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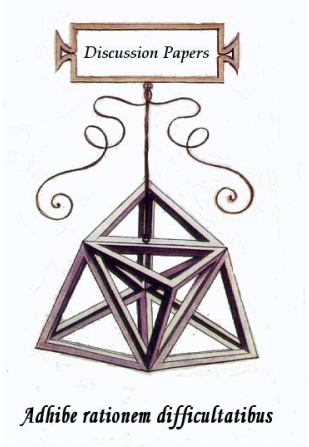

Giovanni Carnazza, Federica Lanterna,
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Measuring time-varying fiscal cyclicality of the revenue side with a new cyclically-adjusted methodology: Does the European fiscal framework play a pivotal role?

Discussion paper n. 321

2025

Discussion paper n. 321, presented: **March 2025**

Authors' address/Indirizzo degli autori:

Giovanni Carnazza — University of Pisa — Department of Economics and Management, Via Cosimo Ridolfi 10, 56124 Pisa — Italy. E-mail: giovanni.carnazza@unipi.it

Federica Lanterna — University of Urbino — Department of Economics, Society, Politics, Via Saffi 42, 61029 Urbino — Italy. E-mail: federica.lanterna@uniurb.it

Paolo Liberati — University Roma Tre — Department of Economics, Via Silvio D'Amico 77, 00145 Roma — Italy. E-mail: paolo.liberati@uniroma3.it

Please cite as:/Si prega di citare come:

Giovanni Carnazza, Federica Lanterna, Paolo Liberati (2025), "Measuring time-varying fiscal cyclicality of the revenue side with a new cyclically-adjusted methodology: Does the European fiscal framework play a pivotal role?", Discussion Papers, Department of Economics and Management – University of Pisa, n. 321 (http://www.ec.unipi.it/ricerca/discussion-papers).

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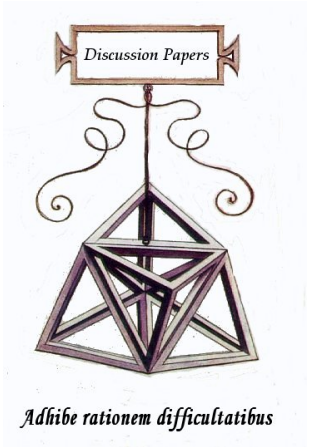
n. 321



Giovanni Carnazza, Federica Lanterna, Paolo Liberati

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JEL CLassification: E32; E62; H2

Measuring time-varying fiscal cyclicality of the revenue side with a new cyclically-adjusted methodology: Does the European fiscal framework play a pivotal role?

Giovanni Carnazza (*corresponding author*) [(*)]
Federica Lanterna [(**)]
Paolo Liberati [(***)]

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[(*)] University of Pisa (Italy), Department of Economics and Management
E-mail: giovanni.carnazza@unipi.it / ORCID iD: 0000-0002-7719-358X
[(**)] University of Urbino Carlo Bo (Italy), Departments of Economics, Society, Politics
E-mail: federica.lanterna@uniurb.it / ORCID iD: 0009-0001-3529-047X
[(***)] University Roma Tre (Italy), Department of Economics
E-mail: paolo.liberati@uniroma3.it / ORCID iD: 0000-0002-6317-9701

1. Introduction

The theoretical literature has long emphasised the importance of fiscal policy as a tool of macroeconomic stabilisation (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.

Given the two-way relationship between the budget balance and the business cycle, the analysis of the cyclicality of fiscal policy requires distinguishing between discretionary policy and automatic stabilisers. Any fiscal indicator, if not adjusted for the economic cycle, risks providing misleading results regarding the true nature of discretionary fiscal policy at national level. This observation applies to the overall budget balance as well as to the single items of the revenue and the expenditure side. From this perspective, a first significant methodological contribution of this paper consists of adjusting different revenue items for the business cycle by adapting the European Commission (EC)'s official approach. To the best of our knowledge, this is the first time this methodology is used to assess the discretionary fiscal stance of each revenue component, by this way addressing limitations of earlier studies, such as those by Vegh and Vuletin (2015) and Chrysanthakopoulos and Tagkalakis (2023), which focused primarily on tax rates or aggregated revenues.

This adjustment paves the way to a second important contribution of our work, that of assessing the fiscal cyclicality of the tax items using two different notions of the output gap: an *ex-post* notion based on the latest estimate produced by the EC and a real-time notion derived from the backward reconstruction of annual output gaps recorded in the corresponding official forecasts. This approach is justified by the fact that *ex-post* estimates may be subject to significant revisions over time, while real-time measures reflect the data available to policymakers when decisions are taken, ensuring a more accurate assessment of fiscal policy responses. As our analysis will show, although both notions

point to a generalised fiscal pro-cyclicality, the real-time framework reveals a more pronounced pro-cyclical pattern. From an empirical perspective, the cyclicality of tax revenues with respect to the business cycle is examined using a panel covering 27 European Union (EU) countries during the period 1995–2019. Since our underlying hypothesis is that the progressive tightening of fiscal rules has significantly influenced the pro-cyclical behaviour of the budget balance and its components, it is natural to take 2019 as the last year of observation, given the suspension of the European fiscal framework starting in 2020 due to the health crisis.

Finally, as a third contribution of the paper, we investigate whether the European fiscal framework may foster pro-cyclical fiscal policies. This effect has been estimated for each revenue component, allowing the corresponding coefficient to vary over time and incorporating these estimates into a panel dataset covering the same time span (1995-2019) and group of countries (EU-27). To address the impact of the fiscal rules, we use two country- and year-specific indices: the first has been developed using the methodology of Gootjes et al. (2021) and data from the IMF's Fiscal Rules Dataset (Davoodi et al., 2022), capturing the stringency of budget balance, debt, and revenue rules; the second, estimated directly by the EC, measures the institutional strength of fiscal rules at the EU level, enabling a comprehensive evaluation of their influence on fiscal behaviour. Even though the adherence to the target of the structural budget balance should ensure that discretionary fiscal policy remains a-cyclical, with the automatic stabilisers left to mitigate business cycle fluctuations (Eyraud and Wu, 2015; Eyraud et al., 2017), an increasingly stringent European fiscal framework may often mandate restrictive measures regardless of the prevailing cyclical phase of the business cycle (see, for example, Carnazza and Carnevali, 2024). By applying a recent methodology that allows for the calculation of country-specific coefficients able to capture changes in fiscal cyclicality (Schlicht, 2022), we show, also in this case, that the distinction between the *ex-post* and real-time approaches proves crucial: the former appears to conceal the pro-cyclical bias; by contrast, the real-time approach consistently shows that a tightening of fiscal rules leads to an increase in fiscal pro-cyclicality.

The paper is organised as follows. Section 2 introduces the issue with a literature review on fiscal cyclicality from both an empirical and theoretical perspective; Section 3 describes the data and the methodology. Section 4 discusses the main results. Section 5 concludes.

2. Setting the issue

An extensive body of empirical literature has been developed to study the degree of cyclicality of fiscal policy, its properties, and its drivers (Jalles, 2018). It should be noted that any investigation into the cyclical nature of fiscal policy must necessarily embody some adjustments for the business cycle; otherwise, the results risk being distorted by elements of the public budget that react autonomously to the economic cycle and are not influenced by policymakers' discretion. From this point of view, a significant body of empirical research has demonstrated that discretionary fiscal policy often exhibits either pro-cyclicality or a-cyclicality, with the former being predominant in developing countries and the latter instead prevailing in industrialised countries, where cases of counter-cyclicality are also empirically proven (Fatas and Mihov, 2009; Vegh and Vuletin, 2015; Bergman and Hutchison, 2020). Gavin and Perotti (1997) were the first to highlight that fiscal policy in Latin America appeared pro-cyclical. However, growing evidence indicates that this characteristic is not confined to the developing world anymore (Kaminski et al., 2004; Talvi and Végh, 2005), but is becoming frequent also in high-income countries. For example, empirical results focusing on the Eurozone or sub-samples of it are quite contentious, with the results varying depending on the number of countries and years considered.

Notwithstanding these outcomes, there is increasing consensus that the European fiscal policy has been marked by significant and widespread pro-cyclicality in more recent years. Bénétrix and Lane (2013), analysing the Euro area (1980-2007) and using the overall government balance and the cyclically-adjusted primary balance ($CAPB$) to assess fiscal policy's reaction to the business cycle, find that fiscal policy was more counter-cyclical before the Maastricht Treaty but deteriorated after the euro's introduction, appearing on average a-cyclical when measured through the general budget

but significantly pro-cyclical using $CAPB$. This result suggests that when the dependent variable is appropriately adjusted for the economic cycle, the a-cyclical effect may disappear, and a greater pro-cyclicality may emerge, particularly since the beginning of the European Monetary Union and the progressive tightening of the European fiscal framework.

Extending the analysis to the period 1995-2020, Afonso and Carvalho (2022), using real GDP growth and the output gap as measures of economic activity, find that discretionary fiscal policy in the Euro area, while overall counter-cyclical, is more pro-cyclical during recessions. In the same vein, Aldama and Creel (2022) confirm pro-cyclicality during the negative phases of the business cycle and a-cyclicality during expansions. Thus, while the empirical evidence is largely consistent for developing countries, the results for industrialised countries are more mixed, with recent findings converging to pro-cyclicality.

