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A reassessment of discretionary tax policy in the European Union: A cyclically-adjusted approach[§]

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Federica Lanterna [**]
Paolo Liberati [***]

Abstract

An extensive economic literature has investigated the cyclical behaviour of the budget balance in response to the business cycle. However, little is known about the behaviour of one of its two main components, *i.e.* tax revenue. We shed new light on this issue by focusing on a panel of 27 EU countries for the period 1995-2022. Using a novel empirical strategy to pre-adjust each revenue item for the business cycle, we study the behaviour of personal income tax, corporate income tax, indirect taxes, social security contributions, and non-tax revenues. Considering different econometric techniques, we find a general and stable pro-cyclical behaviour for all tax items in the EU, except for corporate income tax. This behaviour is then analysed with the varying-coefficient model, assessing the impact of a novel variable combining the stringency of the European fiscal framework and the debt-to-GDP ratio. Generally, this indicator seems to have intensified the procyclical trend of each revenue item.

Keywords: Tax policy, Pro-cyclicality, Tax Revenue, Cyclical adjustment, European Union
JEL Classification: E320, E620, H200

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1. Introduction

The theoretical literature has since long time stressed the importance of fiscal policy as a tool of macroeconomic stabilization (Musgrave, 1959). According to this strand of literature, fiscal policy should be counter-cyclical, which means that to limit output volatility, to promote economic growth and to smooth business cycle fluctuations, it should be expansionary during recessions, and vice versa (Ramey and Ramey, 1995; Aghion *et al.*, 2005). On the other hand, since Barro (1979), it is thought that fiscal policy should remain neutral over the business cycle, suggesting a policy response only to face unanticipated changes affecting the government's budget constraint. On the basis of these considerations, an extensive empirical literature has developed to study the degree of cyclicality of fiscal policy, its properties, and its drivers (Jalles, 2018), an issue that may be properly addressed only by separating the impact of discretionary policies and automatic stabilisers, the reason why the empirical literature generally adopts cyclically-adjusted fiscal data in order to disentangle those effects (Mourre *et al.*, 2014; Price *et al*., 2015). The general finding of this literature is that fiscal policy is counter-cyclical or a-cyclical in advanced countries and pro-cyclical in developing countries (Fatas and Mihov, 2009; Vegh and Vuletin, 2015), a result that is usually obtained by regressing the fiscal variable of interest against the business cycle variable.

Using a panel covering the 27 countries of the European Union (EU) from 1995 to 2022, this paper answers three interrelated research questions. First, from a theoretical point of view, we introduce a novel empirical strategy in order to adjust each tax item for the business cycle. This adjustment provides the possibility to separate the impact of discretionary policies from the automatic stabiliser component, and thus to study the cyclical behaviour of different revenue sources. To the best of our knowledge, this is the first time this methodology is used to properly assess the discretionary fiscal stance of each revenue item. Secondly, use is made of official data estimated by the European Commission. Considering each revenue item separately, this procedure empirically allows us to correctly evaluate whether government revenue policy has been pro-cyclical or counter-cyclical in the European Union. Thirdly, we estimate how the cyclical behaviour of each revenue item evolved

over time, evaluating – as the main driver – the impact of a novel variable capturing the interaction between the European fiscal framework and the debt-to-GDP ratio.

The new business cycle adjustment methodology proposed in this paper, allows us to properly assess the overall tax policy stance. In this regard, our results highlight the strong pro-cyclical response of discretionary revenues as a whole, limiting the ability of a crucial part of the public budget to weaken the severity of economic downturns and alleviate expansionary phases. This pro-cyclical trap characterises almost all revenue items; however, since pro-cyclicality in this case is observed in developed economies, the traditional explanation that it is mostly observed in developing countries because voters in those countries do not trust corrupt governments (Alesina et al., 2008) does not apply. Rather, pro-cyclicality, in our case, is mostly motivated by the European fiscal framework and by the limited space available to fiscal policy, a framework that has increased the homogeneity of pro-cyclical fiscal responses across countries. To this purpose, this hypothesis is investigated by regressing the time-varying cyclicality on the fiscal rules index, which is an indicator of the homogeneous direction that fiscal policies of the European countries should follow regardless of the specific phase of the cycle. We find that a negative sign is significant in almost all cases, implying that the growing tightening of fiscal rules, interacted with the debt-to-GDP ratio, has exacerbated the pro-cyclical trend of almost all revenue items. In this regard, the relevance of a specific threshold of the debt-to-GDP ratio becomes more pronounced as the enforcement and oversight of supranational fiscal regulations into national legislation become more rigorous. From this point of view, the pro-cyclical trap underlying the European fiscal framework seems to affect the Eurozone countries more than the remaining EU countries.

The paper is organised as follows. The second paragraph introduces the literature review on fiscal cyclicality from an empirical and theoretical perspective. Paragraph 3 describes data and methodology. Paragraph 4 discusses the main results. The fifth paragraph concludes.

2. Setting the issue: literature review

An extensive empirical literature has developed to study the degree of cyclicality of fiscal policy, its properties, and its drivers (Jalles, 2018), an issue that may be properly addressed only by distinguishing between discretionary policies and automatic stabilisers. The first category represents the outcome of policy-makers decisions (*i.e.*, the tools and the actions under their control), while the second category refers to the endogenous changes that arise from the correlated movements of built-in stabilisers and the business cycle. Since the use of the two instruments involves significant differences, the empirical literature generally adopts cyclically-adjusted fiscal data in order to separate the impact of discretionary policies from the adjustments caused by the automatic stabilisers (Mourre *et al.*, 2014; Price *et al*., 2015).

In general terms, the main finding of this literature is that fiscal policy is counter-cyclical or a-cyclical in advanced countries and pro-cyclical in developing countries (Fatas and Mihov, 2009; Vegh and Vuletin, 2015), a result that is usually obtained by regressing the fiscal variable of interest against the business cycle variable.[1] Bénétrix and Lane (2013) estimate both the overall general government balance and the cyclically-adjusted primary balance (CAPB) to assess how the automatic stabilisers and the discretionary components reacts to the business cycle, across the Euro area, for the period 1980-2007. The fiscal indicator is observed separately in two forms, first by considering the percentage point deviations of GDP from its quadratic trend as a measure of cycle, and then the lagged debt-to-GDP ratio as a measure of fiscal sustainability. They argue that fiscal policy was more counter-cyclical before the Maastricht Treaty, in contrast to the deterioration shown after the introduction of the euro. On average, during the period considered, fiscal policy appears a-cyclical only when measured on the general government budget; on the contrary, the cyclically-adjusted budget balance reveals a significant pro-cyclical fiscal stance.

[1] For more information on how to interpret the degree of fiscal cyclicality, see Paragraph 3.2.

The same measures for the fiscal indicator are used by Afonso and Carvalho (2022), whose study still focuses on the Euro area, for the period between 1995-2020. However, in this latter case, a difference exists on the variable used to measure the change of economic activity. Indeed, they first consider real GDP growth and, as a robustness check, the output gap. In doing so, they follow Jalles (2021), where the fiscal indicator is the budget-balance-to-GDP ratio of a sample of 60 countries between 1980-2014. Afonso and Carvalho (2022), after estimating the cyclicality coefficients, also consider some factors that could explain the cyclicality. Among them, they include country and time fixed effects, and a vector of macroeconomic, financial, and institutional variables. The authors conclude that, in the period considered, the discretionary fiscal policy of the Euro area countries has followed, on average, a counter-cyclical trend. However, during recessions, it has become more pro-cyclical. Jalles (2018), on the other hand, focuses on the role of fiscal rules on the degree of fiscal counter-cyclicality, concluding that fiscal rules – mainly the rule associated with debt in advanced countries – reduce the fiscal counter-cyclicality.[2] Larch *et al*. (2021), considering 40 EU and non-EU countries between 1960-2017, point out that the deviations from EU fiscal rules foster pro-cyclicality. Gootjes and de Haan (2022), for a panel of 27 EU countries for the period 2000-2015, argue that stringent fiscal rules, combined with an efficient government, reduce the pro-cyclicality of fiscal policies. Conversely, on a sample of 19 European countries observed over the period 1995-2019, Carnazza *et al.* (2023) shows how the progressive tightening of fiscal rules could represent one of the main causes behind the overall significant fiscal pro-cyclicality. Finally, outside Europe, Fatás and Mihov (2006) study how budget rules and fiscal restrictions affect fiscal policy, considering 48 US states, showing that tighter restrictions reduce both fiscal policy volatility and business cycle volatility.

The cyclical degree of fiscal policy can be also assessed by considering the aggregate budget balance or by splitting it into its main pillars, *i.e.*, government spending and tax revenue. In this

[2] For more information about fiscal rules, see Paragraph 3.3.

regard, to add new insights to the debate on the cyclicality of fiscal policy, one strand of the literature has focused on the different components of the aggregate budget. The prevailing result is that while government expenditure appears pro-cyclical in developing countries and counter-cyclical or a-cyclical in advanced countries, the tax policy seems to be a-cyclical in advanced countries and pro-cyclical in developing countries (Vegh and Vuletin, 2015). For OECD countries, Lane (2003) analyses the properties of the cyclicality of government expenditures and their institutional determinants, including a number of items: current government spending; government consumption; the breakdown between wage and nonwage component; government investment; total government expenditure; non-interest current spending, and non-interest total government expenditure. The cyclicality of the different components is analysed country-by-country considering a measure of output growth, and a set of controls, including output volatility and an index of *power dispersion*.[3] The main results show, on average, that overall government spending tends to be a-cyclical, even though there is a large degree of heterogeneity across the different components. Indeed, current spending is counter-cyclical as well as government transfers; government investment, on the other hand, is the most pro-cyclical component. Égert (2010) disaggregates the overall government spending, for OECD countries, into wage and non-wage final consumption expenditure; social security transfers; subsidies, other payments and property income paid by the government and government investments, by considering both real GDP growth rates and output gap as measures of the cycle. The heterogeneity of the response of the different expenditure components to the business cycle is confirmed. Investment expenditure is reported as one of the most pro-cyclical variables, along with government wages, while government subsidies appear to be counter-cyclical. On the other hand, the components of non-wage consumption and social transfers are found to be essentially a-cyclical.

