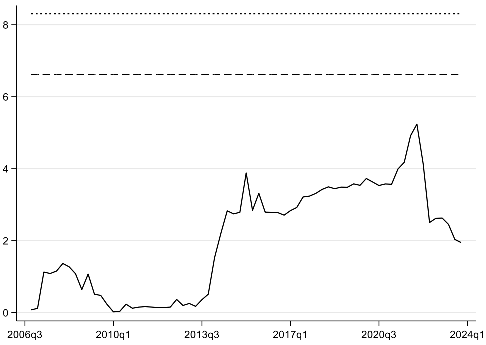
Italy



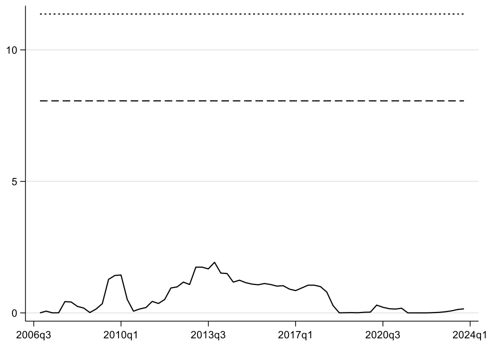
Latvia



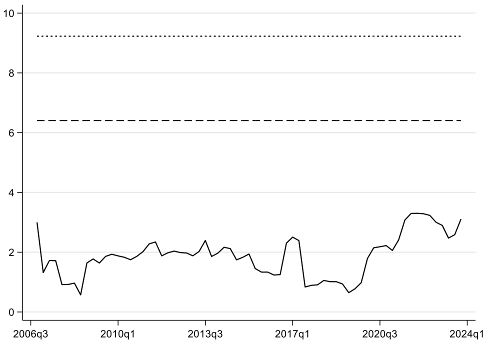
Lithuania



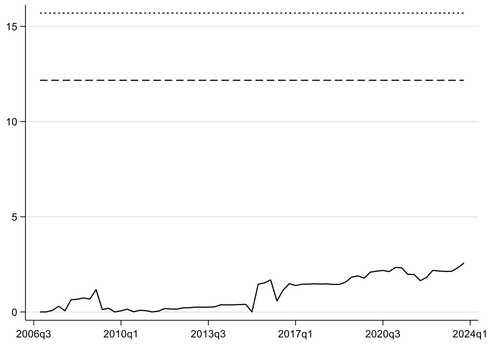
Luxembourg



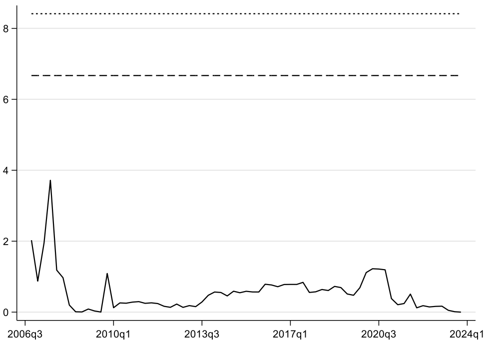
Malta



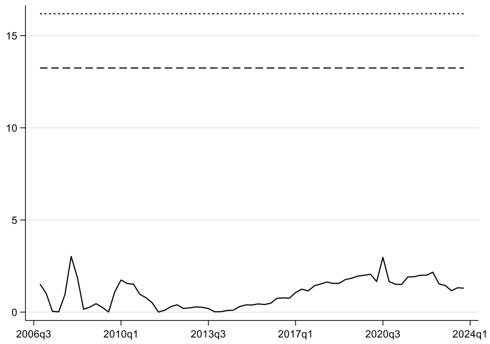
Netherlands



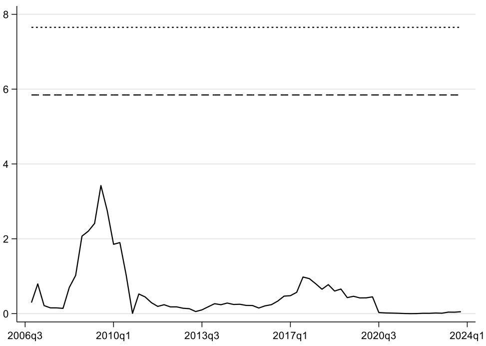
Poland



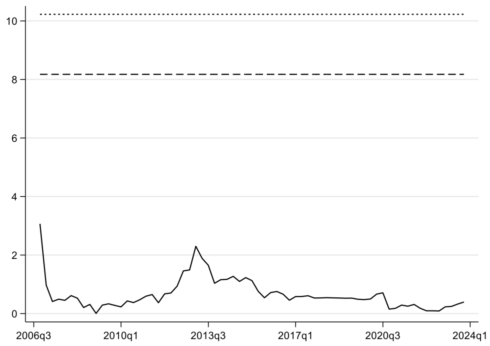
Portugal



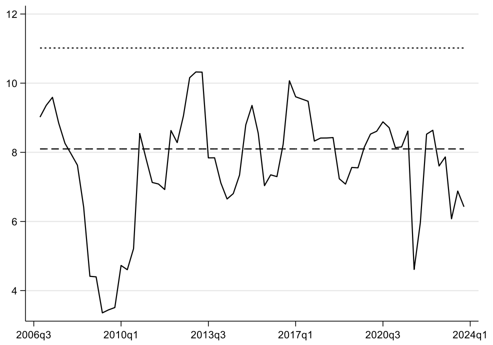
Romania



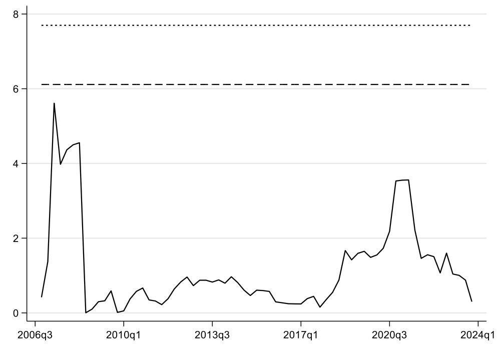
Slovakia



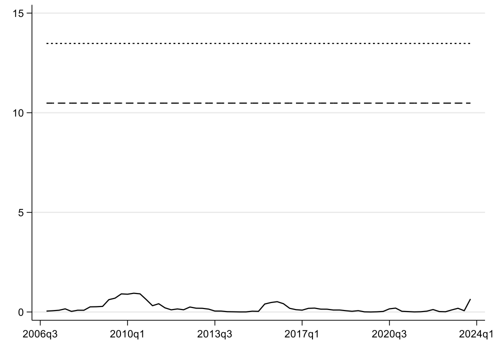
Slovenia



Spain



