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Real-Time Detection of Hidden Fiscal Unsustainability in the EU*

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Abstract

If unanticipated fiscal shocks raise concerns about government solvency, shifts in market expectations can act as potential triggers for a crisis. This study examines whether unanticipated fiscal shocks have influenced the fiscal sustainability criteria within the EU. To reveal such "hidden fiscal unsustainability" in real time, it applies the regression kink model with an unknown threshold into a panel model with heterogeneity. This novel methodology offers several advantages. One advantage is its ability to examine how the fiscal response varies within the EU. Another advantage is that it enables the endogenous estimation of the threshold debt level at which fiscal consolidation occurs. The main findings are twofold. First, the results suggest that planned consolidations in the peripheral Euro Area countries are consistently more optimistic than the actual outcomes. Primary balance responses to changes in government debt, based on real-time data for these countries, are stronger than those based on revised data, indicating the presence of hidden fiscal unsustainability in real time. Second, the peripheral Euro Area countries endeavored to maintain fiscal sustainability during downturns, but failed to do so during periods of economic upturn.

Key Words: *Fiscal sustainability, Real-time data, Fiscal Reaction Function, Heterogeneous Panel Regression Kink Model with an unknown threshold*

JEL Codes: E43,H63

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1 Introduction

Fiscal sustainability is an inherently forward-looking concept. Assessing the sustainability of public debt cannot be based solely on the current debt-to-GDP ratio. Even if two countries have the same level of public debt today, they must be evaluated differently. For example, while the Eurozone experienced a severe sovereign debt crisis during 2010-11, Japan did not, despite Greece, Ireland, Portugal, Italy, and Spain having much lower debt-to-GDP ratios than Japan. Thus, if unanticipated fiscal shocks raise concerns about government solvency, shifts in market expectations can serve as potential triggers for a crisis.

On 8 January 2010, European Commission (2010) pointed out that the government balance revisions illustrated the lack of reliability of Greek fiscal statistics (and of macroeconomic statistics in general), and concluded that deliberate misreporting of data cannot be prevented by the existing framework for fiscal statistics at the EU Level.[1] This statistical revision revealed an unexpectedly large fiscal deficit and became one of the triggers of the European debt crisis. In general, there are several factors for revisions between the preliminary estimate and final vintage; methodological improvement and updates in the data source, inaccurate estimates of the state of the economy, revenues, and the implementation of unexpected fiscal measures (Cimadomo (2016)). Such revisions are propagated in the current year's estimates of professional forecasters: IMF, OECD, European Commission, and other private forecasters, even if they are more politically neutral than the corresponding governments because their original sources are the national statistical offices or local information. Before the sovereign debt crisis, the government bonds yields in several euro zone countries were highly correlated with those of Germany after the introduction of the euro (Ehrmann et al. (2011)). Thus, it should had been difficult for most professionals to predict the crisis.

This study addresses the following question:

- Have unanticipated fiscal shocks influenced the fiscal sustainability criteria within the EU?

This study is not the first to empirically investigate the difference between *ex ante* and *ex post* behavior of fiscal policies. While this paper is similar to Cimadomo (2012), it differs in several respects. First, while Cimadomo (2012) focuses on OECD countries, we shed light on the problem for periphery countries in the Euro Area (Greece, Ireland, Italy, Portugal, and Spain), Second, we employ the novel non-linear model for the EU due

[1] European Commission (2010) find that government balance revisions in Greece were due to inappropriate adjustments to the data, and political interference throughout the year, the unclear responsibility of the national services providing source data or compiling statistical data.

to the existence of the fiscal rule and the heterogeneity, while Cimadomo (2012) use the linear model. Third, in line with the fiscal sustainability criteria developed by Bohn (2007), our approach exposes "hidden fiscal unsustainability" in real time.[2]

The remainder of this paper is organized as follows. Section2 reviews the related literature on the causes of European debt crisis. Section3 describes the theoretical and empirical connections. Section4 constructs a dataset of real-time observations and describes the panel regression kink model with an unknown threshold. Section5 presents the baseline results and the robustness check. It examines a weak criterion for the fiscal sustainability criteria. Section6 examines a stricter criterion. Section7 concludes.