[3] It is a measure that counts the number of veto points and the distribution of preferences in the different branches of government. The greater the number of veto points and the greater the separation of control between the different parties, the greater the dispersion of power.

In a more recent work, Jalles (2021) decomposes public expenditure by looking at total expenditure, spending on wages and salaries, public investment, spending on goods and services, non-interest current government expenditure or primary spending, and debt interest payments, for a panel of 36 advanced countries between 1970 and 2015. The regression equation relates each expenditure category to the real GDP growth rate, through time-varying estimates. The author concludes that spending on wages and goods and services shows a counter-cyclical behaviour, while public investment appears to be pro-cyclical. Moreover, he studies the behaviour of some key factors in the cyclicality of expenditure. Greater trade openness seems to increase the pro-cyclicality of spending, while high institutional quality and a large government reduce the degree of pro-cyclicality. As regards financial factors, expenditure cyclicality is negatively associated with the level of financial development and financial openness.

In contrast, the literature on the degree of cyclicality of tax revenues tends to be less developed, especially for the EU-27. For the United States over the period 1980-2011, McGranahan and Mattoon (2012) investigate the relationship between business cycle and state revenue. The log-difference in revenues in each state between the period t and $t + 4$ is related to the log-differences in economic conditions in the state in the same period. Following this procedure, they obtain the *revenue cyclicality*, defined as the average responsiveness of revenue growth to changes in state economic activity. They consider total revenue, sales tax revenue, individual income tax revenue, corporate income tax revenue, other tax revenue – where all measures are per capita.[4] The coefficient of total revenue appears pro-cyclical; corporate income taxes appear as the most cyclically sensitive revenue source, followed by personal income taxes and sales taxes. The category of other tax revenues is the least sensitive. Vegh and Vuletin (2015) investigate the cyclical behaviour of tax rates for 62 countries for the period 1960-2013. They focus on corporate tax, income tax, and value added tax (VAT), using tax rates as proxies of the policy variables under direct control of policymakers, rather than on tax

[4] We note that if the coefficient is positive tax revenue is pro-cyclical; if the coefficient is negative, tax revenue is counter-cyclical.

revenues or measures such as the tax burden, because they consider these measures to be endogenous to the business cycle. To solve the endogeneity issue, they use the highest marginal tax rate for income tax and the standard tax rate for VAT.[5] They also consider a tax index, which is the weighted average of each tax rate. The percentage change in the tax rate is related to the percentage change in real GDP, through a country fixed effects model. They obtain non-statistically significant estimates for personal income tax and corporate income tax for the advanced countries, indicating essentially a-cyclical behaviour. The coefficient of VAT, on the other hand, is negative for these countries, indicating a pro-cyclical behaviour. For developing countries, on the other hand, all the taxes analysed appear to be pro-cyclical. In a more recent work, Chrysanthakopoulos and Tagkalakis (2023) investigate the degree of cyclicality of VAT, income tax and corporate tax rates for a group of 52 countries over the period 1985-2019. They adopt the same strategy and data as Vegh and Vuletin (2015), and a time-varying methodology also considering the impact of fiscal rules on tax policy. The degree of tax rate cyclicality is estimated considering the change in the logarithm of real GDP as measure of the cycle. During the reporting period, they find that the tax rates of VAT have become counter-cyclical, while personal income taxes and corporate taxes have become pro-cyclical. With regard to tax rules, they argue that the balanced budget rule increases the degree of counter-cyclicality for all taxes examined, while the revenue rule only increases the degree of counter-cyclicality for personal income tax.

Given this framework, we contribute by shedding new light on the cyclicality of tax revenue in the 27 EU countries, thanks to a novel empirical strategy, which allows us to preliminarily adjust each revenue item analysed for the business cycle.

[5] As a control for a set of countries, they use the reduced VAT rates, effective VAT rates and average marginal personal income tax rate data.

3. Data and methodology

3.1 Semi-elasticities of revenues in the European Commission framework

In order to address the issue of cyclicality of the tax revenue side of the public budget, we estimate tax policy cyclicality by considering each revenue item separately and applying a novel cyclically-adjustment approach. Whenever we need to assess the cyclicality of a certain fiscal variable with respect to the business cycle, a cyclically-adjustment approach should be required to ensure that the corresponding dependent variable is not affected by output changes. In its official methodology, the European Commission cyclically adjusts the budget balance by estimating a (constant) semi-elasticity parameter (ε) and the output gap (OG). Since we are interested in the revenue side of the budget balance (R), we use the same methodology isolating this element. The related cyclically-adjusted total revenues (CAR) can be written in the following way:

$$CAR_t = \frac{R_t}{Y_t} - \varepsilon_R \cdot OG_t = \frac{R_t}{Y_t} - CC_R \quad (1)$$

where ε_R is the overall semi-elasticity of revenues and CC_R is the cyclical component of revenues (*i.e.*, the automatic stabilizers on the revenue side). Even though the output gap represents the most important element in determining CC_R, there is a preliminary important aspect that must be considered, *i.e.,* the cyclical adjustment parameter (Mourre *et al.*, 2013).[6]

Before estimating the cyclical component, e therefore need to explain how we deal with the semi-elasticity issue. Generally speaking, the semi-elasticities are computed by combining, on the one hand, the individual elasticities of each revenue category composing the government budget balance

[6] The budgetary semi-elasticity represents the responsiveness of the budget balance, expressed as a percentage of GDP, to changes in the economic cycle. From a mathematical standpoint, it quantifies the absolute change in the budget-to-GDP ratio resulting from relative changes in GDP. It is worth noting that the semi-elasticity of the budget-to-GDP ratio differs from budgetary elasticity, which assesses the monetary variation in the budget balance resulting from a unitary change in output (*i.e.*, an output gap of 1%). The semi-elasticity of revenue is relatively close to zero as the revenue-to-GDP ratio tends to remain stable over time. Revenue in Member States, excluding non-tax sources, generally follows cyclical patterns in GDP. Therefore, the total revenue as a percentage of GDP does not fluctuate significantly with the economic cycle (see also Figure A1 in the Appendix).

and, on the other hand, their weights as a percentage of GDP. The latest official revision is that proposed by Mourre *et al.* (2019), which exclusively focuses on the new weights adopted in relation to revenue categories. These weights are now calculated as ten-year average over the period 2008-2017, instead of 2002-2011 as carried out by Mourre *et al.* (2013) in the previous update (Table A1 in the Appendix). In any case, the individual elasticities are constant and unchanged with respect to their last estimations (Mourre *et al.*, 2014 – Table A2 in the Appendix). From an empirical point of view, this simplification is aimed at computing a unique semi-elasticity for each European country. On a theoretical perspective, the semi-elasticity of revenues (ε_R) can be decomposed into the effect of the revenue-to-GDP ratio (R/Y) and the composition effect reflected by its elasticity (η_R). Formally:

$$\varepsilon_R = \frac{R}{Y} \cdot (\eta_R - 1) \tag{2}$$

The aggregate semi-elasticity of revenues (ε_R) is based on the elasticities of their individual components. In this regard, total revenues (R) can be decomposed into five different categories: Personal Income Tax ($PIT = R^1$), Corporate Income Tax ($CIT = R^2$), Indirect Taxes ($IT = R^3$), Social Security Contributions ($SSC = R^4$) and Non-Tax Revenues ($NTR = R^5$).[7] ε_R can be therefore written as follows:

$$\varepsilon_R = (\eta_R - 1) \cdot \frac{R}{Y} = \sum_{i=1}^{5} \left(\eta_R^j - 1\right) \frac{R^j}{Y} = \sum_{j=1}^{5} \varepsilon_R^j \tag{3}$$

As reported in Mourre *et al.* (2014), the first four individual revenue categories are found sensitive to the economic cycle, while R_5 is assumed to be a-cyclical. Tables A1, A3 and A4 in the Appendix

[7] Direct taxes (DT) are represented by the sum of PIT and CIT. Since PIT and CIT data related to Malta and certain years related to Bulgaria are not available, we will also perform estimates of the overall DT.

show respectively the corresponding estimates of individual elasticities, the shares of revenue categories in terms of GDP – which were implicitly calculated from the official data – and the semi-elasticities used in computing the cyclical adjustment.[8]

3.2 Tax cyclicality and output gap

Once each revenue item has been cyclically adjusted, we are able to estimate the related degree of cyclicality by regressing it over the output gap. Our preliminary analysis is based on 27 countries belonging to the EU observed over the period 1995-2022 on annual basis. The baseline specification can be expressed as a dynamic panel data model, where each discretionary cyclically-adjusted revenue item (CAR^j) is explained by the cyclical conditions (OG). In formal terms, for each revenue item j and for each country i, we have the following equation:

$$CAR_{i,t}^{j} = \alpha + \beta^{j} OG_{i,t} + \gamma_i^{j} + \lambda_t^{j} + \varepsilon_{i,t}^{j} \tag{4}$$

where β is the sign of the coefficient associated with the output gap, γ_i represents country fixed-effects to control for unobserved specific country characteristics, λ_t introduces time fixed-effects to deal with possible exogenous shocks common to all countries in a specific year and $\varepsilon_{i,t}$ is the error component. More specifically, β captures the cyclical reaction of the revenue item: if β is negative, this implies a pro-cyclical reaction, while a positive value indicates counter-cyclicality. A pro-cyclical reaction implies that, during the recessionary phases of the business cycle, governments discretionally increase revenues (the opposite happens during economic booms). The extended specification of our model includes five macroeconomic controls represented by the vector $\boldsymbol{V}$ (trade openness, terms of trade, unemployment rate, inflation, and age dependency ratio).[9] The choice of the fundamentals is based on previous empirical studies investigating the cyclical and structural behaviour of fiscal policy

[8] Descriptive statistics, definitions and sources are provided in Table A5 in the Appendix.
[9] Descriptive statistics, definitions and sources are provided in Table A6 in the Appendix.