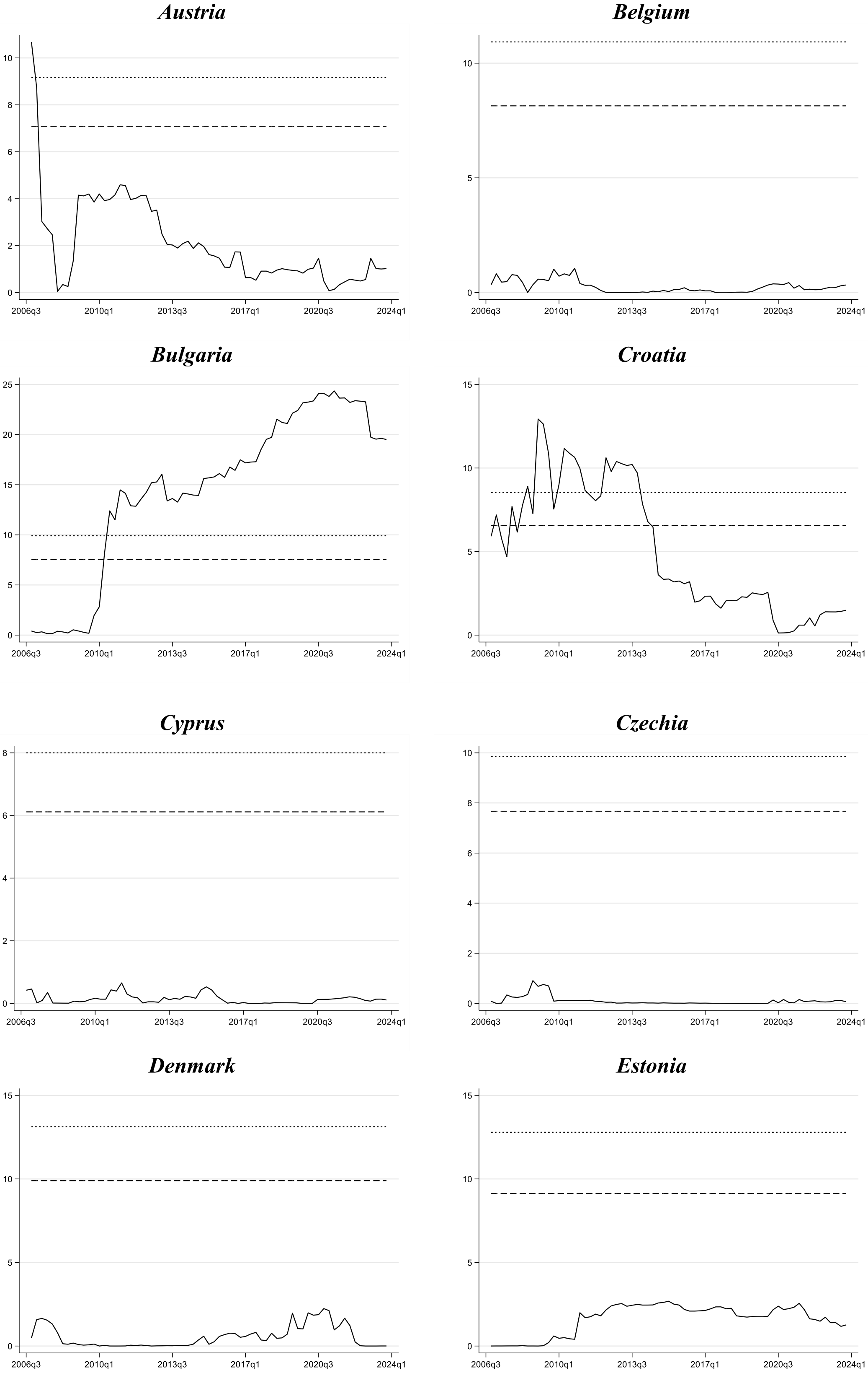
Sweden

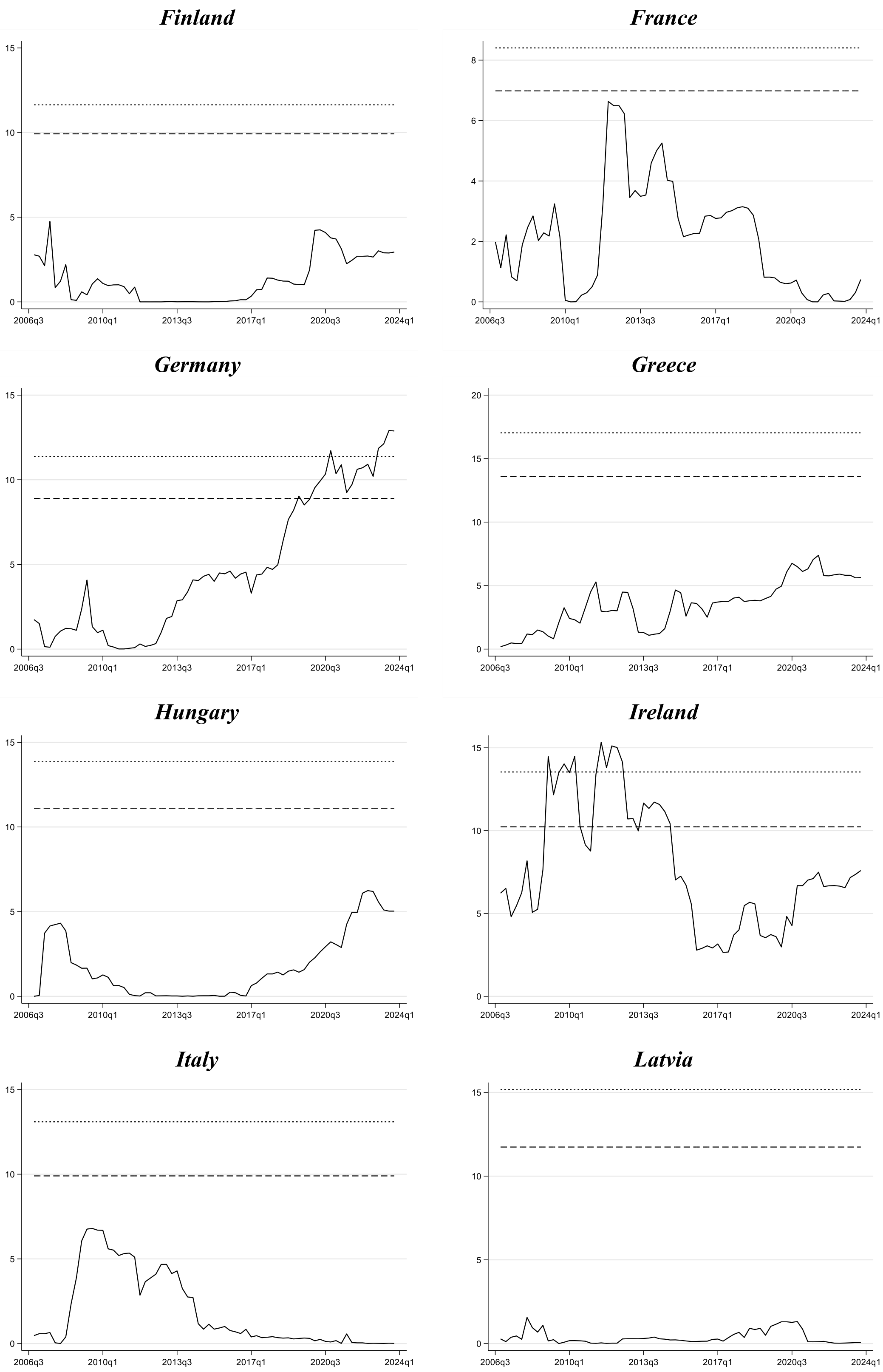


Notes: We select a minimum window size of 20 quarters. We include a trend in the underlying VAR model. The size of the tests is controlled during 10 quarters. These statistics are robust to heteroskedasticity. The dotted line indicates the 90*th* (lower line) and 95*th* (upper line) percentile of test statistics, where 499 bootstrap replications have been used. We present the results of the forward window at the 5 and 10% levels for readability purposes. Source: Authors' calculations.