Building on these findings, further research has examined additional factors affecting the cyclicality of fiscal policy, with particular attention paid to the role of fiscal rules. Considering the United States, Fatás and Mihov (2006) find that tighter fiscal rules reduce both fiscal policy volatility and the magnitude of business cycle fluctuations. Furthermore, Jalles (2018), for the case of advanced economies, finds that rules associated with debt increase counter-cyclicality, while Larch et al. (2021) highlight how deviations from EU fiscal rules increase pro-cyclicality in 40 EU and non-EU countries from 1960 to 2017. For a panel of 27 EU countries (2000-2015), Gootjes and de Haan (2022) also argue that stringent fiscal rules, when combined with efficient governance, mitigate fiscal pro-cyclicality. In striking contrast to these outcomes, Carnazza et al. (2023) instead suggest that the increasing tightening of fiscal rules has driven significant fiscal pro-cyclicality in 19 European countries over the period 1995-2019.

In general, while a virtuous role of fiscal rules in mitigating the pro-cyclical outcomes of fiscal policy may appear, these results do not seem to be conclusive. As we will see, each outcome is likely to depend on the framework considered (whether *ex-post* or real-time) (Carnazza, 2023), on the methodology used to estimate fiscal rules and on whether the budget balance has been adjusted for

the business cycle. To this regard, it is worth noting that the importance of the real-time approach is hardly recognised; secondly, fiscal rules are often treated as simple dummy variables and not as year- and country-specific indicators; finally, the failure to account for the economic cycle can significantly distort the results, as the budget balance inherently embodies the automatic variations driven by the functioning of the business cycle.

Alongside the broader body of literature that examines the cyclicality of overall fiscal policy, more recent studies have focused on the behaviour of the main components of fiscal policy, namely government spending and tax revenues. The prevailing result is that while government expenditure appears pro-cyclical in developing countries and counter-cyclical or a-cyclical in advanced countries, tax policy appears to be a-cyclical in advanced countries and pro-cyclical in developing countries (Vegh and Vuletin, 2015). Lane (2003), by analysing various spending item in relation to output growth, show that, on average, overall government spending is a-cyclical, although there is significant heterogeneity across the components. In particular, current spending and government transfers are found to be counter-cyclical, while government investment appears to be the most pro-cyclical. Similarly, Égert (2010), by disaggregating government spending in OECD countries into several categories and using both real GDP growth rates and the output gap as measures of the business cycle, confirm the presence of heterogeneity in the cyclicality of different components; in this case, public investments and government wages are found to be pro-cyclical, government subsidies tend to be counter-cyclical, and non-wage consumption and social transfers are largely a-cyclical.

In a more recent study, Jalles (2021) further disaggregates public expenditure for a panel of 36 advanced countries between 1970 and 2015. Using time-varying estimates, the study concludes that spending on wages and goods and services tends to be counter-cyclical, while public investment remains pro-cyclical. The author also investigates factors influencing expenditure cyclicality, noting that higher trade openness increases pro-cyclicality, while stronger institutional quality and larger governments reduce it. Additionally, the study finds that greater financial development and openness are associated with less pro-cyclical expenditure.

In this context, the literature on the cyclicality of tax revenues is less developed, particularly for the EU. Some key studies have addressed this issue in different contexts, providing a solid background. For the United States over the period 1980-2011, McGranahan and Mattoon (2012) investigate the relationship between business cycle and state revenues, using total revenue, sales tax revenue, individual income tax revenue, corporate income tax revenue, and other tax revenue in per capita terms. Their main findings can be summarised as follows: total revenue appears pro-cyclical; corporate income taxes is estimated 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.

In the same perspective, Vegh and Vuletin (2015) investigate the cyclical behaviour of tax rates for 62 countries for the period 1960-2013, focusing on corporate tax, income tax, and value added tax (VAT), and using tax rates as proxies of the policy variables under direct control of policymakers, rather than either tax revenues or the tax burden, because they consider these measures endogenous to the business cycle. To solve the endogeneity issue, the authors use the highest marginal tax rate for income tax and the standard tax rate for VAT.[1] 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

[1] 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.

cyclicality is estimated considering the change in the logarithm of real GDP as a measure of the cycle. They find that VAT rates 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.

3. Data and methodology

From a methodological perspective, there are a number of issues that need to be addressed in order to provide an accurate and insightful assessment of the cyclical characterisation of discretionary fiscal policy. To this purpose, we will first show how to deal with the concept of semi-elasticities of the tax components of the public budget and how to implement them in order to cyclically adjust the revenue side (Section 3.1); second, we will provide important justifications for considering two different series of the output gap based on *ex-post* and on real-time values, which lead to very different results (Section 3.2); third, we will show how to measure the stringency of European fiscal rules over time with two different indices (Section 3.3); finally, , we will address the possibility that cyclicality may vary over time and define the possible contribution of fiscal rules in shaping it (Section 3.4 and Section 3.5).

3.1 The semi-elasticities of revenues within the European Commission framework: a formalisation

To tackle the challenge posed by the cyclicality of the revenue components of the government budget, we assess the cyclicality of tax policy by examining each revenue category separately and employing an innovative cyclically-adjusted methodology. The strength of this novel approach lies in the integration of the EC 's official estimates concerning individual semi-elasticity parameters and various revisions of the output gap within a framework that enables the isolation of the distinct structural components of government revenues. This methodology ensures that the dependent variable under consideration remains unaffected by fluctuations in output. Otherwise, biased

estimates of fiscal cyclicality would arise, which depend on the automatic effects of the business cycle. The introduction of this methodology provides an advancement with respect to the two main reference works by Vegh and Vuletin (2015) and Chrysanthakopoulos and Tagkalakis (2023) and represents a first significant contribution to the empirical literature on this topic.

The official methodology of the EC 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 apply the same methodology on taxes only. The Cyclically-Adjusted Total Revenue (ca_TR) can be written in the following way:

$$ca\_TR_t = \frac{TR_t}{Y_t} - \varepsilon_R \cdot OG_t = \frac{TR_t}{Y_t} - CC_R \quad (1)$$

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).[2]

From a theoretical perspective, the semi-elasticity of revenues (ε_R) can be decomposed into the effect of the revenue-to-GDP ratio (TR/Y) and the composition effect reflected by its elasticity (η_R). Formally:

$$\varepsilon_R = \frac{TR}{Y} \cdot (\eta_R - 1) \quad (2)$$

The aggregate semi-elasticity of revenues (ε_R) is then based on the elasticities of their individual components. The EC breaks down total revenue (R) into five different categories: Personal Income

[2] Even though the output gap represents the most important element in determining CC_R, there is an important preliminary aspect to be considered, namely the cyclical adjustment parameter (Mourre et al., 2013). Before estimating the cyclical component, we therefore need to explain how to 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 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 (see Table A1 in the Appendix for the new weights). From an empirical point of view, this simplification is aimed at computing a unique semi-elasticity for each European country that does not vary over time. The individual elasticities are constant and unchanged with respect to their last estimations (Mourre et al., 2014) (see Table A2 in the Appendix for the individual elasticities).

Tax ($PIT = R^1$); Corporate Income Tax ($CIT = R^2$); Indirect Taxes ($IT = R^3$); Social Security Contributions ($SSC = R^4$); Non-Tax Revenues ($NTR = R^5$).[3] As a consequence, ε_R can be expressed as a sum of the five individual semi-elasticities (i.e., ε_R^j with $j = 1, \dots, 5$):

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

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 completely a-cyclical. Tables A1, A3 and A4 in the Appendix 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 as they are not explicitly provided by the EC – and the semi-elasticities used in computing the cyclical adjustment. In this way, it is possible to replicate our methodology for the cyclical adjustment of individual revenue categories. In formal terms, each revenue item adjusted for the business cycle can finally be expressed as follows:

$$ca\_R_t^j = \frac{ca\_R_t^j}{Y_t} - \varepsilon_R^j \cdot OG_t = \frac{ca\_R_t^j}{Y_t} - CC_R^j \;\; with \;\; j = 1, \dots, 5 \tag{4}$$

3.2 Revenue cyclicality: ex-post vs real-time approach

After applying cyclical adjustments to each revenue item, the degree of cyclicality can be accurately estimated by regressing each adjusted revenue item on the output gap. Our analysis is based on 27 countries belonging to the EU observed over the period 1995-2019 on annual basis. Our database is based on the revision of the AMECO dataset released in autumn 2024; however, our estimates are limited to 2019, as the European fiscal framework was suspended in 2020. The baseline specification relies on a dynamic panel data model, where each discretionary cyclically-adjusted revenue item

[3] Direct taxes (DT) are represented by the sum of PIT and CIT. As PIT and CIT data are not always available, we will also perform estimates of the overall DT. Total revenues (TR) will also be taken into consideration.

(ca_R^j) is mainly explained by the cyclical conditions (OG). In formal terms, for each revenue item j and for each country i, we have the following equation:

$$ca\_R_{i,t}^{j} = \alpha + \theta^{j} ca\_R_{i,t-1}^{j} + \beta^{j} OG_{i,t} + \gamma_i^{j} + \lambda_t^{j} + u_{i,t}^{j} \;\; with \;\; j = 1, \dots, 5 \qquad (5)$$

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 u is the error component.[4] More specifically, β represents the cyclical responsiveness of the revenue item: a negative value of β indicates a pro-cyclical response, while a positive value reflects counter-cyclicality. A pro-cyclical response implies that governments discretionarily increase revenues during the recessionary phases of the business cycle, while the opposite occurs during periods of economic expansion.