(see, among others, Lane, 2003; Jalles, 2018; Gootjes and de Haan, 2022). Formally, for each revenue item j and for each country i, the overall model can be expressed in the following way:

$$CAR_{i,t}^{j} = \alpha + \beta^{j} OG_{i,t} + \tau'^{,j} \boldsymbol{V}_{i,t} + \gamma_{i}^{j} + \lambda_{t}^{j} + \varepsilon_{i,t}^{j} \quad (5)$$

About the technical methods, we mainly rely on a Generalized Least Squares (GLS) estimator controlling for panel specific autocorrelation structure (AR1) and heteroskedastic and correlated error structure.[10] A standard assumption in panel data models is that the error terms are independent across cross-sections. In the worst case, cross-sectional dependence can lead to endogeneity and therefore to inconsistent estimates. In this context, the previous estimator allows us to deal with cross-sectional dependence in the error term. For robustness, we also adopt the Arellano-Bond (AB) model, which uses the conventionally derived variance estimator for Generalised Method of Moments (GMM) estimation (Arellano and Bond, 1991). In this way, we take into account a possible persistence in the revenue item resulting from the progressive convergence to a target budget (Galí and Perotti, 2003), as well as the potential endogeneity issue of the main regressor.

3.3 Fiscal Rules Index

A certain level of the debt-to-GDP ratio will be more important the more stringent the implementation and supervision of the supranational fiscal rules in national law (Carnazza *et al.*, 2023). In countries with high public debts, governments may be bound to implement a restrictive discretionary fiscal policy during bad times to keep public deficits at low levels and avoid breaching the reference value of 3% of GDP (Huart, 2013; Reuter, 2019). The role of fiscal rules is particularly relevant in the EU context where the number of national fiscal rules has increased significantly in recent years: in 2019, there were roughly two times as many national fiscal rules in force in the EU compared to a decade

[10] We also consider Fixed Effects (FE) estimator and GLS estimator controlling for heteroskedastic but uncorrelated error structure.

earlier and three times as many since the adoption of the Stability and Growth Pact in 1997 (Manescu *et al.*, 2023). Following Gootjes *et al.* (2021), we rely on the IMF's Fiscal Rules Dataset (Davoodi *et al.*, 2022), which includes national and supranational fiscal rules covering budget balances rules (BBR), debt rules (DR), revenue rules (RR) and expenditure rules (ER). Dealing with the revenue side of the budget balance, we decide to focus on the first three types of rules (*i.e.,* BBR, DR and RR), estimating three different sub-indexes at national and supranational levels. For each country i in year t, specific fiscal sub-index (*FSI*) has been calculated:

$$FSI_{i,t}^{j} = coverage_{i,t}^{j} + legal\ basis_{i,t}^{j} + supporting\ procedures_{i,t}^{j} + enforcement_{i,t}^{j} \qquad (6)$$

where $j = 1, \dots, 6$ defines the type of the rule combined with the relative level under consideration, *i.e.* BBR at national (1) and supranational (2) levels, DR at national (3) and supranational (4) levels and RR at national (5) and supranational (6) levels.[11]

With regard to the single component of each rule, we have: *coverage* that identifies which sector of the government is covered by the rule (*i.e.*, central government or general government or wider public sector); *legal basis* considers the highest legal basis of the rule (*i.e.*, political commitment, coalition agreement, statutory rule, international treaty or constitutional rule); *supporting procedures* examines the existence of multi-year expenditure ceilings, a fiscal responsibility law and an independent fiscal body setting budget assumptions and monitoring its implementation; *enforcement* checks what kind of enforcement mechanism is in place (*i.e.*, a formal enforcement procedure and a monitoring mechanism of compliance outside the government). Since only the last two components are dummy variables that are equal to 1 when a certain supporting procedure or enforcement mechanism is in place (0 otherwise), we normalize to unity *coverage* and *legal basis*. The country

[11] We also perform our estimates considering different compositions of the fiscal rules. Differences are negligible and are available upon request.

specific time-varying Fiscal Rules Index (namely FRI) is then calculated as a normalisation to unity of the sum of the previous three sub-indexes, assigning equal weight to each sub-index:

$$FRI_{i,t} = \left(normalisation \sum_{j=1}^{6} FSI_{i,t}^{j} \right) \quad (7)$$

The outcome of the previous equation, where 0 represents the minimum fiscal constraint and 1 the maximum fiscal constraint, is finally multiplied by the level of the debt-to-GDP ratio to get the variable FRI_Debt. Figure 1 displays the outcome of this interaction in our sample.[12]

[Figure 1 around here]

3.4 Measuring time-varying cyclicality

After assessing the overall fiscal stance of each cyclically-adjusted revenue item in relation to the business cycle, we regress our fiscal variables on the output gap (OG) to estimate the coefficient indicating the cyclical effect for country i on year t (*i.e.*, μ in eq. 8). For each country i and for each revenue item j, we build the following equation:

$$CAR_{i,t}^{j} = \delta_{i,t}^{j} + \mu_{i,t}^{j} OG_{i,t} + \varepsilon_{i,t}^{j} \quad (8)$$

This equation is jointly estimated with the equation that introduces the possibility for the μ parameter to change gradually as the years go by (this is the reason why the δ parameter is not constant in the previous specification). In particular, μ is assumed to modify slowly and unsystematically over time with its conditional expected value in a given period equal to its value at the previous period. The change in μ is denoted by $v_{i,t}$, which is assumed to be normally distributed with expectation zero and variance σ_i^2:

[12] Descriptive statistics and sources are reported in Table A7 in the Appendix.

$$\mu_{i,t}^{j} = \mu_{i,t-1}^{j} + v_{i,t} \; where \; v_{i,t} \sim N(0; \sigma_i^2) \tag{9}$$

The jointly estimation is based on the Varying-Coefficient model proposed by Schlicht (2022). This model is a generalization of the standard linear model: the classical regression model is the case when the variance of the disturbances (σ_i^2) tends to zero, which implies that the μ coefficient remains constant over time ($\mu_{i,t} = \mu_{i,t-1}$). By departing from this assumption and allowing σ_i^2 to be small but different from zero, we reflect changes from the fiscal stance that occurred in that year. In other words, in this way we reflect changes of the reaction of our fiscal variables to economic conditions observed, which seems to be a more realistic assumption (Afonso and Carvalho, 2022). According to Aghion and Marinescu (2007), this method offers various advantages compared to alternative approaches for computing time-varying coefficients.[13] Firstly, changes in the degree of government revenue cyclicality within a specific year originate from innovations taking place in the same year, rather than from shocks occurring in adjacent years. Secondly, this approach allows for the utilization of all observations in the sample to estimate the degree of government revenue cyclicality for each year. This is not possible, for instance, in the rolling window approach. Thirdly, it takes into account that policy changes are gradual and rely on the immediate past. Fourthly, reverse causality is reduced.

This further analysis is also based on 27 countries belonging to the EU observed over the period 1995-2022 on annual basis. The time-varying analysis of the μ coefficient can be expressed as a dynamic panel data model, where each specific cyclical coefficient (μ^j) is explained by the joint intensity of fiscal rules and debt-to-GDP ratio (FRI_Debt). In formal terms, for each revenue item j and for each country i, we consider the following equation:

$$\mu_{i,t}^{j} = \alpha + \rho_{i,t}^{j} FRI\_Debt + \gamma_i^{j} + \lambda_t^{j} + \varepsilon_{i,t}^{j} \tag{10}$$

[13] See also Jalles (2021).

where ρ represents the coefficient associated with FRI_Debt. As before, we take into account country-fixed (γ_i) and time-fixed effects (λ_t). Similarly, the extended specification of the model includes the previous five macroeconomic control variables ($\boldsymbol{V}$):

$$\mu_{i,t}^{j} = \alpha + \rho_{i,t}^{j} FRI\_Debt + \tau'^{,j} \boldsymbol{V}_{i,t} + \gamma_i^{\,j} + \lambda_t^{j} + \varepsilon_{i,t}^{j} \tag{11}$$

4. Main results

The empirical analysis first addresses the estimation of equations (4) (*baseline model*) and (5) (*extended model*), using the cyclically-adjusted tax items as dependent variables and the output gap as independent variable. Table 1 reports the results in two different panels. The first panel does not include control variables, while the bottom panel does. Furthermore, the same analysis is replicated by using fixed effects (FE), GLS and Arellano-Bond (AB) estimators. In both panels, it is remarkable that a stable pro-cyclicality (a negative sign of the coefficient) widely emerges for the personal income tax, for the aggregate figure of direct and indirect taxes and for social security contributions. When considering total revenue as a whole, pro-cyclicality still emerges. The only notable exception to this regularity is provided by the corporate income tax, which is pro-cyclical when using the GLS estimator and control variables with heteroskedasticity and uncorrelated error structure, and counter-cyclical when using the Arellano-Bond estimator without control variables. However, this specific uncertainty on the CIT is overwhelmed by the number of cases in which the corporate income tax may be considered as a-cyclical. The same outcome is also observable when considering non-tax revenues.

[Table 1 around here]

To some extent, our results confirm that the main discretionary use of taxes tends to amplify the cycle, reducing the ability of an important side of the public budget to reduce the depth of recessions and to mitigate expansionary phases, a task that, if any, appears improperly assigned only to public

spending. To some extent, compared to most of the previous studies stating that tax policies are often pro-cyclical in developing countries and a-cyclical in industrial countries, our results show the bad news that in Europe tax policies have fallen into the pro-cyclical trap. Even though we do not deal with spending policies, it is worth recalling some empirical evidence showing that countries with more pro-cyclical tax policies are also countries with more pro-cyclical government spending (Vegh and Vuletin, 2015). Furthermore, the pro-cyclical trap may be fuelled by government spending being pro-cyclical when some degree of citizens' fiscal illusion contributes to increase government spending (Abbott and Jones, 2016).