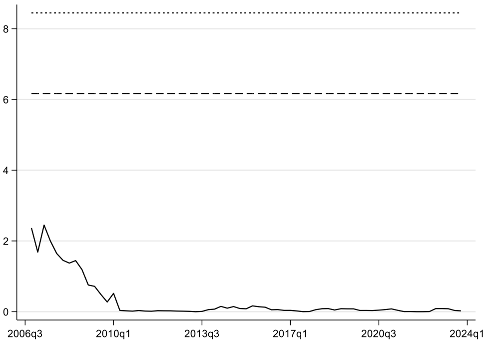
A.1.2. Fiscal causes external sustainability

Figure A2. Forward expanding (FE) window time-varying granger causality, fiscal causes external sustainability

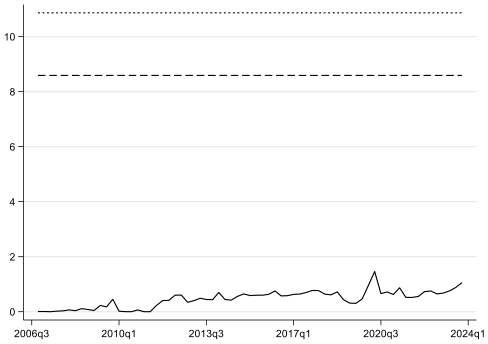



Finland
France
Germany
Greece
Hungary
Ireland
Italy
Latvia
0
5
10
15
20
2
4
6
8
2006q3
2010q1
2013q3
2017q1
2020q3
2024q1