The extended specification of our baseline model includes six macroeconomic control variables (debt-to-GDP ratio, trade openness, terms of trade, unemployment rate, inflation as measured by GDP deflator and the age dependency ratio), which are included with a first-order lag to mitigate the potential impact of endogeneity.[5] The choice is based on previous empirical studies investigating the cyclical and structural behaviour of fiscal policy (see, among others, Lane, 2003; Jalles, 2018; Gootjes and de Haan, 2022).

With regard to the technical methods, we rely on two different estimators. First of all, we use the Generalised Least Squares (GLS) estimator controlling for panel specific autocorrelation structure ($AR1$) and heteroskedastic and correlated error structure that allows us to deal with cross-sectional dependence in the error term, potentially leading to endogeneity if not controlled for. Secondly, given the presence of the lag of the dependent variable, we also adopt the Arellano-Bond (AB) model, which

[4] In addition to the five revenue categories, our empirical estimates also take into account Direct Taxes (ca_R^{DT}) and Total Revenues (ca_R^{TR}).
[5] Descriptive statistics, definitions and sources of the control variables are provided in Table A5 in the Appendix.

uses the conventionally derived variance estimator for Generalised Method of Moments (GMM) estimation (Arellano and Bond, 1991). In this way, we control for the possible persistence of tax items resulting from the convergence to a target budget (Galí and Perotti, 2003), as well as for the potential endogeneity issue of the main regressor. In particular, in this kind of framework, the output gap has been considered endogenous with a maximum of three lags as instruments.

Now, to evaluate the fiscal policy stance, the economic literature generally relies on the latest *ex-post* estimate of the output gap. This approach can be misleading to the extent that the series of potential GDP (and thus of the output gap) are recalculated after a given year interval, a process that the EC has adopted twice a year since autumn 2002, and that has involved not only forecasts in the strict sense but also historical values. This process would not introduce any bias if the estimated potential GDP were stable over time; however, due to its significant variability, the selection of which forecast to consider can affect and potentially bias our findings. In particular, the *ex-post* output gap does not embody the progressive revisions of the output gap due to the pro-cyclical nature of one of the main unobservable variable underlying the production function approach, namely the Non-Accelerating Wage Rate of Unemployment ($NAWRU$)[6]. Second, it must be taken into account that fiscal policy decisions are taken on the basis of the output gap officially recorded and communicated to national governments in the past for the corresponding year. As evident from Equation 4, changing the definition of the output gap would change the definition of the cyclically-adjusted tax items.

To address this issue, we differentiate our estimates by using two different series of the output gap, namely the *ex-post* output gap ($OGex$) and the real-time output gap ($OGrt$), leading to a distinction between the estimation of *ex-post* and real-time coefficients.[7] Since the real-time indicator is available only from 2002 onwards, in order to provide a consistent comparison of the coefficients we also

[6] In other words, despite the theoretical requirement that potential GDP follows a stable trajectory over time, the methodology employed by the EC makes it dependent on actual GDP realisations.

[7] Descriptive statistics of *ex-post* and real-time dependent variables and main regressors (i.e., $OGex$ and $OGrt$) are provided in Table A5.

provide separate estimations of the *ex-post* output gap recorded between 1995 and 2001 ($OGex\_1$) and that recorded between 2002 and 2019 ($OGex\_2$).

3.3 How to measure the stringency of European fiscal rules over time

The number of national fiscal rules in the EU 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 earlier and three times as many since the adoption of the Stability and Growth Pact in 1997 (Manescu et al., 2023). In order to estimate the potential impact that fiscal rules have had on fiscal cyclicality, we rely on two different indices varying by years and countries to enhance the overall robustness of the empirical framework.

The first index – the Fiscal Rule Index (FRI) – is based on our own elaborations, following the methodology explained in Gootjes et al. (2021) and relying on the IMF's Fiscal Rules Dataset (Davoodi et al., 2022). This index focuses on budget balances rules, debt rules and revenue rules, and it is normalised to range from zero (representing the minimum fiscal constraint) and 1 (indicating the maximum level of fiscal constraint). The second index – that we define Standard Fiscal Rule Index (StdFRI) – is a standardised version across 27 member States of the index directly estimated by the EC, whose aim is to capture the strength of fiscal rules at the European level. As before, higher values indicate stricter fiscal rules, although in this case there are no minimum or maximum values. The overall trend of the two indices is very similar and is illustrated in Figure 1 (along with their descriptive statistics) in panels (a) and (b), respectively, for the 27 EU countries. The progressive tightening of fiscal rules is evident, with a notable acceleration observed during the European sovereign debt crisis.

[Figure 1 around here]

3.4 Measuring time-varying fiscal cyclicality: the TVC model

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 cyclical effect of each tax item *j* in each country *i* over years *t*. To this purpose, we build the following equation[8]:

$$ca\_R_{i,t}^{j} = \delta_i^j + \mu_{i,t}^{j} OG_{i,t} + u_{i,t}^{j} \;\; with \;\; j = 1, \dots, 5 \tag{6}$$

where the time-varying coefficient is identified by μ, and estimated using both the *ex-post* output gap ($OGex$) and the real-time output gap ($OGrt$). 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 $v_{i,t}$, that captures variations in the fiscal stance occurring within a given year and provides a more realistic representation of the changes in the responsiveness of fiscal variables to economic conditions (Afonso and Carvalho, 2022). The coefficient μ is assumed to be normally distributed with expectation zero and variance σ_i^2:

$$\mu_{i,t}^{j} = \mu_{i,t-1}^{j} + v_{i,t} \; where \; v_{i,t} \sim N(0; \sigma_i^2) \;\; with \;\; j = 1, \dots, 5 \tag{7}$$

The joint estimation of equations (6) and (7) is based on the Time-Varying Coefficient (TVC) model developed by Schlicht (2022), which extends the standard linear regression model. As highlighted by Aghion and Marinescu (2007), the TVC model provides several advantages over alternative approaches for estimating time-varying coefficients.[9] Among them, three are particularly important for our analysis: first, the approach uses all observations in the sample to estimate the degree of government revenue cyclicality for each year, unlike methods such as the rolling window approach; second, it accounts for the gradual nature of policy changes and their dependence on recent past trends; finally, it helps mitigate reverse causality.

[8] As in the previous case (see Equation 5), our empirical estimates also take into account cyclically-adjusted direct taxes ($ca\_R^{DT} = ca\_R^1 + ca\_R^2 = ca\_PIT + ca\_CIT$) and cyclically-adjusted total revenues ($ca\_R^{TR} = \sum_{j=1}^{5} ca\_R^j$).
[9] See also Jalles (2021).

As an example, Figure 2 illustrates the trend of average fiscal cyclicality coefficient for total revenues over the period under consideration: negative values indicate years of pro-cyclicality, while positive values denote years of anti-cyclicality. In the *ex-post* case, fiscal revenues were characterised by significant a-cyclicality until 2010, followed by a transitional period of pro-cyclicality during the European sovereign debt crisis. In the real-time case, however, fiscal revenues exhibit a predominantly anti-cyclical pattern before the aforementioned crisis, followed by a progressive and sustained increase in pro-cyclicality that is significantly more pronounced. It is clear that focusing solely on the *ex-post* case appears to obscure the true nature of fiscal cyclicality that has characterised the fiscal policies of the EU member states.[10]

[Figure 2 around here]

3.5 The role of the European fiscal framework in shaping fiscal cyclicality

The time-varying coefficient of the previous section can now be used to understand whether fiscal rules may have affected the evolution of the cyclicality coefficients over time. This further analysis is again based on 27 countries belonging to the EU observed over the period 1995-2019 on an annual basis. To this purpose, each specific cyclical coefficient (μ^j) is regressed against the intensity of the European fiscal rules using both fiscal indices (FRI and $StdFRI$). In formal terms, for each revenue item j and for each country i, we consider the following equation:

$$\mu_{i,t}^{j} = \alpha + \rho_{i,t}^{j} fiscal\_stringency + \gamma_i^j + \lambda_t^j + u_{i,t}^j \;\; with \;\; j = 1, \dots, 5 \qquad (8)$$

where ρ is the coefficient associated with $fiscal\_stringency$, represented by FRI and $StdFRI$. As before, we take into account country-fixed (γ_i) and time-fixed effects (λ_t), while u represents the error component. Since the trend of the cyclicality coefficient is not linked to a specific target, and thus we do not need to include the lag of the dependent variable, we use the Generalised Least Squares

[10] Descriptive statistics of the time-varying cyclicality coefficients of revenue items in the *ex-post* and real-time framework are provided in Table A5 in the Appendix.

(GLS) estimator controlling for panel specific autocorrelation structure ($AR1$) and heteroskedastic and correlated error structure, with the same structure of control variables as before.

4. Main results

4.1 Tax revenue cyclicality in an ex-post and real-time approach

The empirical analysis first addresses the estimation of Equation 5 (in its baseline and extended version when considering the control variables), using the cyclically-adjusted tax items as dependent variables and the output gap as independent variable (Table 1 and Table 2), considering both the *ex-post* perspective (a measure of the output gap based on the latest autumn forecast[11]) and a real-time perspective, consisting in using a measure of the output gap derived from all the previous autumn forecasts. This differentiation is highly significant and often overlooked in the literature, the reason why we interpret the real-time coefficient as more proper benchmark of the analysis.