As also shown in a related paper (Carnazza *et al*., 2023), the fact that discretionary tax policies are mostly pro-cyclical may be due to the limited role that politics (*i.e.*, government choices) may play in the presence of a heavily constrained environment represented by the implementation of fiscal rules governing the size of the public budget. In order to analyse the contribution of fiscal rules to the pro-cyclicality of taxes, Table 2 reports the results of regressing the time-varying $\mu_{i,t}^{j}$ on the index of fiscal rules defined in equation (7).[14] These regressions allow us to investigate whether the rigidity of the rules may either reduce the counter-cyclicality of tax policies or increase their pro-cyclicality. Since the index of fiscal rules ranges between 0 and 1 and achieves its maximum severity when assuming a value 1, its impact will reinforce the pro-cyclicality of $\mu_{i,t}^{j}$ in the presence of a negative sign. As can be seen from Table 2, a negative sign is prominent in all cases, without exceptions neither for specific tax items nor for the set of both direct and indirect taxes. If any, an exception can be found with regard to the use of non-tax revenue, which in the context of a stabilisation policy does not play a relevant role. Furthermore, it is worth observing from Table 2 that the impact of fiscal rules, as expected and with the exception of the time-varying coefficient of the corporate income tax, is always

[14] Figure A2 in the Appendix shows the time-varying cyclicality coefficient $-\mu$ of equations 8 and 9 – of individual (cyclically-adjusted) revenue categories over time in relation to the European Union (27) average. For each category, an unknown structural break is identified by performing the Quandt Likelihood Ratio (QLR) test on the quadratic trend. In other words, Figure A2 graphically shows the relative increase of either the pro-cyclical behaviour or the reduction of the counter-cyclical behaviour of the different tax items over time.

greater in the countries of the Euro area, suggesting a higher pro-cyclical impact compared to what happens in the countries of the European Union that do not adopt the Euro.

[Table 2 around here]

The quantitative and qualitative results obtained in Table 2 are robust also to the introduction of various control variables, as in Table 3, spreading the pro-cyclical behaviour to non-tax revenues. A graphical synthesis of the direction and the intensity of the pro-cyclical behaviour determined by fiscal rules is finally reported in Figure 2. The upper panel reports the data of the model without control variables, where it is clear that non-tax revenue is the only item to show a counter-cyclical behaviour. When moving to the bottom panel, including control variable, the only exception to pro-cyclicality is represented by the case of social security contribution in the countries of the non-Euro area.

[Table 3 around here]

[Figure 2 around here]

As a further robustness check, the analysis has been replicated by using a different real time definition of the output gap, as derived from Carnazza *et al.* (2023).[15] The results are reported in Tables A8 and A9 in the Appendix – as well as in Figure A3 which summarises the previous results – where the negative sign of the coefficient and the relative higher intensity of the pro-cyclical effect in the countries of the Euro area are both confirmed.

[15] Since Autumn 2002, the European Commission recalculates the output gap twice a year, *i.e.* spring and autumn forecasts. Consequently, many time series exist since those revisions take into consideration not only forecasts of future levels but they are also based on past values. This would not be problematic if the estimated output gap was stable over time, but unfortunately this is not the case: given its high variability, the choice of which forecast to consider could affect the outcome as well as distorting its results. Given this scenario, Carnazza *et al.* (2023) introduces a new real time variable whose aim is to capture the effective level of the output gap observed at the time the decisions on fiscal policy are taken. This variable is denominated *OGmatched* since it matches the timing of the fiscal policy decision with the estimated output gap at that time.

5. Conclusions and policy implications

There is a general consensus on the importance of analysing the behaviour of fiscal policy in response to the business cycle. However, while the literature on the role of the aggregate budget balance is now extensive and thorough, little is known about the behaviour of one of its main components, *i.e.*, tax revenue. To fill this gap in the literature, this paper analyses the cyclical degree of personal income tax, corporate income tax, indirect taxes, social security contributions, and non-tax revenue for the European Union. To this purpose, we adopt a novel empirical strategy that allows to preliminarily adjusts each revenue item for the business cycle. In this way, it is possible to study only the discretionary effects of tax policy. Our main results show a stable pro-cyclical behaviour for personal income tax, for the aggregate direct and indirect taxes, and for social security contributions. Corporate income taxes, on the other hand, show less regular behaviour: they are pro-cyclical when using the GLS estimator and control variables with heteroskedasticity and uncorrelated error structure, and counter-cyclical when using the Arellano-Bond estimator without control variables. Pro-cyclicality is confirmed when studying, through the time-varying methodology, the impact of fiscal rules, except for the non-tax revenue category. Moreover, it is shown that the impact of fiscal rules, with the exception of corporate income taxes, appears to be consistently higher in Euro Area countries. In a nutshell, our results have shown that in European Union tax policies have fallen into the pro-cyclical trap, and that the (old) European fiscal framework seems to have played an important role in shaping this pattern. In order to deal with the consequences of the Covid-19 outbreak, the European Commission has activated in 2020 the general escape clause of the Stability and Growth Pact (SGP). After a long period of negotiations, in December 2023 European leaders agreed to reform the SGP in order to simplify the EU governance framework by using a single operational indicator (i.e., the so-called net expenditure). The pro-cyclical impact of the European fiscal framework will then have to be reassessed later in the light of the new rules. In any case, the new European fiscal framework remains far from being simple and, although an exhaustive description is beyond our scope, the critical elements that have fostered pro-cyclical budgetary dynamics seem to have remained intact.

For this reason, it is very likely that the worrying dynamics highlighted on the revenue side will continue to unfold in the new setting.

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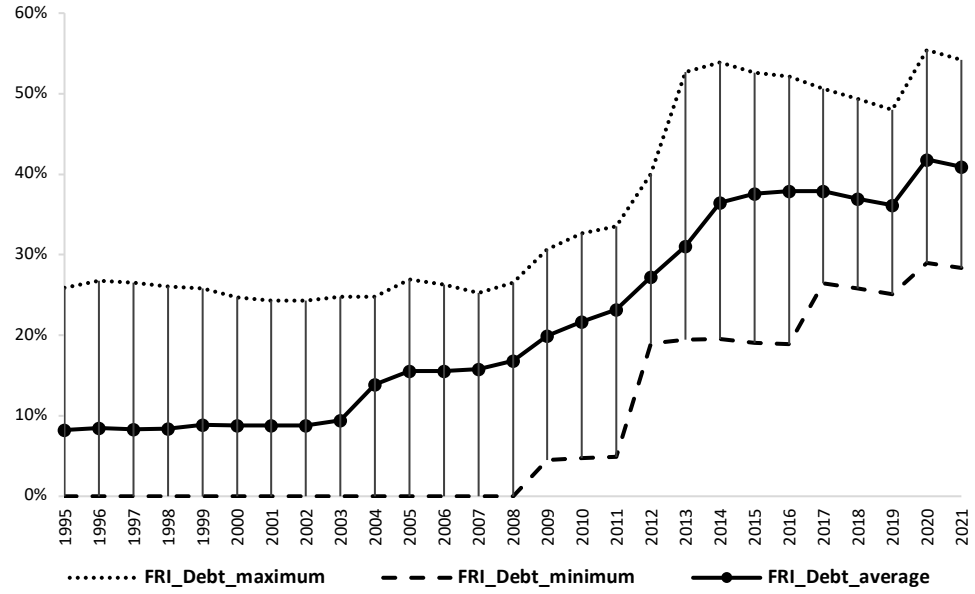
Figures and Tables

Figure 1 – The FRI_Debt variable in the European Union (27)



Note: debt-to-GDP ratios for Bulgaria and Denmark are not available for 1995 and 1996 and for the years 1995 to 1999, respectively. Accordingly, the Fiscal Rules Index was not considered for these countries in the aforementioned years. The Fiscal Rules Index takes into consideration the Debt rule, the Budget Balance rule and the Revenue rule.

Table 1 – Tax cyclicality and output gap

Model		(1)	(2)	(3)	(4)
Estimator		FE	GLS	GLS	AB
(Cyclically-adjusted) dependent variable	***Independent variable***				
Personal Income Tax (PIT)	**OG** (without control variables)	-0.047 *	-0.056 ***	-0.056 ***	-0.029 ***
Corporate Income Tax (CIT)		0.012	-0.004	-0.002	0.014 **
Direct Taxes (DT)		-0.064 *	-0.079 ***	-0.086 ***	-0.032 ***
Social Security Contributions (SSC)		-0.054 ***	-0.046 ***	-0.048 ***	-0.013 *
Indirect Taxes (IT)		-0.069 ***	-0.036 ***	-0.037 ***	-0.050 ***
Non-Tax Revenues (NTR)		0.021	0.006	0.020 ***	-0.004
Total Revenues (TR)		-0.168 **	-0.144 ***	-0.162 ***	-0.083 ***
Number of observations	Number of observations	756 (723)	756 (723)	756 (700)	702 (671)
Number of countries	Number of countries	27 (26)	27 (26)	27 (25)	27 (26)
Model		(5)	(6)	(7)	(8)
Estimator		FE	GLS	GLS	AB
(Cyclically-adjusted) dependent variable	***Independent variable***				
Personal Income Tax (PIT)	**OG** (with control variables)	-0.012	-0.057 ***	-0.060 ***	-0.040 ***
Corporate Income Tax (CIT)		0.012	-0.017 **	-0.005	0.011
Direct Taxes (DT)		-0.023	-0.079 ***	-0.080 ***	-0.038 ***
Social Security Contributions (SSC)		-0.029	-0.047 ***	-0.055 ***	-0.017 *
Indirect Taxes (IT)		-0.076 ***	-0.049 ***	-0.051 ***	-0.062 ***
Non-Tax Revenues (NTR)		0.010	0.014	0.031 ***	0.007
Total Revenues (TR)		-0.124 *	-0.139 ***	-0.168 ***	-0.112 ***
Number of observations	Number of observations	748 (715)	748 (715)	700 (644)	696 (665)
Number of countries	Number of countries	27 (26)	27 (26)	25 (23)	27 (26)
Country dummies		Yes	Yes	Yes	Yes
Time dummies		Yes	Yes	Yes	Yes
Heteroskedastic and uncorrelated error structure			Yes	No	
Heteroskedastic and correlated error structure			No	Yes	
Panel-specific AR1 autocorrelation structure			Yes	Yes	
Time span		1995 - 2022	1995 - 2022	1995 - 2022	1995 - 2022
Wald chi^2			***	***	***