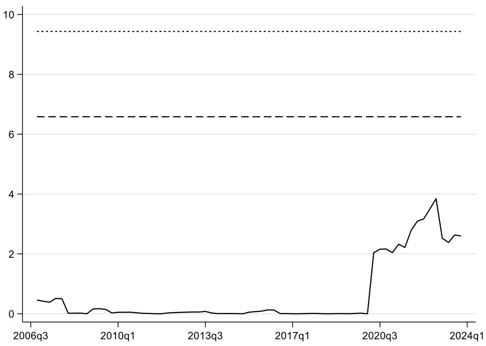
Lithuania



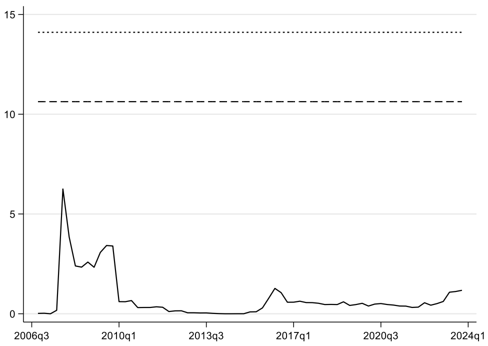
Luxembourg



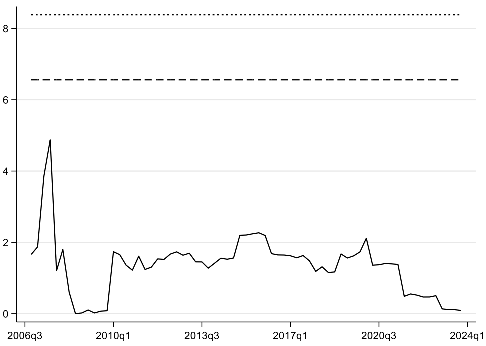
Malta



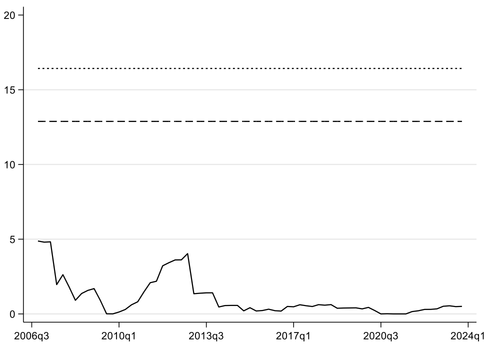
Netherlands



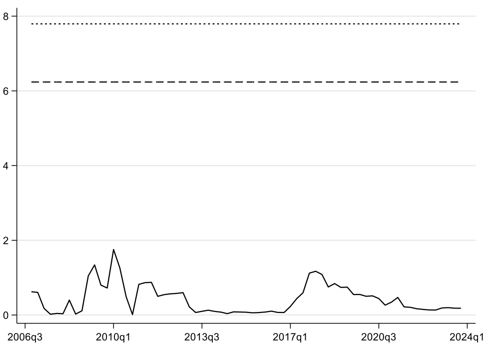
Poland



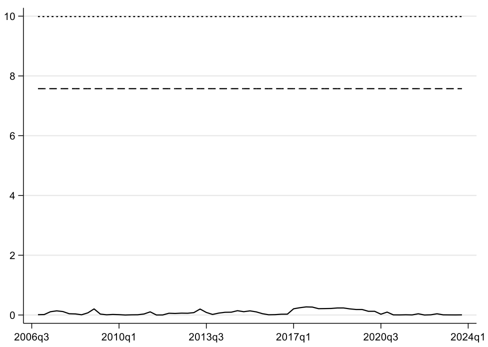
Portugal

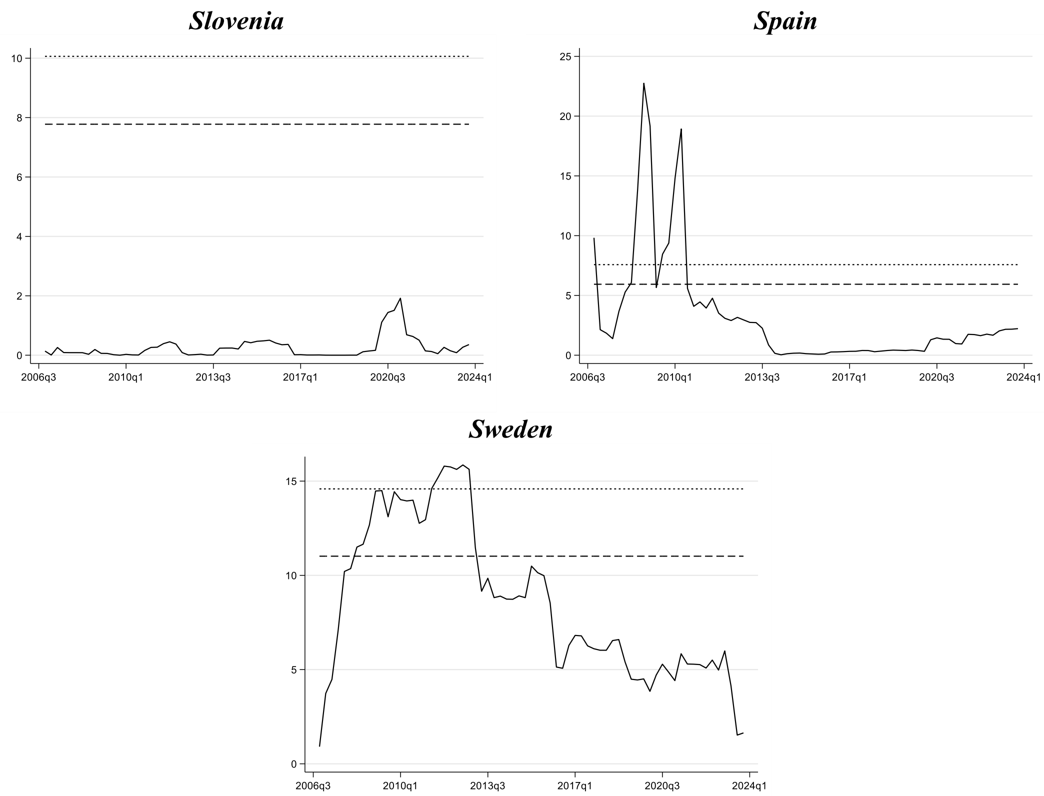


Romania



Slovakia





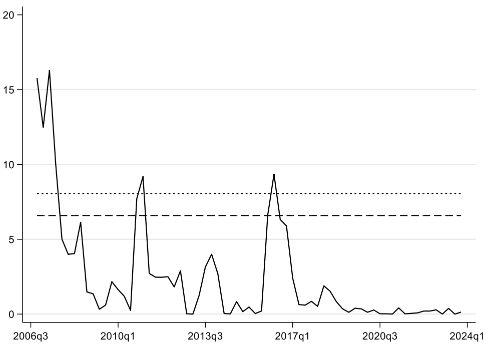
Notes: We select a minimum window size of 20 quarters. We include a trend in the underlying VAR model. The size of the tests is controlled during 10 quarters. These statistics are robust to heteroskedasticity. The dotted line indicates the 90*th* (lower line) and 95*th* (upper line) percentile of test statistics, where 499 bootstrap replications have been used. We present the results of the forward window at the 5 and 10% levels for readability purposes. Source: Authors' calculations.

A.2. Rolling Window

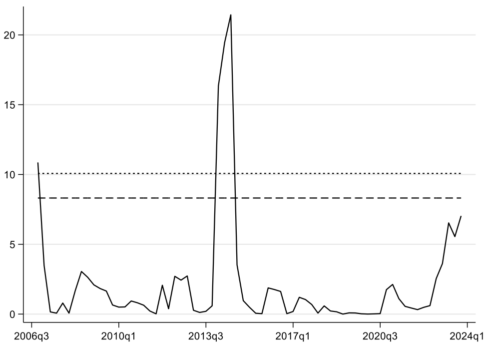
A.2.1. External causes fiscal sustainability

Figure A3. Rolling window (RW) time-varying granger causality, external causes fiscal sustainability