Table 1 reports the results for the *ex-post* perspective, using both the Generalised Least Squares (GLS) and the Arellano-Bond (AB) estimators. Considering first the regressions involving the whole period with GLS (columns *1a_ex* without control variables and *1b_ex* with control variables), pro-cyclicality widely emerges for the personal income tax (PIT), for all direct and indirect taxes (DT and IT), for social security contributions (SSC). The only notable exception to pro-cyclicality is provided by the corporate income tax (CIT), which is anti-cyclical in both cases. This is probably explained by the fact that a recession strongly impacts on the level of profits, making the CIT more cycle-dependent than other taxes. Finally, non-tax revenue (NTR) – being a residual element of the total revenue – is unaffected by the output gap. It is also worth noting that when considering total tax revenue (TR), pro-cyclicality still emerges, which means that the intensity of the pro-cyclical effect of almost all taxes overwhelms the anti-cyclical effect of the corporate income tax. The same outcome emerges when considering the AB estimator: all cases of pro-cyclicality are confirmed, while CIT

[11] At the time of writing, 2024.

and NTR do not appear significantly related to the economic cycle. In this AB framework, the a-cyclical behaviour of CIT would suggest that the policymakers may hardly affect and stimulate firms' investment decisions through changes in the corporate taxation and thus stimulate the economic performance with corporate taxes (Arnold et al., 2011; Bournakis and Mallick, 2021; Gechert and Heimberger, 2022). It is also worth observing that when the analysis is split by sub-periods (1995-2001 and 2002-2019) results are widely stable confirming pro-cyclicality in a large number of cases. While the previous results are confirmed, it should be noted that the most pronounced pro-cyclicality effects are more concentrated in the second sub-period, when fiscal rules have progressively become more stringent.

[Table 1 around here]

When moving to the real-time analysis – focusing on the period from 2002 to 2019 – the pro-cyclical effect appears even stronger, again with some exceptions for CIT and NTR, but especially with regard to the magnitude of the coefficients (Table 2). As depicted in Figure 2 for both estimation methods, the pro-cyclical effect of almost all tax items is higher when considering the real-time perspective; the reason lies in the fact that the *ex-post* estimation appears to smooth or even eliminate the dependence of potential GDP on actual GDP realisations, thereby reducing the strongly pro-cyclical outcomes (an adjustment that is not possible within the real-time approach).[12] This is why, in our view, the real-time approach appears to be a more appropriate method to estimate and examine the impact of the business cycle on fiscal variables.

[Table 2 around here]

[Figure 2 around here]

[12] In a recent paper, Carnazza and Carnevali (2024) attempt to explain the underlying reasons for fiscal pro-cyclicality in the European context and, in particular, why *ex-post* estimates tend to yield less pronounced pro-cyclical outcomes compared to the real-time approach. According to their perspective, the methodology for calculating potential GDP (and thus the output gap), which is significantly influenced by actual GDP realisations, is one of the key factors, alongside the increasingly stringent European fiscal framework

These results strongly suggest that the discretionary use of taxes tends to amplify the cycle, compromising the ability of the tax side of the public budget to address 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 disclose 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 that some empirical evidence shows 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 set by the fiscal rules governing the size and the intensity of discretionary public budget actions. The impact of these rules – which can be traced back to the old debate between rules and discretion in public intervention including the theory of fiscal constitutionalism (Buchanan and Wagner, 1977) – is worthy observing to understand whether they are able to affect the size and the intensity of the discretionary fiscal policy. In a nutshell, our findings appear to confirm the existence of a pro-cyclical trap in fiscal terms that hinders national governments from adequately counterbalancing the expansionary and recessionary phases of the economic cycle. Although this study focuses primarily on fiscal revenues, the set of available evidence and the existing literature suggest that the role of overall discretionary fiscal policy has been significantly curtailed, running opposite to that of automatic stabilisers.

4.2 Fiscal rules and the time-varying cyclical nature of tax revenues

The use of a time-varying cyclicality coefficient enables us to determine whether, and in which direction, there has been a change in the characterisation of the fiscal cyclicality of the revenue components. These coefficients, shown as average values in Figure 2 which distinguishes between the *ex-post* and real-time approaches, can then be econometrically compared to the evolution of the European fiscal framework. This evolution is summarised using two distinct indices introduced to enhance the robustness of our conclusions.

In this context, Tables 3 and 4 report the results of regressing the time-varying $\mu_{i,t}^{j}$ coefficient on the previous indices (FRI and $StdFRI$) again considering the *ex-post* and the real-time perspective, respectively. In the absence of a dynamic panel, we use the Generalised Least Squares (GLS) estimator controlling for panel specific autocorrelation and heteroskedastic and correlated error structure. Since an increase in the two indices can be interpreted as an intensification of fiscal rigidity, a positive coefficient associated with the main regressor $fiscal\_stringency$ indicates that an increase in the stringency of fiscal rules leads to greater counter-cyclicality (or a reduction in pro-cyclicality) of the cyclicality of a given revenue component; conversely, a negative coefficient associated with the fiscal index suggests the opposite effect. Our hypothesis is that fiscal rules are one of the underlying causes of the pro-cyclicality of fiscal policy; this is why we expect the $fiscal\_stringency$ coefficient to be negative.

Table 3 takes into consideration the *ex-post* framework without (a) and with (b) control variables. Pro-cyclicality appears strengthened over time in the case of PIT and CIT, and for DT as a whole; on the contrary, all other revenue items indicate a strengthening of the counter-cyclical impact of the fiscal rules indices. This would imply that a counter-cyclical discretionary action, if any, is mainly driven by the use of indirect taxes (mainly VAT and excise taxes) and social security contributions (for example, by a reduction of labour costs to hire workers). The same conclusion applies to tax revenues considered as a whole. These results appear to contradict our core intuition regarding the impact of fiscal rules on the cyclical behaviour of the budget balance. However, as previously

emphasised, they rest on a fundamentally flawed premise: the *ex-post* output gap implicitly removes the pro-cyclical distortions that have occurred over time, stemming from the dependency of potential GDP on actual GDP realisations.

Adopting a real-time approach, instead, provides a more accurate and truthful representation. As expected (Table 4) this method reveals a fundamental shift in the results obtained (panels a and b represent models without and with macroeconomic controls, respectively). The significant pro-cyclical impact of the progressive tightening of the European fiscal framework is now evident, widespread and more pronounced with the exception of SSC and NTR.

[Table 3 around here]

[Table 4 around here]

To ensure a consistent comparison between the *ex-post* and real-time coefficients, Table 3 also considers a distinction between the period from 1995 to 2001 and that from 2002 to 2019. A graphical synthesis of the direction and the intensity of the pro-cyclical behaviour determined by fiscal rules is then finally reported in Figure 4. The upper panel reports the data of the model using FRI, while the bottom panel reports the same information for $StdFRI$; both panels make evident the risks associated with adopting an *ex-post* approach, given its potential to produce misleading results.

[Figure 4 around here]

5. Conclusions

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 its main components, especially tax revenues. To fill this gap in the literature, this paper analyses the cyclical degree of PIT, CIT, IT, SSC, and NTR for the EU. To this purpose, we adopt a novel empirical strategy that allows to

preliminary adjusts each revenue item for the business cycle, isolating their discretionary effects. In this way, we are able to estimate the cyclicality of each revenue item while introducing, as a second important contribution, the distinction between the *ex-post* approach and the real-time approach. The former, by revising all past observations, risks eliminating the pro-cyclical outcomes induced by the European fiscal framework and the calculation methodology adopted by the EC. The real-time approach should then become the standard for examining this type of issue. Our main results show a wide and stable pro-cyclical behaviour for PIT, for the aggregate direct (DT) and indirect taxes (IT), and – with some exceptions – for SSC. CIT, on the other hand, show less regular behaviour, as they swing from pro-cyclicality to anti-cyclicality depending on the estimation method and on the time period considered. When moving to the real-time approach the pro-cyclical effect is confirmed and even stronger. Finally, the fundamental question that motivated this study concerns the potential impact of fiscal rules in shaping the previously observed pro-cyclicality. To address this, two different country- and year-specific indices were considered. From this perspective, the real-time approach reveals a profoundly different (and more realistic) scenario compared to the *ex-post* approach, as it is based on actual data recorded over time without retrospective adjustments. Fiscal rules seem to have played a decisive role in influencing the pro-cyclical behaviour of revenues over time, with the exception of SSC and NTR.

Even though with some exceptions, our paper clearly show that the tax policies in the EU have fallen into the pro-cyclical trap, and that the European fiscal framework seems to have played an important role in shaping this pattern, an outcome that may give important insights on how to shape future tax policies in the European area. In a monetary union, counter-cyclical fiscal policy may be more effectively implemented at the federal level. This underscores the need for a more radical shift toward establishing a genuine fiscal and budgetary union. The issuance of Eurobonds and the launch of the Next Generation EU recovery plans during the Covid-19 pandemic appeared to mark a significant initial step toward European federalism. However, the momentum behind this transformative effort has since waned. Ultimately, the success of the European project may depend

on how we, as Europeans, collectively address these substantial challenges. Unfortunately, the updated version of the Stability and Growth Pact, approved by the European Parliament and the European Commission in April 2024, seems to have retained the fundamental mechanisms of its predecessor, most notably the central role of the structural balance. This may imply that the challenges observed during the 1995–2019 period are likely to persist in the years ahead.