Note: ***, **, * denote significance at 1%, 5% and 10% level, respectively. FE = Fixed Effects (robust standard errors); GLS = Generalised Least Squares (controlling for panel-specific AR1 autocorrelation structure, heteroskedastic but uncorrelated error structure, and heteroskedastic and correlated error structure); AB = Arellano-Bond (using the conventionally derived variance estimator for Generalised Method of Moments estimation). The AB estimator implies the presence of the lag of the dependent variable within regressors that has not been reported; the output gap has been considered endogenous in this kind of framework with a maximum of three lags as instruments. The constant term is included, but not reported. The number of observations and countries given in parentheses refers to PIT and CIT. Control variables include trade openness, terms of trade, unemployment rate, inflation (GDP deflator) and age dependency ratio.

Table 2 – Tax cyclicality and fiscal rules: The baseline model

Dependent variable	***PIT***		***CIP***		***DT***		***SSC***		***IT***		***NTR***		***TR***	
Model	**(1a)**	**(1b)**	**(2a)**	**(2b)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5a)**	**(5b)**	**(6a)**	**(6b)**	**(7a)**	**(7b)**
Estimator	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**
FRI_Debt	-0.00195 ***		-0.00015 ***		-0.00064 ***		-0.00014 ***		-0.00016 ***		0.00194 ***		-0.00095 ***	
FRI_Debt_noEA		-0.00146 ***		-0.00046 ***		-0.00033 ***		0.00014 ***		-0.00012 ***		0.00200 ***		-0.00080 ***
FRI_Debt_EA		-0.00253 ***		-0.00004 ***		-0.00105 ***		-0.00033 ***		-0.00021 ***		0.00189 ***		-0.00099 ***
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Heteroskedastic and correlated error structure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel-specific AR1 autocorrelation structure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time span	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021
Number of observations	648	648	594	594	675	675	675	675	675	675	621	621	675	675
Number of countries	24	24	22	22	25	25	25	25	25	25	23	23	25	25

Note: ***, **, * denote significance at 1%, 5% and 10% level, respectively. GLS = Generalised Least Squares (controlling for panel specific autocorrelation and heteroskedastic and correlated error structure).

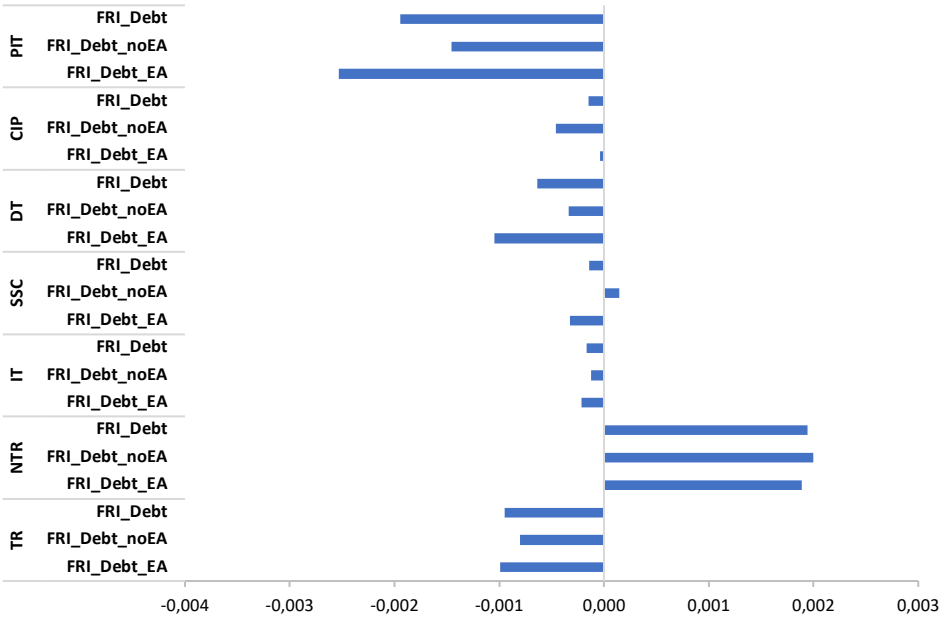
Table 3 – Tax cyclicality and fiscal rules: Model with control variables

Dependent variable	***PIT***		***CIP***		***DT***		***SSC***		***IT***		***NTR***		***TR***	
Model	**(1a)**	**(1b)**	**(2a)**	**(2b)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5a)**	**(5b)**	**(6a)**	**(6b)**	**(7a)**	**(7b)**
Estimator	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**
FRI_Debt	-0.00273 ***		-0.00036 ***		-0.00066 ***		-0.00003		-0.00009 ***		-0.00012 ***		-0.00034 ***	
FRI_Debt_noEA		-0.00218 ***		-0.00047 ***		-0.00037 ***		0.00056 ***		-0.00010 ***		-0.00026 ***		-0.00052 ***
FRI_Debt_EA		-0.00290 ***		-0.00022 ***		-0.00087 ***		-0.00014 ***		-0.00010 ***		-0.00004 **		-0.00025 ***
Openness	0.00043 ***	0.00045 ***	0.00029 ***	0.00031 ***	0.00025 ***	0.00029 ***	-0.00011 ***	-0.00009 ***	0.00004 ***	0.00004 ***	0.00001	0.00000	0.00000	0.00001
ToT	0.00115 ***	0.00093 ***	0.00020 ***	0.00028 ***	0.00077 ***	0.00061 ***	-0.00172 ***	-0.00163 ***	-0.00027 ***	-0.00028 ***	-0.00034 ***	-0.00026 ***	0.00032 ***	0.00039 ***
Unemployment rate	-0.00114 ***	-0.00104 ***	-0.00073 ***	-0.00062 ***	-0.00281 ***	-0.00303 ***	-0.00181 ***	-0.00163 ***	-0.00031 ***	-0.00031 ***	-0.00218 ***	-0.00221 ***	-0.00308 ***	-0.00327 ***
Inflation	-0.00041 ***	-0.00030 ***	0.00016 ***	0.00014 ***	-0.00023 ***	-0.00021 ***	0.00023 ***	0.00026 ***	0.00003 ***	0.00003 ***	0.00012 ***	0.00011 ***	0.00024 ***	0.00026 ***
Age dependency	-0.00668 ***	-0.00610 ***	0.01058 ***	0.00936 ***	-0.00367 ***	-0.00302 ***	0.00101 ***	0.00111 ***	-0.00070 ***	-0.00071 ***	0.00344 ***	0.00326 ***	-0.00101 ***	-0.00128 ***
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Heteroskedastic and correlated error structure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel-specific AR1 autocorrelation structure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time span	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021
Number of observations	594	594	540	540	621	621	621	621	621	621	567	567	621	621
Number of countries	22	22	20	20	23	23	23	23	23	23	21	21	23	23

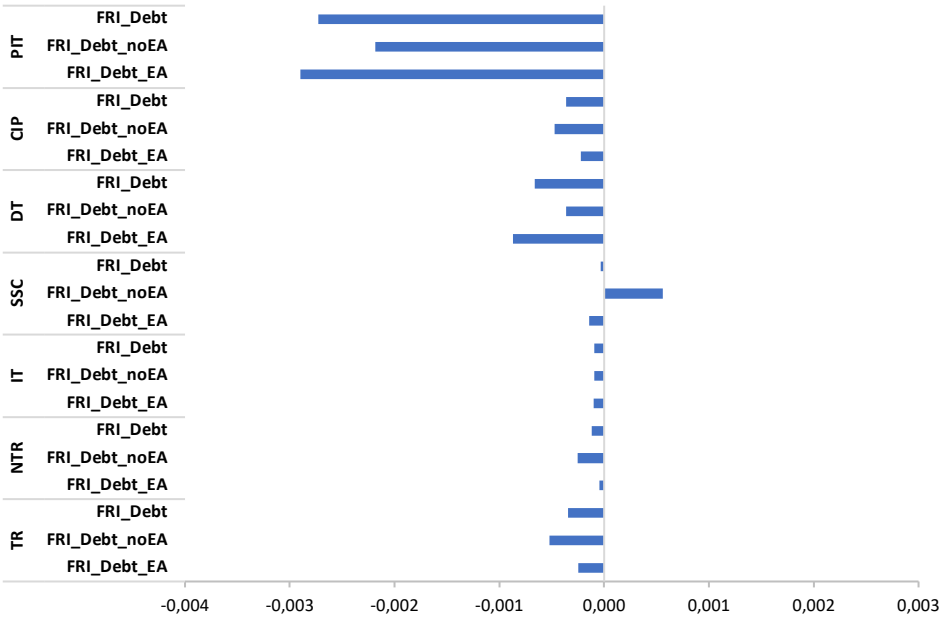
Note: ***, **, * denote significance at 1%, 5% and 10% level, respectively. GLS = Generalised Least Squares (controlling for panel specific autocorrelation and heteroskedastic and correlated error structure).