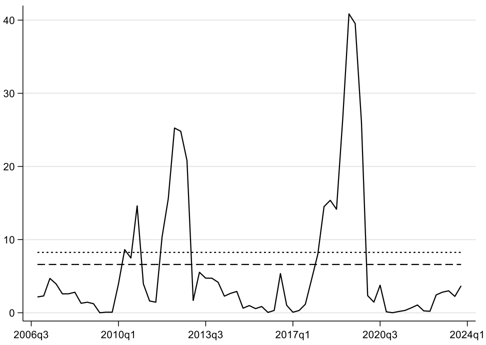
Austria



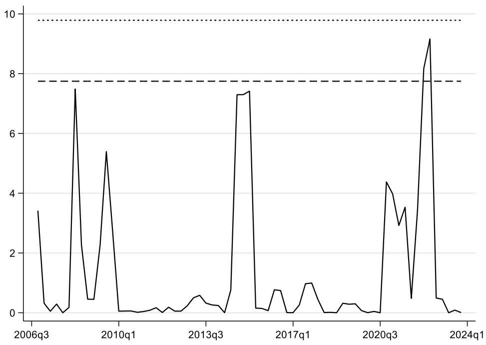
Belgium



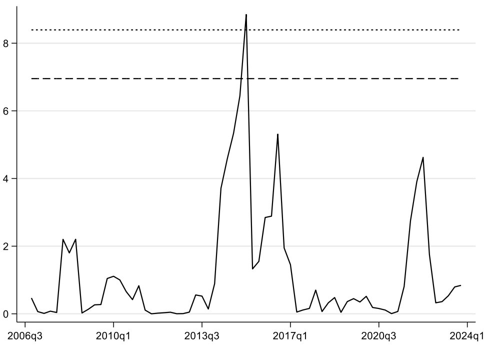
Bulgaria



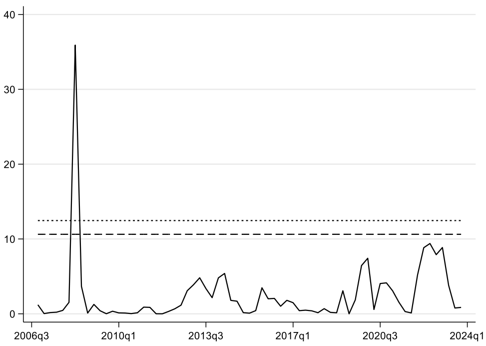
Croatia



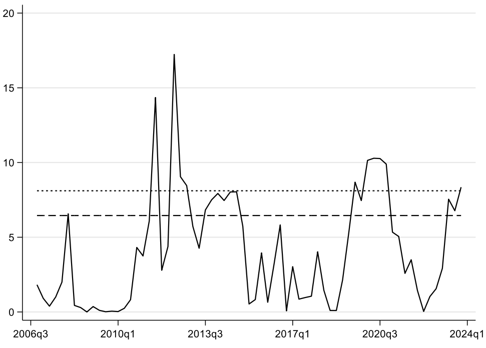
Cyprus



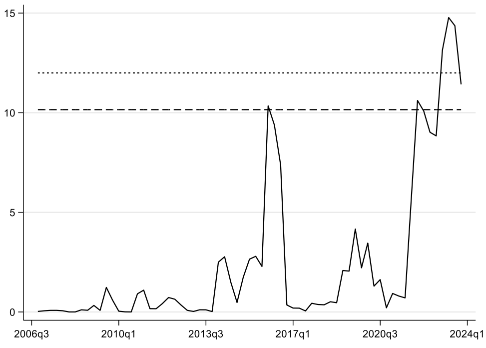
Czechia



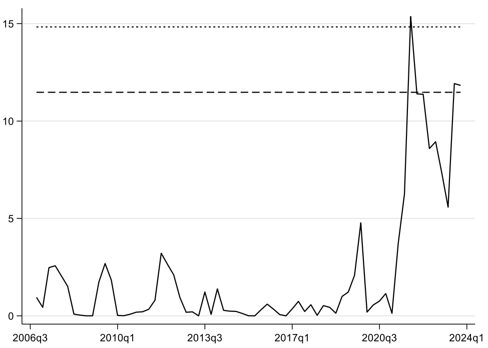
Denmark



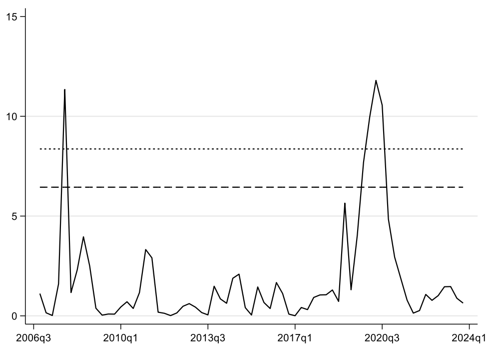
Estonia



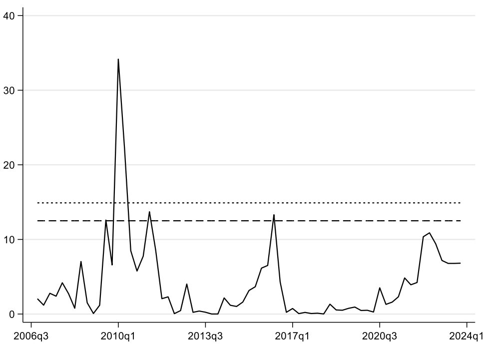
Finland



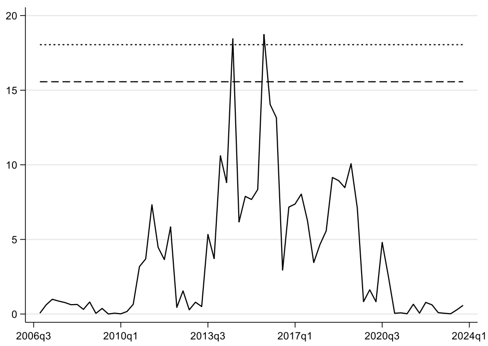
France



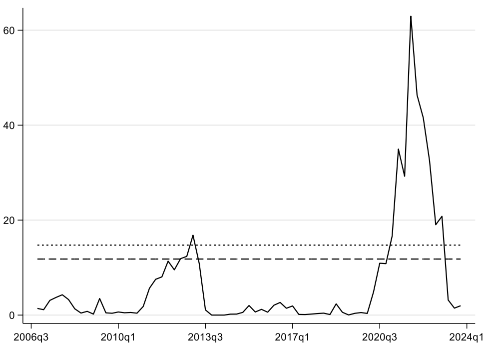
Germany



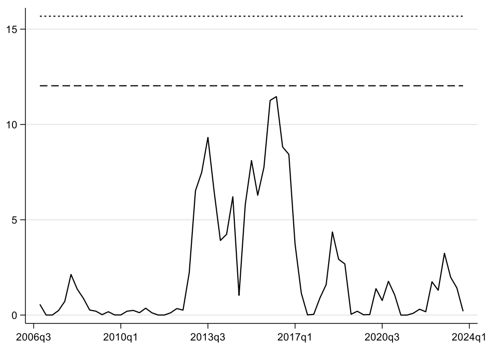
Greece



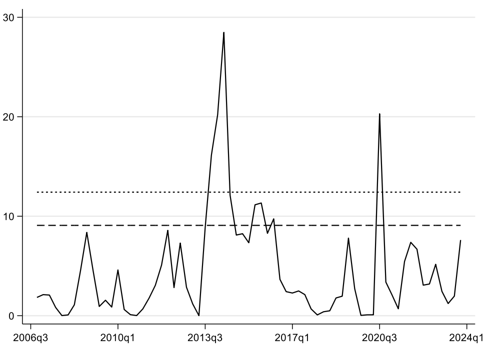
Hungary



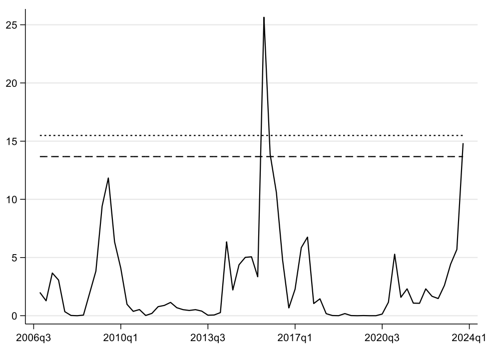