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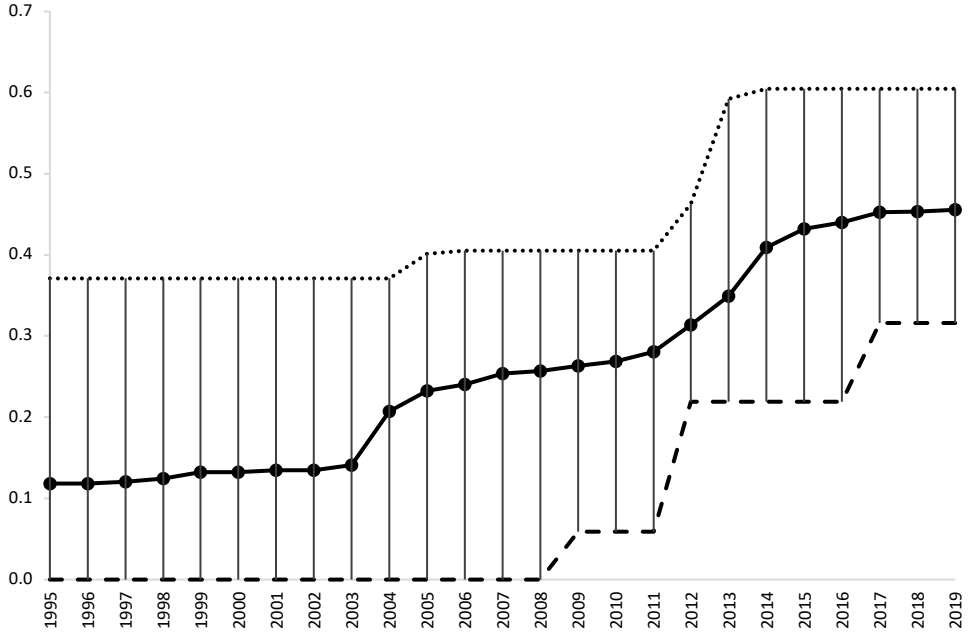
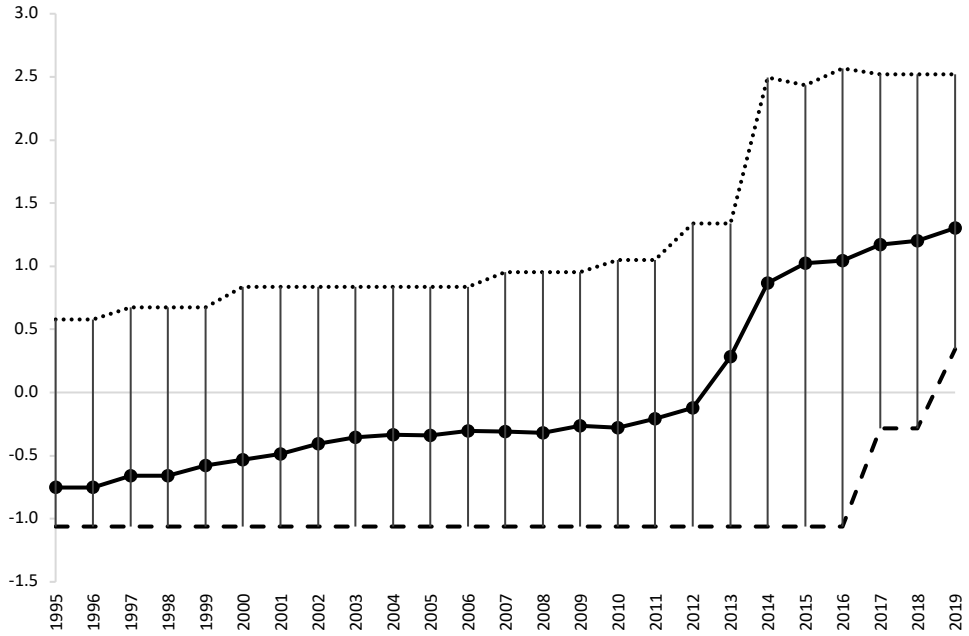
Figures and Tables

Figure 1 – Fiscal rules indicators in the EU-27

(a) FRI



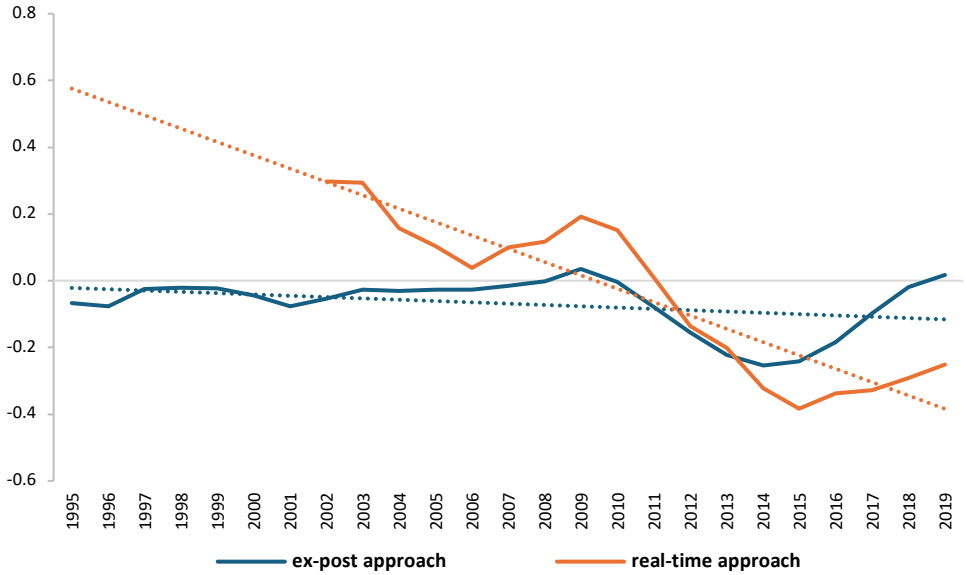
(b) StdFRI



	Observations	Mean	Std. Dev.	Skewness	Kurtosis	Source
FRI	675 (1995 - 2019)	0.26	0.16	-0.01	2.37	Own elaborations on Fiscal Rules Dataset - IMF data
StdFRI	675 (1995 - 2019)	-0.03	0.92	0.62	2.61	Fiscal governance database - European Commission

Note: the two figures show the maximum, minimum and average values of the two year- and country-specific indicators of the stringency of the fiscal framework that characterised the EU-27 from 1995 to 2019, the year in which this framework was suspended to deal with the health crisis.

Figure 2 – Time-varying fiscal cyclicality of EU-27 total revenue



Note: the dotted lines represent the linear trends of the two time-varying coefficients. We have calculated the average for each year for the 27 countries of the European Union; however, especially in the first years, some countries are characterised by missing values, which makes the two series not entirely homogenous over time.

Table 1 – Tax cyclicality and output gap: an *ex-post* perspective

Estimator		Generalised Least Squares (GLS) (controlling for panel specific autocorrelation and heteroskedastic and correlated error structure)				Arellano-Bond (AB) (using the conventionally derived variance estimator for Generalised Method of Moments estimation)			
Dependent variable	*Independent variable*	Model (*ex-post* = ex)							
		(1a_ex)	(1b_ex)	(2a_ex)	(2b_ex)	(3a_ex)	(3b_ex)	(4a_ex)	(4b_ex)
ca_PITex	**OGex** (1995 - 2019)	-0.043 ***	-0.048 ***			-0.028 ***	-0.032 ***		
	OGex_1 (1995 - 2001)			-0.072 ***	-0.065 ***			-0.028	-0.038 *
	OGex_2 (2002 - 2019)			-0.038 ***	-0.041 ***			-0.028 **	-0.030 **
ca_CITex	**OGex** (1995 - 2019)	0.024 ***	0.030 ***			0.013	0.015		
	OGex_1 (1995 - 2001)			0.058 ***	0.070 ***			0.038 **	0.046 **
	OGex_2 (2002 - 2019)			0.018 ***	0.023 ***			0.006	0.005
ca_DTex	**OGex** (1995 - 2019)	-0.018 ***	-0.023 ***			-0.034 ***	-0.039 ***		
	OGex_1 (1995 - 2001)			-0.015 ***	-0.019 ***			-0.033	-0.026
	OGex_2 (2002 - 2019)			-0.019 ***	-0.019 ***			-0.035 **	-0.043 ***
ca_SSCex	**OGex** (1995 - 2019)	-0.024 ***	-0.040 ***			-0.023 **	-0.036 ***		
	OGex_1 (1995 - 2001)			0.004 **	-0.013 ***			-0.009	-0.011
	OGex_2 (2002 - 2019)			-0.031 ***	-0.047 ***			-0.026 ***	-0.043 ***
ca_ITex	**OGex** (1995 - 2019)	-0.051 ***	-0.049 ***			-0.040 ***	-0.037 ***		
	OGex_1 (1995 - 2001)			-0.021 ***	-0.017 ***			-0.054 **	-0.047 *
	OGex_2 (2002 - 2019)			-0.062 ***	-0.061 ***			-0.036 ***	-0.034 **
ca_NTRex	**OGex** (1995 - 2019)	0.000	-0.003			-0.004	0.000		
	OGex_1 (1995 - 2001)			0.025 ***	0.024 ***			0.012	-0.011
	OGex_2 (2002 - 2019)			-0.005 ***	-0.011 ***			-0.007	0.004
ca_TRex	**OGex** (1995 - 2019)	-0.102 ***	-0.139 ***			-0.119 ***	-0.137 ***		
	OGex_1 (1995 - 2001)			-0.027 **	-0.030 **			-0.102 **	-0.091 **
	OGex_2 (2002 - 2019)			-0.130 ***	-0.158 ***			-0.124 ***	-0.151 ***
Observations		600 (576)	600 (576)	600 (576)	600 (576)	613 (611)	613 (611)	613 (611)	613 (611)
Countries		25 (24)	25 (24)	25 (24)	25 (24)	27	27	27	27
Constant		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control variables		No	Yes	No	Yes	No	Yes	No	Yes
Country dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time span		1995 - 2019	1995 - 2019	1995 - 2019	1995 - 2019	1995 - 2019	1995 - 2019	1995 - 2019	1995 - 2019