2 Literature Review

Bohn (2007) argues two types of the fiscal sustainability criteria, namely, (i) a weak criterion and (ii) a stricter criterion : (i) If a response of the primary fiscal balance to changes in government debt is at least positive, the intertemporal budget constraint and transversality condition (that is, no ponzi condition) can be maintained, but with mildly explosive paths, and (ii) If this fiscal response exceeds the growth-adjusted interest rate, public debt is expected to converge at a finite proportion of GDP (i.e., a stable stationary equilibrium). This paper also applies the fiscal sustainability criteria developed by Bohn (2007).

After the European debt crisis, a large body of the literature has investigated the origins of the crisis. Some studies investigate the fundamental aspects by analyzing fiscal and macroeconomic variables. In line with the fiscal sustainability criteria developed by Bohn (2007), Ghosh et al. (2013) conclude that a finite steady-state debt ratio does not exist for Greece, Italy, and Portugal, as the estimated fiscal response falls below the projected growth-adjusted interest rate. Their findings are based on evidence showing that fiscal responses to changes in public debt begin to weaken when debt-to-GDP ratio reaches approximately 90-100 percent, turning negative as the ratio approaches 150 percent of GDP (i.e., "so-called" fiscal fatigue).[3] In addition to the concept of "fiscal fatigue," the notion of the fiscal limit incorporates constraints on fiscal consolidation due to

[2] In the context of non-Paris Club lending in the financing of emerging and developing economies, Guler et al. (2022) develop a quantitative sovereign default model with an asymmetric information between lenders and borrowers. It captures the lack of detailed reporting and distorts bond pricing.

[3] Ghosh et al. (2013) estimate the fiscal responses to changes in public debt, employing the panel cubic specification which divides it into three phases; (1) a phase in which public debt is small and fiscal consolidation does not take place, (2) a phase in which debt is large and fiscal consolidation takes place, and (3) a phase in which debt is too large and the pace of fiscal consolidation slows.

an upper bound on the tax ratio, a lower bound on government expenditure, and political will. The fiscal limit is defined as the sum of the discounted maximum fiscal surpluses over all future periods. Based on estimated fiscal responses from actual data, Daniel and Shiamptanis (2012) concludes that Greece faced a high risk of crisis because the estimated fiscal limit was below the projected debt-to-GDP ratio by the OECD. Italy also faced some risk, as its estimated fiscal limit was slightly higher than the forecasted debt levels. Furthermore, Bi (2012) estimates Greece's fiscal limit by calculating the revenue-maximizing tax rate at the peak of the Laffer curve. This situation indicates that investors in the bond market believe the government will be able to increase the tax rate to prevent the public debt from following an explosive path. Bi (2012) also concludes that Greece faced a high risk of default.

Another important fundamental variable is the mean and volatility of the country's economic growth rate. Collard et al. (2015) argue that a high mean of economic growth rate facilitates a government's ability to serve existing public debt through new borrowing and future primary balance. However, if the volatility of economic growth is high, the likelihood of default increases. They demonstrate that the estimated maximum sustainable borrowing levels in Greece and Portugal are lower than those in other advanced economies.

In addition to the conventional fiscal and macroeconomic variables, Gros (2013) emphasizes that public debt poses significantly greater challenges when it is owed to foreign creditors, highlighting the importance of debt composition. Defaults on foreign debt have occurred more frequently than on domestic debt, as defaulting on foreign investors may enhance a country's consumption possibilities. The reduction in debt service payments can be redirected to finance additional imports. According to Arslanalp and Tsuda (2014), in Greece, the share of foreign holdings accounted for over 70 percent of government debt denominated in local currency in 2010.

Other studies examine both non-fundamental factors (i.e., self-fulfilling debt crises) and fundamental causes. Gros and Ji (2013) decompose the surge in the government bond yield in peripheral Eurozone countries during 2010-11 into two primary factors; fundamentals (e.g., the public debt to GDP ratio, the accumulated current account to GDP ratio, economic growth, etc.) and self-fulfilling market sentiments.[4] In Greece, the majority of the increase in the spread was attributed to deteriorating fundamentals (approximately 60 percent), while self-fulfilling market sentiments accounts for the remaining 40 percent. This result is consistent with the other studies discussed above. In the cases of Portugal and Ireland, the change in the spread was evenly split, with roughly half resulting from self-fulfilling market sentiments and the other half from fundamentals. In Spain, the

[4] Gros and Ji (2013) quantify the impact of self-fulfilling market sentiments by the time dummies across countries.

increase in the spread was predominantly driven by shifts in self-fulfilling market sentiments. Also, Lorenzoni and Werning (2019) argue that after the European debt crisis initially was triggered by self-fulfilling pessimism, the crisis itself eventually damages fundamentals.