Ireland



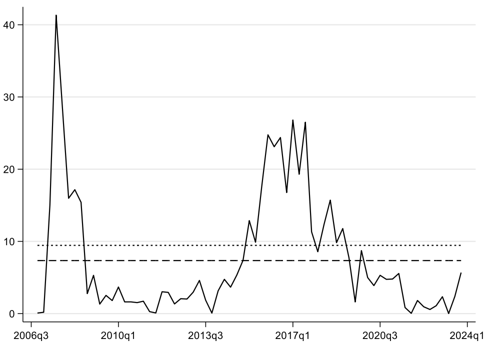
Italy



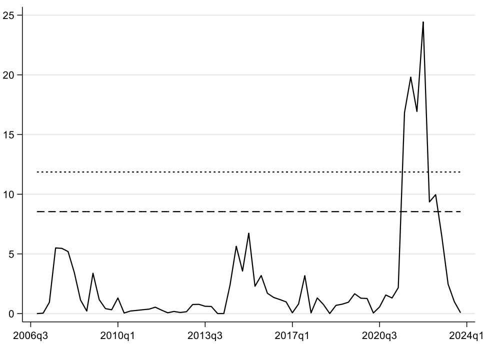
Latvia



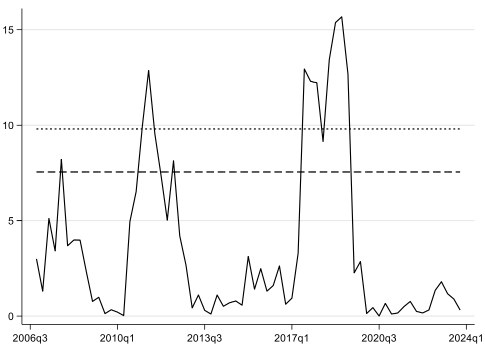
Lithuania



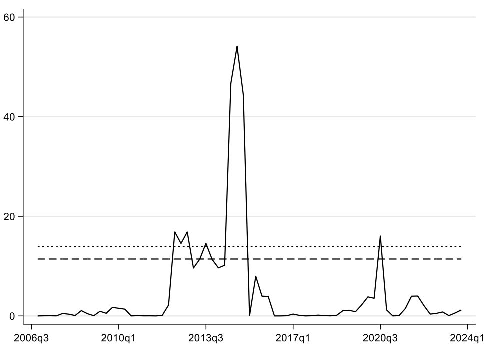
Luxembourg



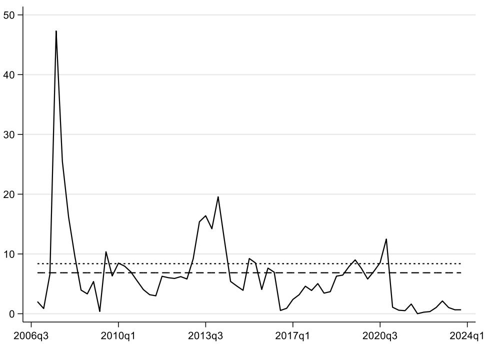
Malta



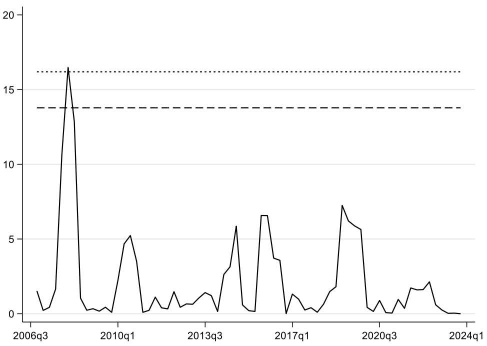
Netherlands



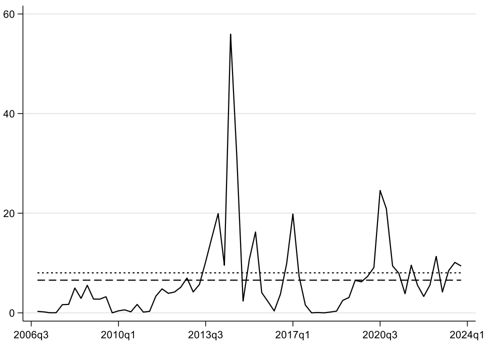
Poland



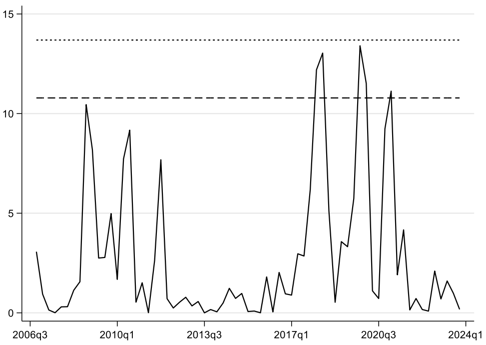
Portugal



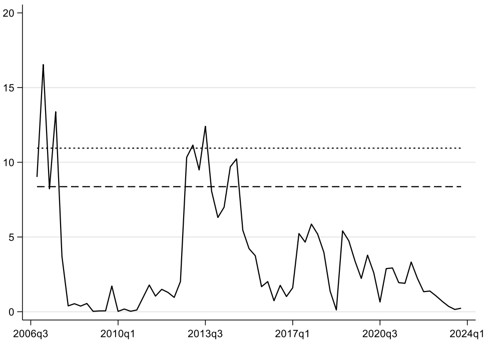
Romania



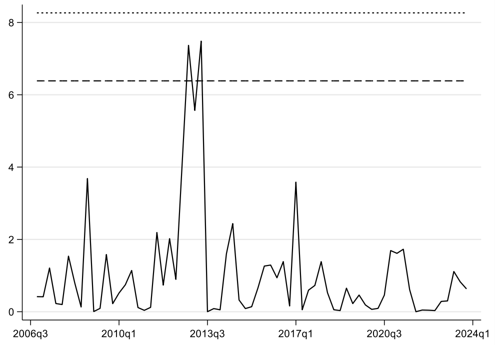
Slovakia



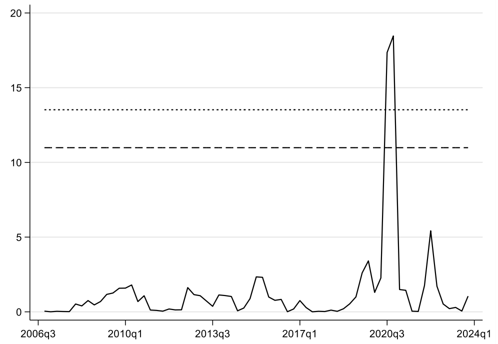
Slovenia



Spain



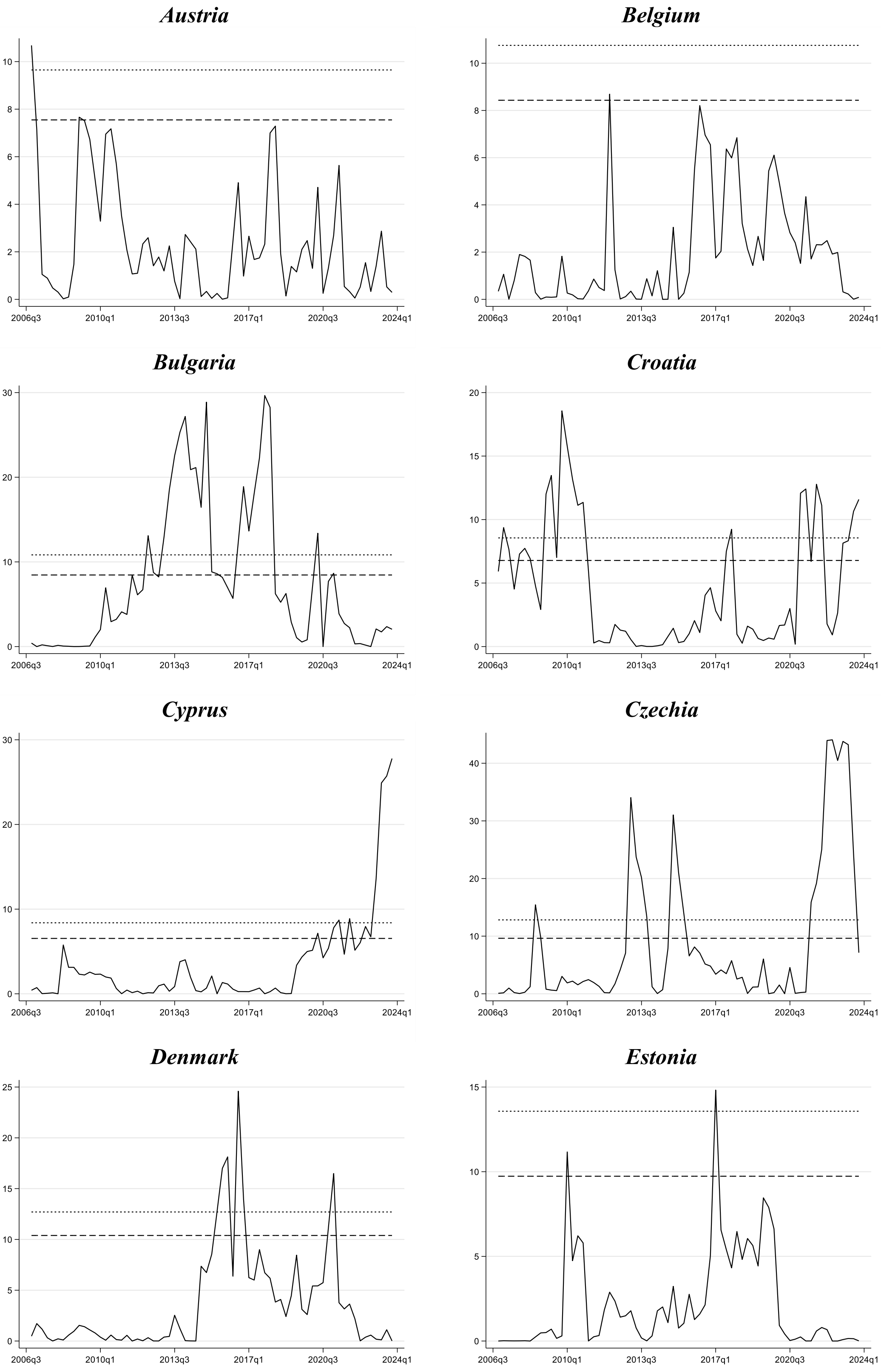
Sweden



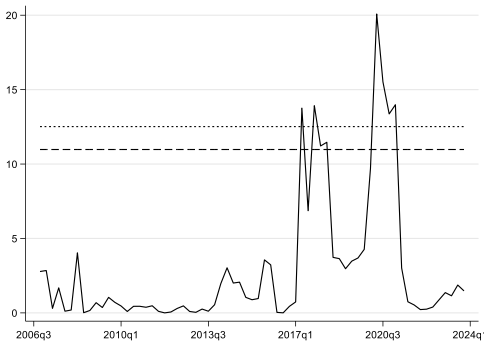
Notes: We select a minimum window size of 20 quarters. We include a trend in the underlying VAR model. The size of the tests is controlled during 10 quarters. These statistics are robust to heteroskedasticity. The dotted line indicates the 90*th* (lower line) and 95*th* (upper line) percentile of test statistics, where 499 bootstrap replications have been used. We present the results of the rolling window at the 5 and 10% levels for readability purposes. Source: Authors' calculations.

A.2.2. Fiscal causes external sustainability

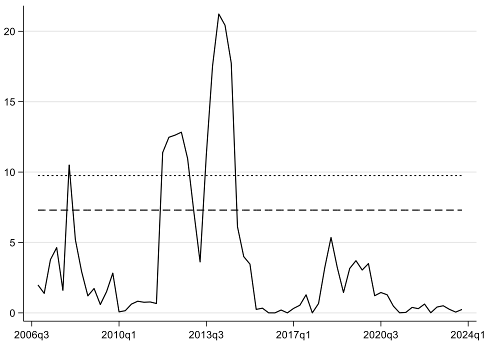
Figure A4. Rolling window (RW) time-varying granger causality, fiscal causes external sustainability