Note: ***, **, * denote significance at 1%, 5% and 10% level, respectively. The GLS estimator (controlling for panel-specific AR1 autocorrelation structure, heteroskedastic and correlated error structure) requires perfectly balanced panels. This is the reason why some countries were excluded from the estimates. The AB estimator implies the presence of the lag of the dependent variable within regressors that was not reported; the output gap has been considered endogenous in this kind of framework with a maximum of three lags as instruments. The number of observations and countries given in brackets refer to the PIT and the CIT. Control variables include first-order lags of the debt-to-GDP ratio, trade openness, terms of trade, unemployment rate, inflation based on GDP deflator and the age dependency ratio. Orange values denote pro-cyclical coefficients, while green values the counter-cyclical ones. The (*ex-post*) output gap used as the main regressor is solely based on the EC's 2024 autumn forecast. For more methodological details, see Section 3.2.

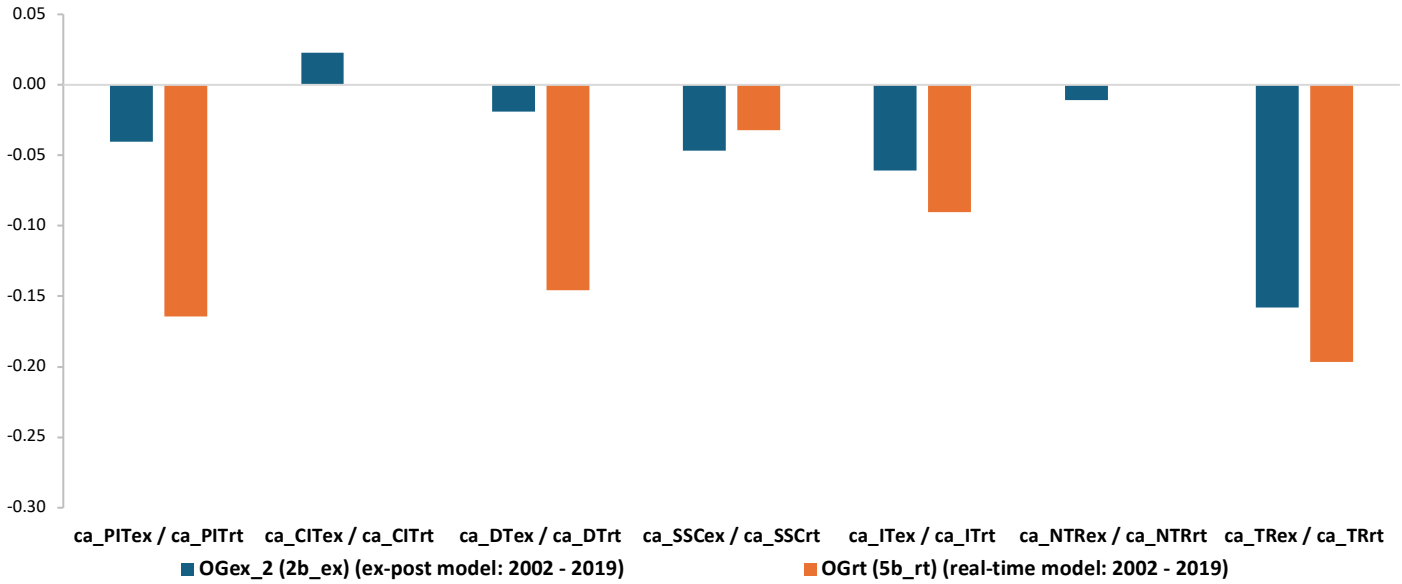
Table 2 – Tax cyclicality and output gap: a real-time perspective

Model		**Generalised Least Squares (GLS)** (controlling for panel specific autocorrelation and heteroskedastic and correlated error structure)		**Arellano-Bond (AB)** (using the conventionally derived variance estimator for Generalised Method of Moments estimation)	
Estimator					
Dependent variable	***Independent variable***	**Model (*real-time* = rt)**			
		(5a_rt)	**(5b_rt)**	**(6a_rt)**	**(6b_rt)**
ca_PITrt	**OGrt** (2002 - 2019)	-0.125 ***	-0.164 ***	-0.061 ***	-0.067 ***
ca_CITrt	**OGrt** (2002 - 2019)	0.014 **	0.004	0.009	-0.009
ca_DTrt	**OGrt** (2002 - 2019)	-0.103 ***	-0.146 ***	-0.054 **	-0.068 **
ca_SSCrt	**OGrt** (2002 - 2019)	-0.029 ***	-0.032 ***	-0.043 ***	-0.072 ***
ca_ITrt	**OGrt** (2002 - 2019)	-0.090 ***	-0.090 ***	-0.090 ***	-0.107 ***
ca_NTRrt	**OGrt** (2002 - 2019)	-0.028 ***	0.004	-0.023	-0.010
ca_TRrt	**OGrt** (2002 - 2019)	-0.182 ***	-0.196 ***	-0.242 ***	-0.269 ***
Observations		238	238	391	391
Countries		14	14	27	27
Constant		Yes	Yes	Yes	Yes
Control variables		No	Yes	No	Yes
Country dummies		Yes	Yes	Yes	Yes
Time dummies		Yes	Yes	Yes	Yes
Time span		2002 - 2019	2002 - 2019	2002 - 2019	2002 - 2019

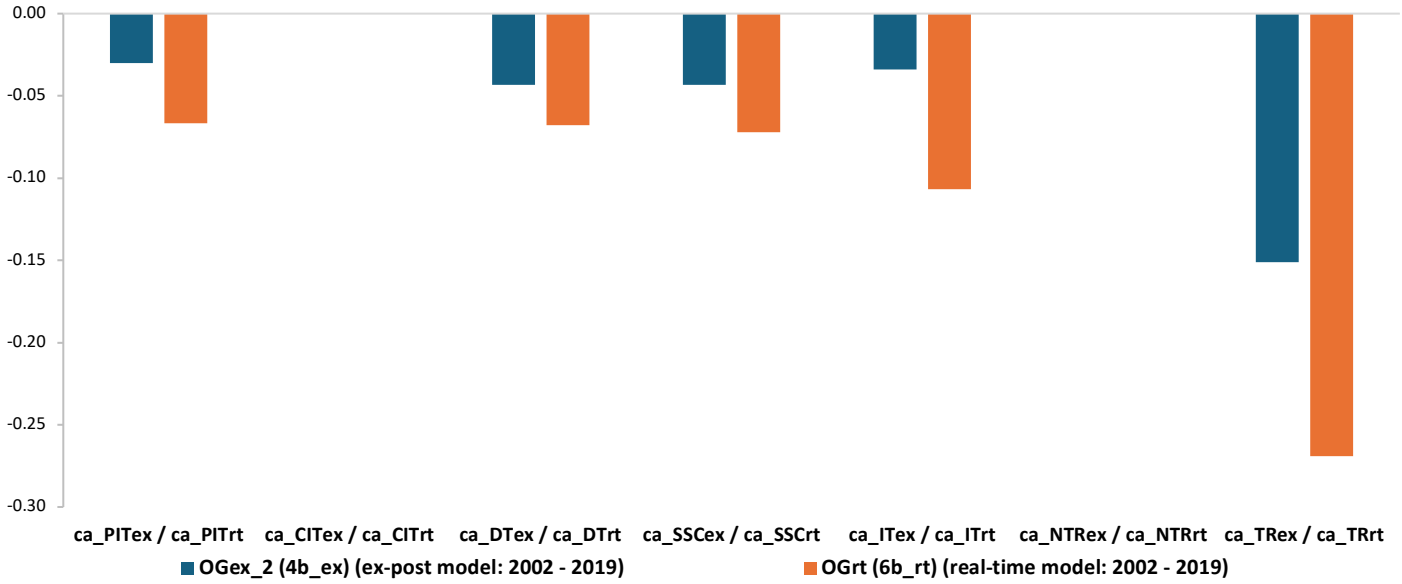
Note: ***, **, * denote significance at 1%, 5% and 10% level, respectively. The AB estimator implies the presence of the lag of the dependent variable within regressors that was not reported; the output gap has been considered endogenous in this kind of framework with a maximum of three lags as instruments. Control variables include first-order lags of the debt-to-GDP ratio, trade openness, terms of trade, unemployment rate, inflation based on the GDP deflator and the age dependency ratio. Orange values denote pro-cyclical coefficients, while green values the counter-cyclical ones. The (real-time) output gap used as the main regressor is derived manually from all the EC's autumn forecasts since 2002. For more methodological details, see Section 3.2.