This study focuses on an unanticipated fundamental aspects.[5] It contributes to two strands of the literature on fiscal sustainability in the EU. First, it identifies the disparity between *ex ante* and *ex post* behavior of fiscal responses to changes in public debt in the periphery countries in the Euro Area (Greece, Ireland, Italy, Portugal, and Spain). Specifically, the planned consolidations in these countries are more optimistic than the actual outcomes. To expose such "hidden fiscal unsustainability" in real time, we apply the regression kink model with an unknown threshold (RKU) developed by Hansen (2017) into a panel model with heterogeneity. This novel methodology offers several advantages. One advantage of RKU is its ability to examine how the fiscal response varies within the EU. In fact, Kraemer and Lehtimäki (2024) demonstrates that the establishment of the EU fiscal framework has had varying impacts on government debt across EU Member States. The RKU easily accommodates heterogeneity by introducing the slope dummy variables because the RKU investigates combinations of straight-lines.[6] Another advantage of RKU is that it enables the endogenous estimation of the threshold debt level at which fiscal consolidation occurs. Although the threshold debt level at which fiscal consolidation occurs is expected to be approximately 60 percent under EU rules, this remains unclear for several reasons: (i) The 60 percent threshold for government debt has been largely neglected before the introduction of the "so-called" Six-pack regulations in 2011 (European Commission (2011)). The Excessive Deficit Procedure (EDP) recommended by the European Commission had been on adherence to the 3 percent threshold for government deficit, not the 60 percent threshold for government debt.[7] (ii) The EU reform (i.e., Six-pack regulations) introduced the Euro area member states whose debt exceeds 60 percent of GDP face an Excessive Deficit Procedure (EDP). De Jong and Gilbert (2020) and Haan et al. (2016) point out that even after this reform, however, it has mainly focused on budget balance rules. Previous studies on the threshold debt level hardly existed beyond a few papers and these studies reached at different conclusions. Mendoza and Ostry (2008) find that the response of the primary fiscal balance to changes in government debt is insignificant

[5] An unanticipated fundamental aspect may be a key driver of changes in self-fulfilling market sentiments. Future research could explore the interaction between economic fundamentals and self-fulfilling market sentiments.

[6] On the other hand, Ghosh et al. (2013) employs a panel cubic specification, which represents a fully curved relationship.

[7] Previous studies focus on the government deficit, not the government debt. For instance, Caselli and Wingender (2021) show that the 3 percent deficit ceiling could have different influence on the high- and low-deficit countries, and illustrate that it has a positive impact on countries with large deficits. In contrast, it has a negative but negligible one in countries with a budget surplus.

when debt-to-GDP ratio exceeds the 60 percent in 22 advanced economies, whereas Shiamptanis (2015) shows that the corresponding response in Canada becomes larger when debt-to-GDP ratio exceeds about 90 percent. Given the EU fiscal debt rule, we examine whether the planned consolidation is more optimistic than the actual fiscal consolidation by estimating the threshold of debt level.[8]

Second, this study investigates whether the responses of primary balance to changes in government debt depend on the business cycle. As Jordá and Taylor (2016) find that the impact of fiscal consolidation on growth is negatively larger when the economy grows below its long-run trend than otherwise, it would be important to figure out when the fiscal consolidation has occurred. Ahmad et al. (2021), Aldama and Creel (2022) and Larch et al. (2021) investigate this issue, but these studies reached at disparate conclusions. While Aldama and Creel (2022) show no evidence that fiscal consolidation (i.e., the response of primary balance to changes in government debt) depends on the business cycle in OECD and Euro Area, Larch et al. (2021) find that the degree of procyclicality increases when debt exceeds a specific exogenous threshold in the EU. Furthermore, Ahmad et al. (2021) also show the relationship between fiscal space and fiscal procyclicality in 133 countries.[9] We reconcile these mixed results by investigating thresholds endogenously and find that the peripheral countries of the Euro Area whose debt exceeds 60 percent of GDP have maintained their fiscal sustainability during downtown and have not done so during upturns.