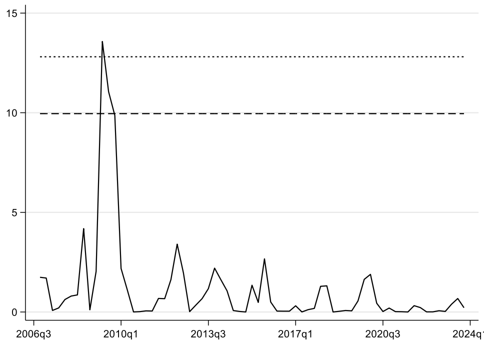
Finland



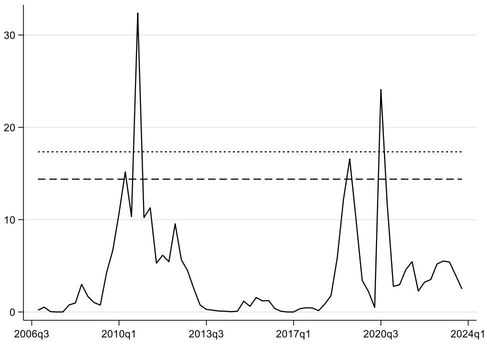
France



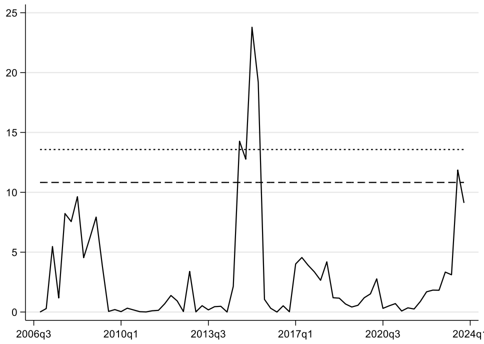
Germany



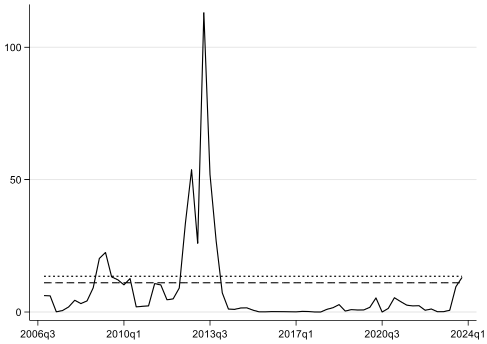
Greece



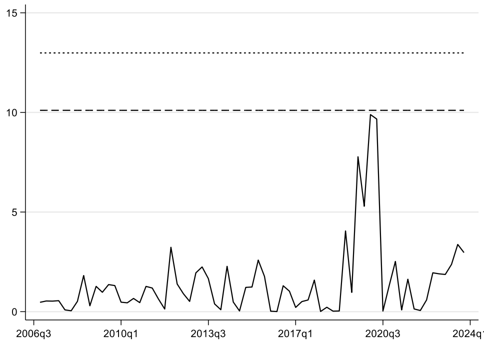
Hungary



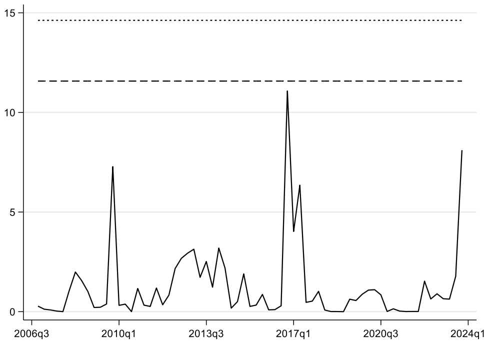
Ireland



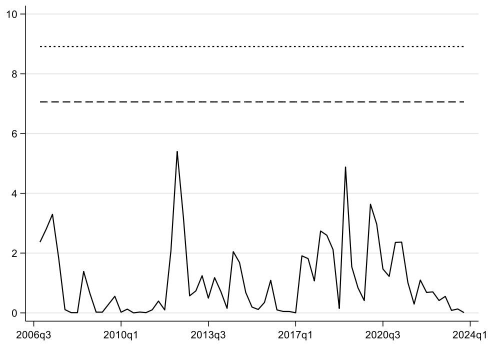
Italy



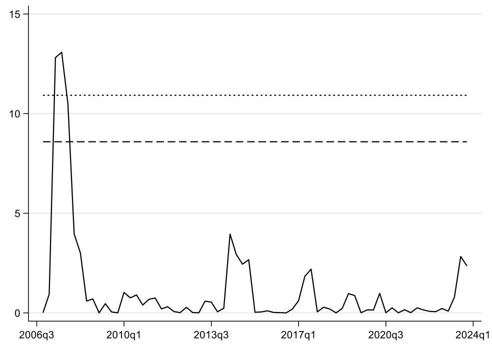
Latvia



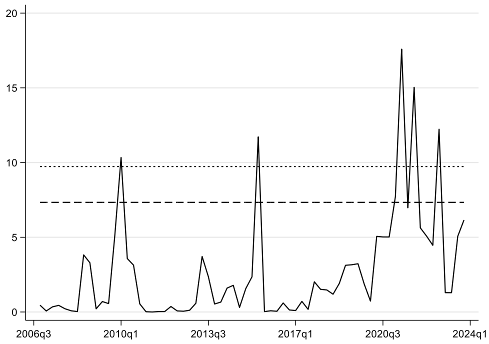
Lithuania



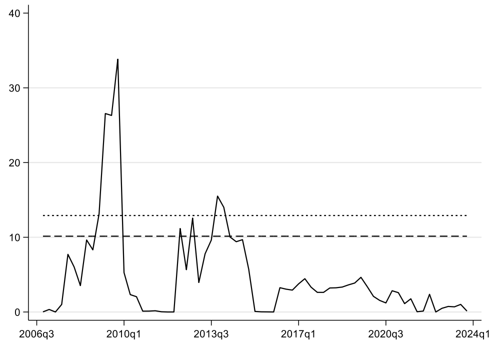
Luxembourg



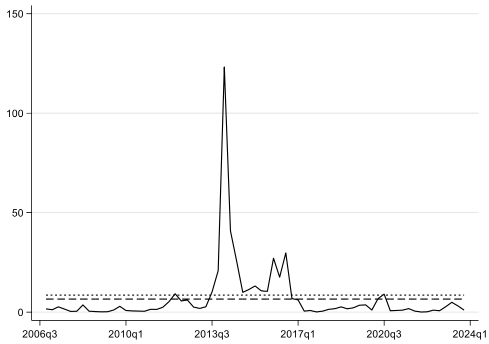
Malta



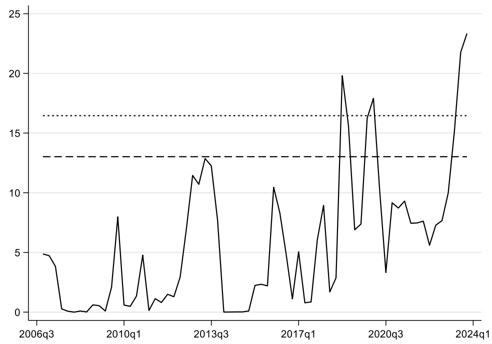
Netherlands



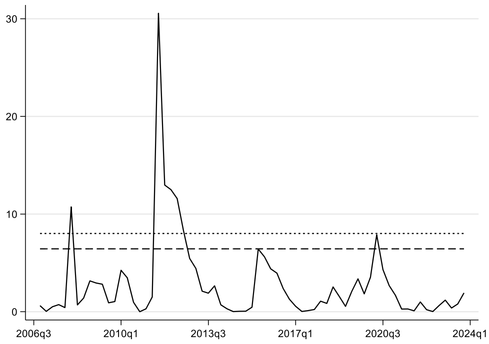
Poland



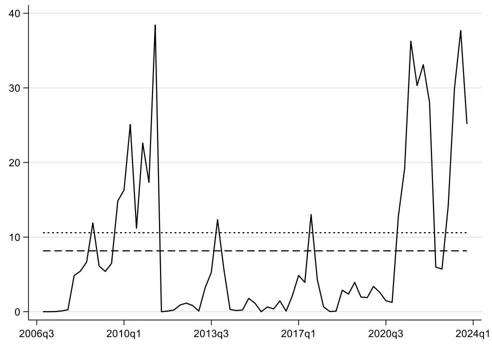
Portugal



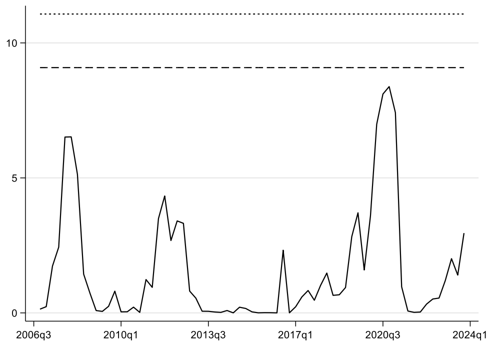
Romania



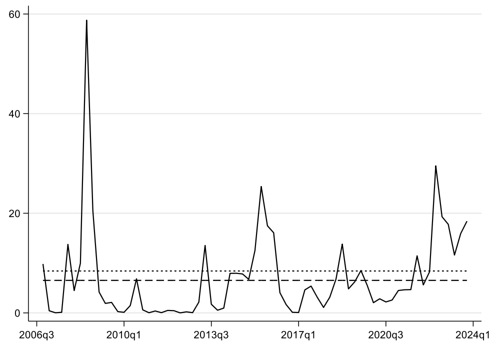
Slovakia



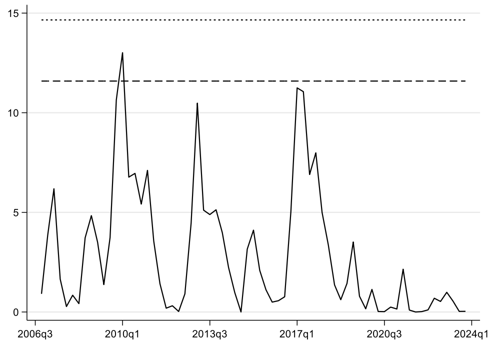
Slovenia



Spain



Sweden



Notes: We select a minimum window size of 20 quarters. We include a trend in the underlying VAR model. The size of the tests is controlled during 10 quarters. These statistics are robust to heteroskedasticity. The dotted line indicates the 90*th* (lower line) and 95*th* (upper line) percentile of test statistics, where 499 bootstrap replications have been used. We present the results of the rolling window at the 5 and 10% levels for readability purposes. Source: Authors' calculations.