Figure 3 – Tax cyclicality and output gap: comparing *ex-post* and real-time approaches

(a) Generalised Least Squares (GLS) estimator



(b) Arellano-Bond (AB) estimator



Note: the fiscal cyclicality coefficients are taken from the models presented in Table 1 and Table 2 that include the control variables. These coefficients are represented by the two different histograms: the blue one refers to the *ex-post* approach, while the orange one to the real-time framework. The two dependent variable alternatives depend on the type of regressor used, whether *ex-post* or real-time. As real-time models by definition start from 2002, we compared the *ex-post* coefficients over the same period.

Table 3 – Tax cyclicality and fiscal rules: an *ex-post* perspective

Estimator		Generalised Least Squares (GLS) (controlling for panel specific autocorrelation and heteroskedastic and correlated error structure)							
Dependent variable	***Independent variable***	**Model (*ex-post* = ex)**							
		(7a_ex)	**(7b_ex)**	**(8a_ex)**	**(8b_ex)**	**(9a_ex)**	**(9b_ex)**	**(10a_ex)**	**(10b_ex)**
ca_TVC_PITex	**FRI_1** (1995-2019)	-0.092 ***	-0.117 ***						
	StdFRI_1 (1995-2019)			-0.019 ***	-0.016 ***				
	FRI_1 (1995-2001)					-0.130 ***	-0.164 ***		
	FRI_2 (2002-2019)					-0.089 ***	-0.088 ***		
	StdFRI_1 (1995-2001)							-0.026 ***	-0.017 ***
	StdFRI_2 (2002-2019)							-0.018 ***	-0.014 ***
ca_TVC_CITex	**FRI_1** (1995-2019)	-0.003 ***	-0.024 ***						
	StdFRI_1 (1995-2019)			0.009 ***	0.009 ***				
	FRI_1 (1995-2001)					0.036 ***	-0.009 *		
	FRI_2 (2002-2019)					-0.008 ***	-0.023 ***		
	StdFRI_1 (1995-2001)							0.017 ***	0.016 ***
	StdFRI_2 (2002-2019)							0.009 ***	0.008 ***
ca_TVC_DTex	**FRI_1** (1995-2019)	-0.146 ***	-0.18266 ***						
	StdFRI_1 (1995-2019)			-0.010 ***	-0.005 ***				
	FRI_1 (1995-2001)					-0.177 ***	-0.224 ***		
	FRI_2 (2002-2019)					-0.146 ***	-0.176 ***		
	StdFRI_1 (1995-2001)							-0.009 ***	-0.002 **
	StdFRI_2 (2002-2019)							-0.009 ***	-0.005 ***
ca_TVC_SSCex	**FRI_1** (1995-2019)	0.124 ***	0.127 ***						
	StdFRI_1 (1995-2019)			0.014 ***	0.016 ***				
	FRI_1 (1995-2001)					0.132 ***	0.222 ***		
	FRI_2 (2002-2019)					0.142 ***	0.124 ***		
	StdFRI_1 (1995-2001)							0.028 ***	0.043 ***
	StdFRI_2 (2002-2019)							0.010 ***	0.010 ***
ca_TVC_ITex	**FRI_1** (1995-2019)	0.082 ***	0.077 ***						
	StdFRI_1 (1995-2019)			0.005 ***	0.002 ***				
	FRI_1 (1995-2001)					0.191 ***	0.150 ***		
	FRI_2 (2002-2019)					0.072 ***	0.071 ***		
	StdFRI_1 (1995-2001)							0.009 ***	0.005 ***
	StdFRI_2 (2002-2019)							0.004 ***	0.002 ***
ca_TVC_NTRex	**FRI_1** (1995-2019)	0.022 ***	0.033 ***						
	StdFRI_1 (1995-2019)			0.020 ***	0.017 ***				
	FRI_1 (1995-2001)					-0.068 ***	-0.039 ***		
	FRI_2 (2002-2019)					0.036 ***	0.038 ***		
	StdFRI_1 (1995-2001)							0.014 ***	0.010 ***
	StdFRI_2 (2002-2019)							0.024 ***	0.018 ***
ca_TVC_TRex	**FRI_1** (1995-2019)	0.140 ***	0.102 ***						
	StdFRI_1 (1995-2019)			0.017 ***	0.019 ***				
	FRI_1 (1995-2001)					0.034 ***	0.040 ***		
	FRI_2 (2002-2019)					0.168 ***	0.109 ***		
	StdFRI_1 (1995-2001)							0.010 ***	0.016 ***
	StdFRI_2 (2002-2019)							0.019 ***	0.020 ***
Observations		625 (600)	600 (576)	625 (600)	600 (576)	625 (600)	600 (576)	625 (600)	600 (576)
Countries		25 (24)	25 (24)	25 (24)	25 (24)	25 (24)	25 (24)	25 (24)	25 (24)
Constant		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control variables		No	Yes	No	Yes	No	Yes	No	Yes
Country dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time span		1995 - 2019	1995 - 2019	1995 - 2019	1995 - 2019	1995 - 2019	1995 - 2019	1995 - 2019	1995 - 2019

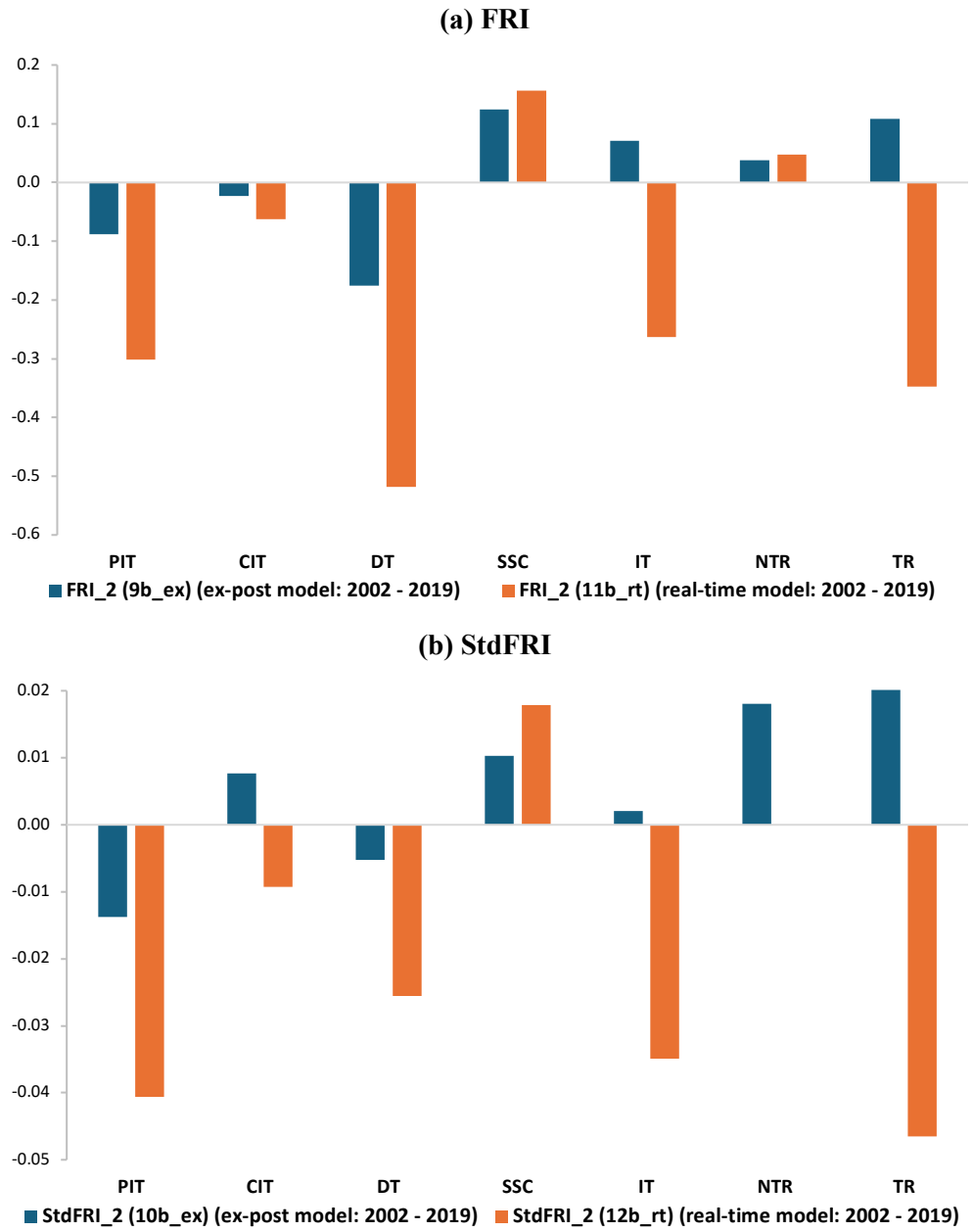
ote: ***, **, * denote significance at 1%, 5% and 10% level, respectively. The GLS estimator (controlling for panel-specific AR1 autocorrelation structure, eteroskedastic and correlated error structure) requires perfectly balanced panels. This is the reason why some countries were excluded from the estimates. he number of observations and countries given in brackets refer to the *PIT* and the *CIT*. Control variables include first-order lags of the debt-to-GDP ratio, ade openness, terms of trade, unemployment rate, inflation based on GDP deflator and the age dependency ratio. Orange values denote pro-cyclical oefficients, while green values the counter-cyclical ones. For more methodological details, see Section 3.4.