3 Connection between theoretical and empirical framework

This section explains the connection between the theoretical framework and our empirical approach by applying seminal works on fiscal sustainability in Bohn (1998), Bohn (2007) , and Ghosh et al. (2013).

3.1 Theoretical framework

The nominal government budget constraint is

$$D_t = (1+i_t)D_{t-1} - PB_t$$

[8]Our approach is similar to Shiamptanis (2015) because it endogenously finds the threshold debt level in Canada, using the threshold regression (Hansen (2000)). On the other hand, Mendoza and Ostry (2008) employs the exogenous threshold (i.e., 60 percent for the gross debt-to-GDP ratio).

[9]Ahmad et al. (2021) employ the government debt to GDP ratio as long-run indicator for fiscal space.

where D_t is the public debt, i_t is the implied nominal interest rate on public debt (i.e., the ratio of gross interest payments to the lagged public debt), and PB_t is the primary fiscal balance. Dividing both sides by Y_t (nominal GDP) yields:

$$\frac{D_t}{Y_t} = \left(\frac{1+i_t}{1+ng_t}\right)\frac{D_{t-1}}{Y_{t-1}} - \frac{PB_t}{Y_t}$$

$$d_t = \left(\frac{1+i_t}{1+ng_t}\right)d_{t-1} - pb_t \tag{1}$$

where d_t is the public debt to GDP ratio, ng_t is the nominal growth rate, and pb_t is primary fiscal balance to GDP ratio. Following Ghosh et al. (2013), this government's budget constraint (1) is approximately

$$d_t - d_{t-1} = (r_t - g_t)d_{t-1} - pb_t \tag{2}$$

where r_t is the implied real interest rate and g_t is the real growth rate. The government's fiscal reaction to lagged public debt is assumed to be

$$pb_t = f(d_{t-1}) + \mu_t \tag{3}$$

where $\mu_t = Z_t + u_t$. Z_t captures a set of other determinants of the primary balance and u_t is an error term. $f(d_{t-1})$ is the primary balance's response to lagged public debt, which is assumed to be continuously differentiable. We introduce a kink function for $f(d_{t-1})$, whereas Bohn (1998) and Ghosh et al. (2013) employ a linear function and cubic function, respectively. The kink function is a combination for straight-lines and is defined as follows:

$$f(d_{t-1}) = \beta_1^-(d_{t-1} - d^{Threshold})_- + \beta_2^+(d_{t-1} - d^{Threshold})_+ \tag{4}$$

where $(d_{t-1} - d^{Threshold})_-= \min\left[d_{t-1} - d^{Threshold}, 0\right]$ and $(d_{t-1} - d^{Threshold})_+= \max\left[d_{t-1} - d^{Threshold}, 0\right]$. β_1^- is assumed to be negative below threshold $d^{Threshold}$, while β_2^+ is assumed to be positive above the same threshold ; a phase in which public debt is small and fiscal consolidation does not occur, whereas a phase in which debt is large and fiscal consolidation occurs because of the debt rule.

Substituting the government's fiscal reaction (3) into the government's budget constraint (2) gives

$$d_t - d_{t-1} = (r_t - g_t)d_{t-1} - f(d_{t-1}) - \mu_t.$$

The steady-state condition is as follows.

$$(r-g)d = f(d) + \mu \tag{5}$$

In Figure 1, the thick blue lines represent the kink function $f(d)+\mu$ and the thick red line represents the interest payment schedule with a slope of $r-g$. The kink function has a threshold due to the debt rule (green dotted line). There are two stationary equilibria: two intersections between these two functions: (i) $f(d)+\mu$ and (ii) $(r-g)d$. While the lower intersection is an unstable stationary equilibrium, the higher one is a stable stationary equilibrium.[10] The condition for the stable stationary equilibrium is $r-g < f'(d) = \beta_2^+$ (that is, the stringent fiscal consolidation). In contrast, Figure 2 shows that if $r-g \geqq f'(d) = \beta_2^+$ (i.e., weak fiscal consolidation), the higher intersection does not exist, and there is no stable stationary equilibrium.