Figure 2 – Tax cyclicality and fiscal rules

(a) Baseline model



(b) Model with control variables



Note: the blue columns report the value of the coefficient associated with the variable describing the interaction between fiscal rules and debt-to-GDP ratio (a negative value implies that the *FRI_Debt* variable is reducing counter-cyclicality or increasing pro-cyclicality of the related revenue item; the opposite happens when the coefficient is positive).

Appendix

Table A1 – Updated shares of revenue categories (% of total revenue)

	Personal Income Tax (PIT)	Corporate Income Tax (CIT)	Social Security Contributions (SSC)	Indirect Tax (IT)	Non-Tax Revenue (NTR)
Austria	22.56	4.49	30.62	29.25	13.07
Belgium	25.95	6.42	32.72	25.82	9.10
Bulgaria	8.70	6.18	21.04	42.32	21.76
Croatia	11.09	4.12	27.30	42.58	14.91
Cyprus	9.58	16.65	21.01	38.36	14.40
Czechia	9.93	8.18	36.62	29.45	15.82
Denmark	50.28	4.82	2.14	30.32	12.44
Estonia	14.28	3.95	29.77	34.94	17.06
Finland	25.35	5.03	23.43	25.84	20.35
France	18.73	4.87	35.98	29.93	10.48
Germany	21.33	5.53	37.49	24.50	11.15
Greece	13.11	7.95	29.91	32.00	17.02
Hungary	12.81	3.85	28.44	38.67	16.23
Ireland	29.13	8.48	17.02	32.26	13.11
Italy	26.21	5.08	28.54	31.14	9.04
Latvia	17.07	4.68	24.29	35.04	18.92
Lithuania	11.80	4.36	34.27	33.59	15.99
Luxembourg	19.46	13.43	28.14	28.44	10.53
Malta	22.44	11.24	17.41	33.80	15.11
Netherlands	19.84	5.82	33.80	25.97	14.57
Poland	12.35	5.82	33.19	34.31	14.33
Portugal	15.60	7.43	27.59	32.70	16.68
Romania	10.85	7.90	27.56	36.50	17.20
Slovakia	9.09	8.06	34.89	27.68	20.28
Slovenia	13.81	3.75	33.92	32.84	15.68
Spain	21.10	5.97	34.23	28.90	9.80
Sweden	30.44	5.48	6.59	43.83	13.65

Note: the updated weights are calculated as ten-year averages over the period 2008-2017, instead of 2002-2011 as carried out by Mourre *et al.* (2013).
Source: Mourre *et al.* (2019).

Table A2 – Elasticities of individual revenue categories (η_R^j)

	Personal Income Tax ($PIT = \eta_R^1$)	Corporate Income Tax ($CIT = \eta_R^2$)	Social Security Contributions ($SSC = \eta_R^3$)	Indirect Tax ($IT = \eta_R^4$)	Non-Tax Revenue ($NTR = \eta_R^5$)
Austria	1.66	2.74	0.65	1.00	0.00
Belgium	1.31	2.48	0.71	1.00	0.00
Bulgaria	1.15	2.13	0.61	1.00	0.00
Croatia	1.71	2.29	0.70	1.00	0.00
Cyprus	2.28	2.26	0.91	1.00	0.00
Czechia	1.65	1.78	0.86	1.00	0.00
Denmark	1.00	3.15	0.41	1.00	0.00
Estonia	1.58	1.78	1.40	1.00	0.00
Finland	1.41	2.03	0.77	1.00	0.00
France	1.86	2.76	0.63	1.00	0.00
Germany	1.87	1.91	0.60	1.00	0.00
Greece	2.22	1.90	0.58	1.00	0.00
Hungary	1.73	2.21	0.76	1.00	0.00
Ireland	1.58	1.25	1.04	1.00	0.00
Italy	1.46	3.07	0.58	1.00	0.00
Latvia	1.50	1.99	0.81	1.00	0.00
Lithuania	1.79	1.67	1.04	1.00	0.00
Luxembourg	1.34	2.36	0.39	1.00	0.00
Malta	2.07	2.11	0.71	1.00	0.00
Netherlands	2.37	3.13	0.62	1.00	0.00
Poland	1.88	2.92	0.97	1.00	0.00
Portugal	1.97	1.33	0.79	1.00	0.00
Romania	1.29	2.02	0.62	1.00	0.00
Slovakia	1.93	1.58	0.89	1.00	0.00
Slovenia	1.63	3.76	0.66	1.00	0.00
Spain	1.84	1.56	0.72	1.00	0.00
Sweden	1.32	1.56	0.71	1.00	0.00

Note: individual elasticities are constant and unchanged with respect to their last estimations (Mourre *et al.*, 2014).
Source: Mourre *et al.* (2014).

Table A3 – Updated shares of revenue categories (% of GDP)

	Personal Income Tax (PIT)	Corporate Income Tax (CIT)	Social Security Contributions (SSC)	Indirect Tax (IT)	Non-Tax Revenue (NTR)	Total Revenue (TR)
Austria	11.05	2.20	14.99	14.32	6.40	48.96
Belgium	13.17	3.26	16.60	13.10	4.62	50.75
Bulgaria	3.11	2.21	7.52	15.12	7.77	35.73
Croatia	4.78	1.78	11.76	18.35	6.42	43.09
Cyprus	3.65	6.34	8.00	14.62	5.49	38.10
Czechia	3.98	3.28	14.68	11.81	6.34	40.09
Denmark	27.17	2.60	1.16	16.38	6.72	54.04
Estonia	5.67	1.57	11.82	13.88	6.78	39.72
Finland	13.58	2.69	12.55	13.84	10.90	53.57
France	9.74	2.53	18.71	15.56	5.45	51.98
Germany	9.44	2.45	16.59	10.84	4.93	44.26
Greece	5.96	3.61	13.59	14.54	7.74	45.45
Hungary	5.85	1.76	12.99	17.66	7.41	45.67
Ireland	9.21	2.68	5.38	10.19	4.14	31.60
Italy	12.26	2.38	13.35	14.56	4.23	46.76
Latvia	6.20	1.70	8.82	12.72	6.87	36.30
Lithuania	4.04	1.49	11.74	11.50	5.48	34.25
Luxembourg	8.50	5.86	12.29	12.42	4.60	43.67
Malta	8.76	4.39	6.80	13.20	5.90	39.05
Netherlands	8.60	2.52	14.66	11.26	6.32	43.37
Poland	4.81	2.27	12.93	13.36	5.58	38.95
Portugal	6.67	3.18	11.79	13.98	7.13	42.75
Romania	3.55	2.59	9.02	11.95	5.63	32.73
Slovakia	3.43	3.04	13.17	10.45	7.66	37.75
Slovenia	6.03	1.64	14.82	14.34	6.85	43.68
Spain	7.87	2.23	12.77	10.79	3.66	37.32
Sweden	15.41	2.77	3.34	22.19	6.91	50.61

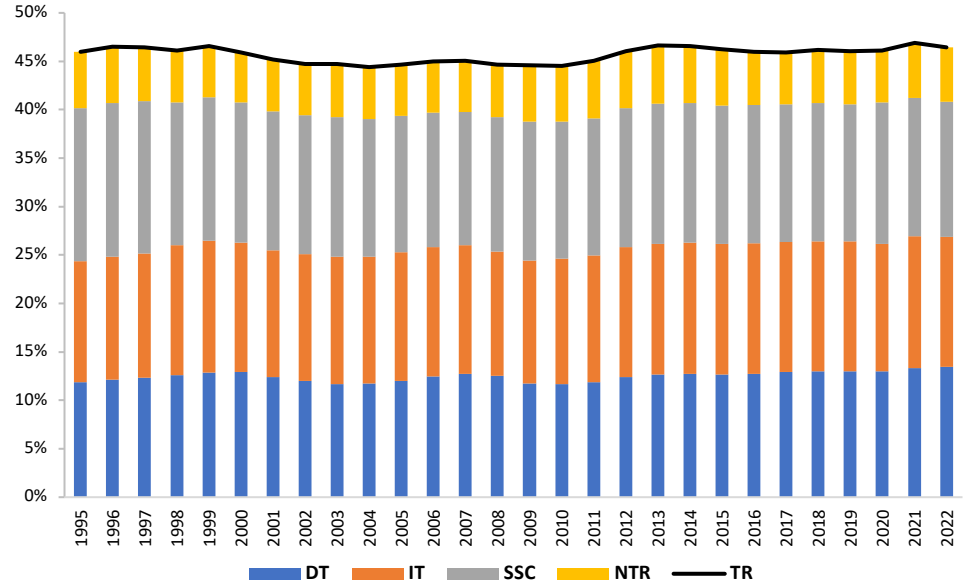
Note: the shares of revenue categories in relation to GDP were calculated from official data in Table A1 e in the last column of Table A3. These shares are required to estimate the semi-elasticities of individual revenue categories (see Table A4 and Paragraph 3.1).
Source: own elaborations on Mourre *et al.* (2019) data.