Table 4 – Tax cyclicality and fiscal rules: a real-time perspective

Estimator		**Generalised Least Squares (GLS)** (controlling for panel specifc autocorrelation and heteroskedastic and correlated error structure)			
Dependent variable	***Independent variable***	**Model (*real-time = rt*)**			
		(11a_rt)	**(11b_rt)**	**(12a_rt)**	**(12b_rt)**
ca_TVC_PITrt	**FRI_2** (2002-2019)	-0.293 ***	-0.302 ***		
	StdFRI_2 (2002-2019)			-0.053 ***	-0.041 ***
ca_TVC_CITrt	**FRI_2** (2002-2019)	0.057 ***	-0.062 ***		
	StdFRI_2 (2002-2019)			-0.006 ***	-0.009 ***
ca_TVC_DTrt	**FRI_2** (2002-2019)	-0.365 ***	-0.519 ***		
	StdFRI_2 (2002-2019)			-0.024 ***	-0.026 ***
ca_TVC_SSCrt	**FRI_2** (2002-2019)	0.156 ***	0.156 ***		
	StdFRI_2 (2002-2019)			0.006 ***	0.018 ***
ca_TVC_Itrt	**FRI_2** (2002-2019)	-0.125 ***	-0.263 ***		
	StdFRI_2 (2002-2019)			-0.032 ***	-0.035 ***
ca_TVC_NTRrt	**FRI_2** (2002-2019)	0.081 ***	0.047 **		
	StdFRI_2 (2002-2019)			0.011 ***	-0.002
ca_TVC_TRrt	**FRI_2** (2002-2019)	-0.178 ***	-0.347 ***		
	StdFRI_2 (2002-2019)			-0.029 ***	-0.047 ***
Observations		252	238	252	238
Countries		14	14	14	14
Constant		Yes	Yes	Yes	Yes
Control variables		No	Yes	No	Yes
Country dummies		Yes	Yes	Yes	Yes
Time dummies		Yes	Yes	Yes	Yes

Note: ***, **, * denote significance at 1%, 5% and 10% level, respectively. The GLS estimator (controlling for panel-specific AR1 autocorrelation structure, heteroskedastic and correlated error structure) requires perfectly balanced panels. This is the reason why some countries were excluded from the estimates. The number of observations and countries given in brackets refer to the *PIT* and the *CIT*. Control variables include first-order lags of the debt-to-GDP ratio, trade openness, terms of trade, unemployment rate, inflation based on the GDP deflator and the age dependency ratio. Orange values denote pro-cyclical coefficients, while green values the counter-cyclical ones. For more methodological details, see Section 3.4.

Figure 4 – Tax cyclicality and fiscal rules: comparing *ex-post* and real-time approaches



Note: the coefficients of the impact of fiscal rules on the cyclicality of different revenue items are taken from the models presented in Table 3 and Table 4 that include the control variables. As real-time models by definition start from 2002, we compared the *ex-post* coefficients over the same period.

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)	Corporate Income Tax (CIT)	Social Security Contributions (SSC)	Indirect Tax (IT)	Non-Tax Revenue (NTR)
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 (for more details, see Table A4 and Section 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)	Corporate Income Tax (CIT)	Social Security Contributions (SSC)	Indirect Tax (IT)	Non-Tax Revenue (NTR)	Total Revenue (TR)
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 Section 3.1).
Source: own elaborations on Mourre *et al.* (2014) and Mourre *et al.* (2019) data

Table A5 – Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Skewness	Kurtosis	Source
Revenue cyclicality in the *ex-post* framework						
Personal Income Tax (ca_PITex)	665 (1995 - 2019)	8.167	4.938	2.021	7.862	Own elaborations on AMECO data
Corporate Income Tax (ca_CITex)	665 (1995 - 2019)	2.934	1.321	1.567	5.840	Own elaborations on AMECO data
Direct Taxes (ca_DTex)	667 (1995 - 2019)	11.173	5.065	1.834	7.213	Own elaborations on AMECO data
Social Security Contributions (ca_SSCex)	667 (1995 - 2019)	11.566	3.973	-0.693	3.204	Own elaborations on AMECO data
Indirect Taxes (ca_ITex)	667 (1995 - 2019)	13.731	2.737	1.135	4.870	Own elaborations on AMECO data
Non-Tax Revenues (ca_NTRex)	667 (1995 - 2019)	6.102	1.501	0.695	3.894	Own elaborations on AMECO data
Total Revenues (ca_TRex)	667 (1995 - 2019)	42.567	6.556	0.165	2.408	Own elaborations on AMECO data
***Ex-post* output gap (OGex)**	667 (1995 - 2019)	-0.235	3.394	-0.964	8.059	Own elaborations on AMECO data
Revenue cyclicality in the *real-time* framework						
Personal Income Tax (ca_PITrt)	443 (2002 - 2019)	8.428	4.960	1.963	7.600	Own elaborations on AMECO data
Corporate Income Tax (ca_CITrt)	443 (2002 - 2019)	2.925	1.281	1.705	6.311	Own elaborations on AMECO data
Direct Taxes (ca_DTrt)	445 (2002 - 2019)	11.414	5.161	1.746	7.001	Own elaborations on AMECO data
Social Security Contributions (ca_SSCrt)	445 (2002 - 2019)	11.509	4.060	-0.824	3.219	Own elaborations on AMECO data
Indirect Taxes (ca_ITrt)	445 (2002 - 2019)	13.797	2.719	1.126	4.882	Own elaborations on AMECO data
Non-Tax Revenues (ca_NTRrt)	445 (2002 - 2019)	6.189	1.480	0.710	4.050	Own elaborations on AMECO data
Total Revenues (ca_TRrt)	445 (2002 - 2019)	42.898	6.425	0.004	2.419	Own elaborations on AMECO data
Real-time output gap (OGrt)	445 (2002 - 2019)	-1.022	2.428	-1.359	6.837	Own elaborations on AMECO data
Control variables						
Debt-to-GDP ratio	675 (1995 - 2019)	56.700	33.901	0.900	4.071	Own elaborations on AMECO data
Openness	675 (1995 - 2019)	110.119	54.473	1.664	7.115	Own elaborations on AMECO data
Terms of Trade	675 (1995 - 2019)	97.951	7.195	-2.269	12.990	Own elaborations on AMECO data
Unemployment Rate	675 (1995 - 2019)	9.116	4.351	1.301	5.003	Own elaborations on AMECO data
Inflation (GDP deflator)	675 (1995 - 2019)	2.940	4.822	1.238	18.285	Own elaborations on AMECO data
Age dependency ratio	675 (1995 - 2019)	49.282	4.197	0.151	3.015	Own elaborations on AMECO data
Time-varying fiscal cyclicality in the *ex-post* framework						
Personal Income Tax (ca_TVC_PITex)	665 (1995 - 2019)	-0.071	0.213	-0.142	10.917	Own elaborations on AMECO data
Corporate Income Tax (ca_TVC_CITex)	665 (1995 - 2019)	0.064	0.127	-0.540	7.723	Own elaborations on AMECO data
Direct Taxes (ca_TVC_DTex)	667 (1995 - 2019)	0.007	0.249	-0.052	8.274	Own elaborations on AMECO data
Social Security Contributions (ca_TVC_SSCex)	667 (1995 - 2019)	-0.065	0.197	-0.530	6.281	Own elaborations on AMECO data
Indirect Taxes (ca_TVC_ITex)	667 (1995 - 2019)	0.024	0.209	0.227	4.942	Own elaborations on AMECO data
Non-Tax Revenues (ca_TVC_NTRex)	667 (1995 - 2019)	-0.033	0.181	0.366	12.583	Own elaborations on AMECO data
Total Revenues (ca_TVC_TRex)	667 (1995 - 2019)	-0.069	0.425	-0.812	6.280	Own elaborations on AMECO data
Time-varying fiscal cyclicality in the real-time framework						
Personal Income Tax (ca_TVC_PITrt)	443 (2002 - 2019)	-0.025	0.318	0.142	6.252	Own elaborations on AMECO data
Corporate Income Tax (ca_TVC_CITrt)	443 (2002 - 2019)	0.088	0.191	-0.317	7.184	Own elaborations on AMECO data
Direct Taxes (ca_TVC_DTrt)	445 (2002 - 2019)	0.107	0.393	0.629	6.030	Own elaborations on AMECO data
Social Security Contributions (ca_TVC_SSCrt)	445 (2002 - 2019)	-0.018	0.343	0.191	5.513	Own elaborations on AMECO data
Indirect Taxes (ca_TVC_ITrt)	445 (2002 - 2019)	-0.055	0.368	-1.514	6.821	Own elaborations on AMECO data
Non-Tax Revenues (ca_TVC_NTRrt)	445 (2002 - 2019)	-0.095	0.271	0.531	8.494	Own elaborations on AMECO data
Total Revenues (ca_TVC_TRrt)	445 (2002 - 2019)	-0.068	0.810	-1.161	6.550	Own elaborations on AMECO data

Note (1): 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 ($TR = DT + SSC + IT + NTR$).

Note (2): (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; 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.

Note (3): the real-time output gap is based on all AMECO autumn forecasts from 2002 onwards. Other data are based on the latest AMECO forecast available at the time of writing, i.e. the 2024 autumn forecast.