Table A4 – Semi-elasticities of individual revenue categories (ε_R^j)

	Personal Income Tax ($PIT = \varepsilon_R^1$)	Corporate Income Tax ($CIT = \varepsilon_R^2$)	Social Security Contributions ($SSC = \varepsilon_R^3$)	Indirect Tax ($IT = \varepsilon_R^1$)	Non-Tax Revenue ($NTR = \varepsilon_R^1$)	Total Revenue ($TR = \varepsilon_R$)
Austria	0.073	0.038	-0.052	0.000	-0.064	-0.005
Belgium	0.041	0.048	-0.048	0.000	-0.046	-0.005
Bulgaria	0.005	0.025	-0.029	0.000	-0.078	-0.077
Croatia	0.034	0.023	-0.035	0.000	-0.064	-0.043
Cyprus	0.047	0.080	-0.007	0.000	-0.055	0.065
Czechia	0.026	0.026	-0.021	0.000	-0.063	-0.033
Denmark	0.000	0.056	-0.007	0.000	-0.067	-0.018
Estonia	0.033	0.012	0.047	0.000	-0.068	0.025
Finland	0.056	0.028	-0.029	0.000	-0.109	-0.054
France	0.084	0.045	-0.069	0.000	-0.054	0.005
Germany	0.082	0.022	-0.066	0.000	-0.049	-0.011
Greece	0.073	0.033	-0.057	0.000	-0.077	-0.029
Hungary	0.043	0.021	-0.031	0.000	-0.074	-0.041
Ireland	0.053	0.007	0.002	0.000	-0.041	0.021
Italy	0.056	0.049	-0.056	0.000	-0.042	0.007
Latvia	0.031	0.017	-0.017	0.000	-0.069	-0.038
Lithuania	0.032	0.010	0.005	0.000	-0.055	-0.008
Luxembourg	0.029	0.080	-0.075	0.000	-0.046	-0.012
Malta	0.094	0.049	-0.020	0.000	-0.059	0.064
Netherlands	0.118	0.054	-0.056	0.000	-0.063	0.053
Poland	0.042	0.044	-0.004	0.000	-0.056	0.026
Portugal	0.065	0.010	-0.025	0.000	-0.071	-0.021
Romania	0.010	0.026	-0.034	0.000	-0.056	-0.054
Slovakia	0.032	0.018	-0.014	0.000	-0.077	-0.041
Slovenia	0.038	0.045	-0.050	0.000	-0.068	-0.036
Spain	0.066	0.012	-0.036	0.000	-0.037	0.006
Sweden	0.049	0.016	-0.010	0.000	-0.069	-0.014

Note: each semi-elasticity is estimated in the following way: $\varepsilon_R^i = (\eta_R^i - 1)(R_i/Y)$ (see Paragraph 3.1).
Source: own elaborations on Mourre *et al.* (2014) and Mourre *et al.* (2019) data.

Figure A1 – Composition of the general government revenue (EU 27, % of GDP)



Note: DT = Direct Taxes; IT = Indirect Taxes; SSC = Social Security Contributions; NTR = Non-Tax Revenues; TR = Total Revenues. Since Personal Income Tax (PIT) and Corporate Income Tax (CIT) data are not available at European level in certain years, we display their aggregate (Direct Taxes).
Source: own elaborations on AMECO (Spring forecast 2023) data.

Table A5 – Descriptive statistics of cyclically-adjusted revenue items

	Obs	Mean	Std. Dev.	Skewness	Kurtosis	Source
Personal Income Tax (PIT)	723	8.206	5.010	1.950	7.532	Own elaborations on AMECO data
Corporate Income Tax (CIT)	723	2.864	1.289	1.658	6.552	Own elaborations on AMECO data
Direct Taxes (DT)	756	11.139	5.081	1.794	7.074	Own elaborations on AMECO data
Social Security Contributions (SSC)	756	11.538	4.047	-0.681	3.067	Own elaborations on AMECO data
Indirect Taxes (IT)	756	13.680	2.770	1.037	4.641	Own elaborations on AMECO data
Non-Tax Revenues (NTR)	756	6.134	1.666	1.126	6.321	Own elaborations on AMECO data
Total Revenues (TR)	756	42.494	6.619	0.065	2.523	Own elaborations on AMECO data
Output gap (OG)	756	0.011	3.706	0.727	7.275	AMECO - Spring 2023 forecast

Note: PIT comprises taxes on income (incomes, profits, and capital gains) and other current taxes, paid by households and non-profit institutions serving households; CIT comprises taxes on income (incomes, profits, and capital gains) and other current taxes, paid by corporations; DT is obtained as the sum of PIT and CIT ($DT = PIT + CIT$); SSC consists of employers' actual social contributions, plus employers' imputed social contributions, plus households' actual social contributions and contribution supplements, less social insurance scheme service charges; IT is obtained as the sum of value added taxes (VAT), taxes and duties on imports (excluding VAT), taxes on products (except VAT and import taxes), other taxes on production (this category includes taxes linked to imports and production); NTR is measured as the sum of capital transfers (capital taxes, investment grants, and other capital transfers) and other current revenues including sales of general government (sales, other subsidies on production, property income, other current transfers); TR is defined as the sum of capital transfers, taxes on production and imports, property income, current taxes on income and wealth, social contributions, other current transfers, payments for non-market output, and other subsidies on production ($TR = DT + SSC + IT + NTR$).

Table A6 – Descriptive statistics of macroeconomic control variables

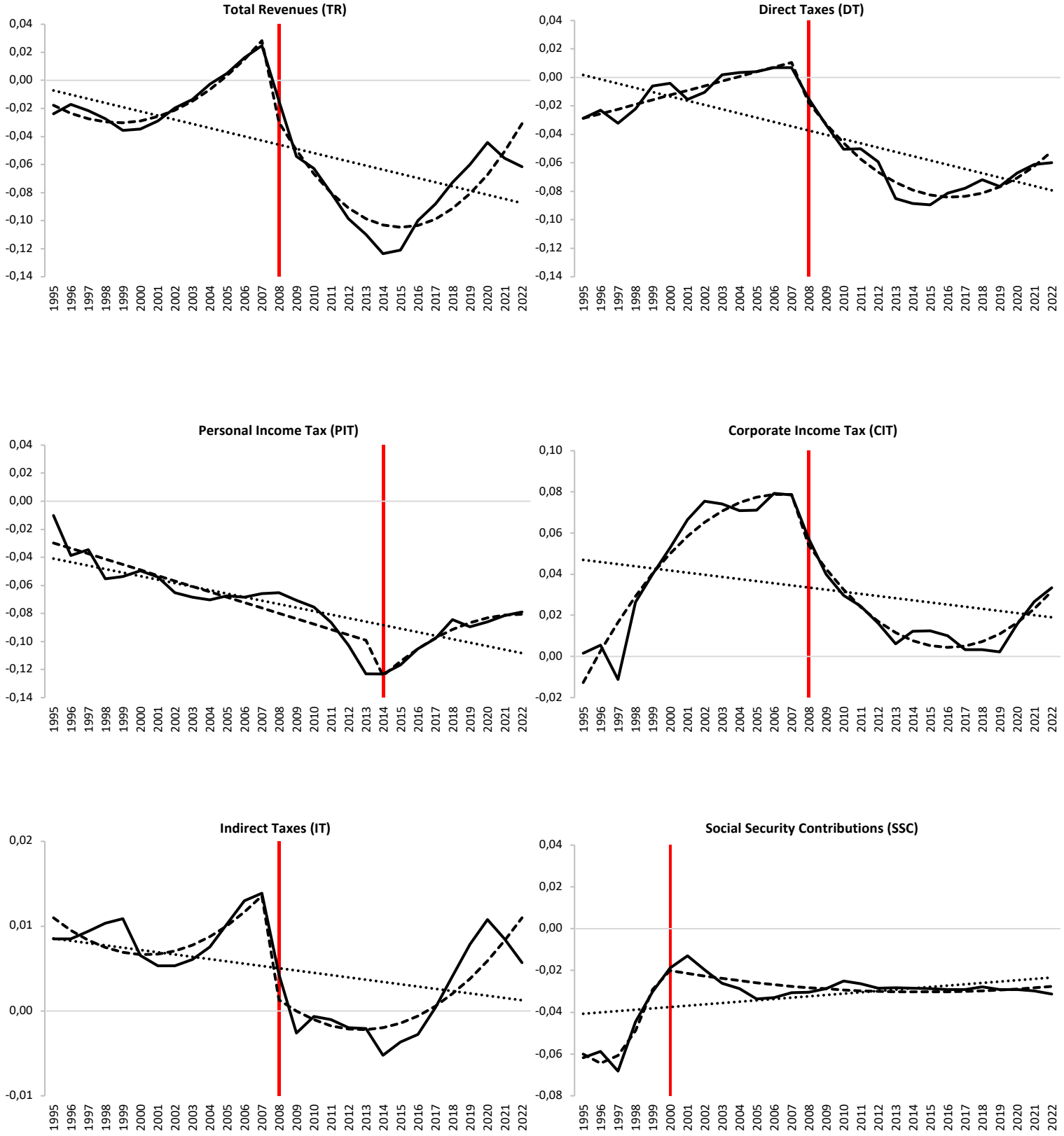
	Obs	Mean	Std. Dev.	Skewness	Kurtosis	Source
Trade openness	756	116.389	63.126	1.726	6.408	AMECO
Terms of trade	756	98.217	7.036	-2.243	13.343	AMECO
Unemployment rate	749	8.805	4.290	1.366	5.254	AMECO
Inflation	755	3.054	4.758	1.174	17.313	AMECO
Age dependency ratio	750	49.785	4.480	0.205	2.931	Eurostat

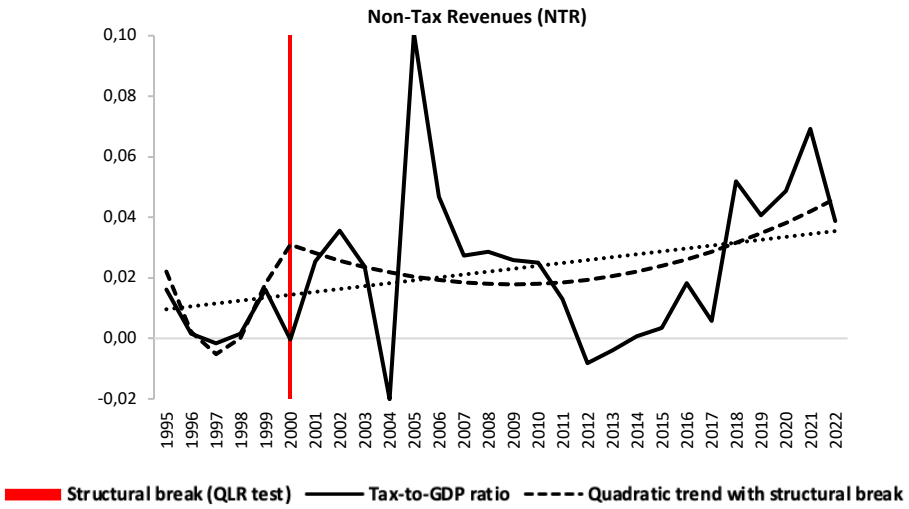
Note: trade openness is measured as the sum of a country's exports and imports of goods and services as a share of that country's GDP (in %); terms of trade represent the ratio between price deflator exports and price deflator imports of goods and services (2015=100); the unemployment rate is the number of unemployed persons as a share of the total active population (labour force); inflation is calculated from the GDP deflator (2015=100); the age dependency ratio considers the population aged 0 to 14 years and 65 years and over compared to the population aged 15 to 64 years.

Table A7 – Descriptive statistics of debt-to-GDP ratio and Fiscal Rules Index

	Obs	Mean	Std. Dev.	Skewness	Kurtosis	Source
Debt-to-GDP ratio (Debt)	749	58.297	35.061	0.983	4.289	AMECO
Fiscal Rules Index (FRI)	729	0.273	0.164	-0.073	2.314	IMF
FRI_Debt (FRI * Debt)	722	16.918	14.229	0.940	3.534	-

Figure A2 – The cyclicality of individual (cyclically-adjusted) revenue categories over time





Note: the unknown structural break, represented by the vertical red line, was identified by performing the Quandt Likelihood Ratio (QLR) test on the quadratic trend. The dashed line shows the quadratic trend when the unknown structural break is considered, while the dotted line the overall linear trend.
Source: own elaborations on AMECO (Spring forecast 2023), Mourre *et al.* (2014) and Mourre *et al.* (2019) data.

Table A8 – Tax cyclicality and fiscal rules in real time: The baseline model

Dependent variable	***PIT_OGmatched***		***CIP_OGmatched***		***DT_OGmatched***		***SSC_OGmatched***		***IT_OGmatched***		***NTR_OGmatched***	
Model	**(1a)**	**(1b)**	**(2a)**	**(2b)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5a)**	**(5b)**	**(6a)**	**(6b)**
Estimator	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**
FRI_Debt	-0.00175 ***		-0.00015 ***		-0.00082 ***		-0.00066 ***		-0.00015 ***		0.00109 ***	
FRI_Debt_noEA		-0.00100 ***		-0.00006 ***		-0.00046 ***		-0.00028 ***		-0.00019 ***		0.00305 ***
FRI_Debt_EA		-0.00219 ***		-0.00018 ***		-0.00093 ***		-0.00074 ***		-0.00015 ***		0.00038 ***
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Heteroskedastic and correlated error structure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel-specific AR1 autocorrelation structure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time span	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021
Number of observations	594	594	621	621	621	621	621	621	594	594	621	621
Number of countries	22	22	23	23	23	23	23	23	22	22	23	23

Note: ***, **, * denote significance at 1%, 5% and 10% level, respectively. GLS = Generalised Least Squares (controlling for panel specific autocorrelation and heteroskedastic and correlated error structure).

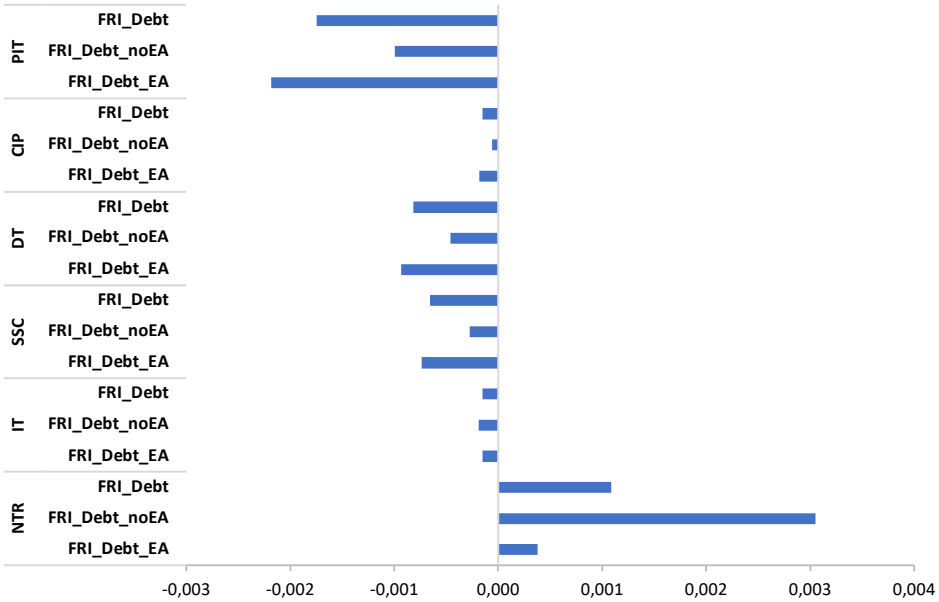
Table A9 – Tax cyclicality and fiscal rules in real time: Model with control variables

Dependent variable	***PIT_OGmatched***		***CIP_OGmatched***		***DT_OGmatched***		***SSC_OGmatched***		***IT_OGmatched***		***NTR_OGmatched***	
Model	**(1a)**	**(1b)**	**(2a)**	**(2b)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5a)**	**(5b)**	**(6a)**	**(6b)**
Estimator	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**	**GLS**
FRI_Debt	-0.00114 ***		-0.00029 ***		-0.00066 ***		-0.00058 ***		-0.00013 ***		0.00157 ***	
FRI_Debt_noEA		-0.00082 ***		-0.00014 ***		-0.00046 ***		0.00002 ***		-0.00010 ***		0.00276 ***
FRI_Debt_EA		-0.00128 ***		-0.00030 ***		-0.00075 ***		-0.00090 ***		-0.00015 ***		0.00104 ***
Openness	0.00029 ***	0.00033 ***	0.00006 ***	0.00007 ***	0.00020 ***	0.00022 ***	-0.00029 ***	-0.00022 ***	0.00006 ***	0.00006 ***	0.00097 ***	0.00101 ***
ToT	0.00039 ***	0.00039 ***	-0.00111 ***	-0.00117 ***	0.00050 ***	0.00050 ***	-0.00144 ***	-0.00155 ***	-0.00042 ***	-0.00044 ***	0.00267 ***	0.00227 ***
Unemployment rate	-0.00418 ***	-0.00422 ***	-0.00006	0.00005	-0.00097 ***	-0.00099 ***	-0.00244 ***	-0.00257 ***	-0.00004 ***	-0.00006 ***	0.00384 ***	0.00408 ***
Inflation	-0.00015 ***	-0.00010 ***	0.00076 ***	0.00083 ***	0.00008 ***	0.00010 ***	0.00012 ***	0.00015 ***	0.00004 ***	0.00004 ***	-0.00138 ***	-0.00121 ***
Age dependency	-0.01088 ***	-0.01075 ***	-0.00429 ***	-0.00447 ***	-0.00394 ***	-0.00378 ***	0.00376 ***	0.00450 ***	0.00173 ***	0.00179 ***	-0.02005 ***	-0.01711 ***
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Heteroskedastic and correlated error structure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel-specific AR1 autocorrelation structure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time span	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021	1995 - 2021
Number of observations	594	594	594	594	594	594	594	594	567	567	594	594
Number of countries	22	22	22	22	22	22	22	22	21	21	22	22

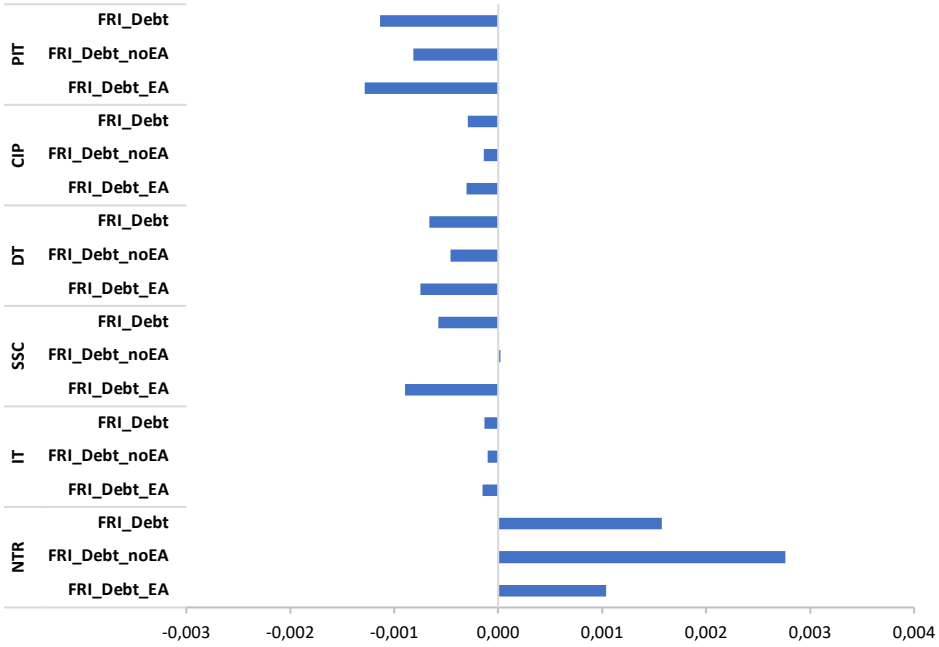
Note: ***, **, * denote significance at 1%, 5% and 10% level, respectively. GLS = Generalised Least Squares (controlling for panel specific autocorrelation and heteroskedastic and correlated error structure).

Figure A3 – Tax cyclicality and fiscal rules in real time

(a) Baseline model



(b) Model with control variables



Note: the blue columns report the value of the coefficient associated with the variable describing the interaction between fiscal rules and debt-to-GDP ratio (a negative value implies that the *FRI_Debt* variable is reducing counter-cyclicality or increasing pro-cyclicality of the related revenue item; the opposite happens when the coefficient is positive).

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