3.2 Empirical framework

Building on the theoretical framework, the empirical approach involves two steps, as outlined below:

- Step1 (**Section**4 and **Section**5): we estimate the response of the primary balance to changes in government debt, incorporating the kink function (4). The main parameter of interest is β_2^+. If β_2^+ is at least positive, the intertemporal budget constraint and the transversality condition (i.e., no ponzi condition) can be maintained but with mildly explosive paths (i.e., a weak criterion). That is, a weak criterion does not require any assumptions about interest rates.

- Step2 (**Section**6): we compare the interest rate-growth rate differential $r-g$ and the estimated fiscal reaction β_2^+. If $r-g < \beta_2^+$ (i.e., stringent fiscal consolidation), the stable stationary equilibrium exists. On the other hand, if $r-g \geqq \beta_2^+$ (i.e., stringent weak consolidation), the public debt would not be converge to a finite steady-state public debt ratio.

[10] Shiamptanis (2015) rules out the instability for low debt when it uses quadratic spline function. This paper also does not focus on the instability for low debt in the empirical section.

Figure 1: Stable stationary equilibrium with stringent fiscal consolidation

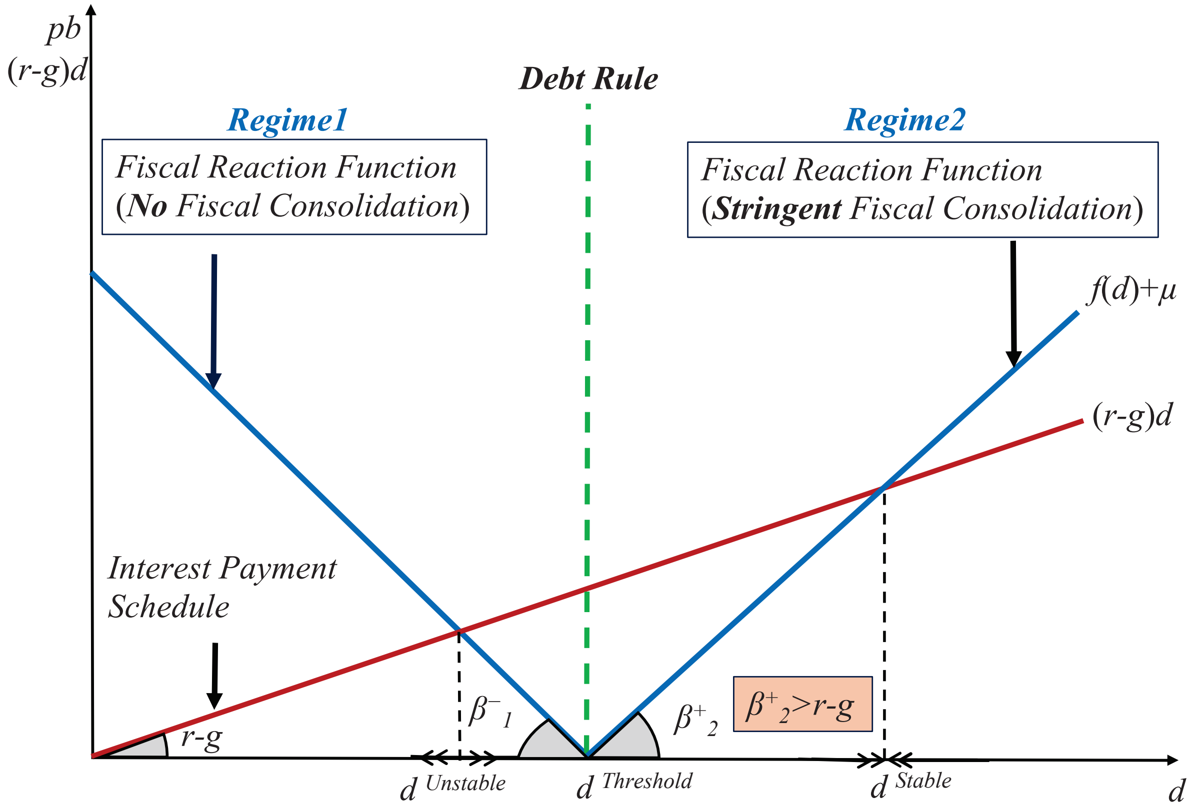
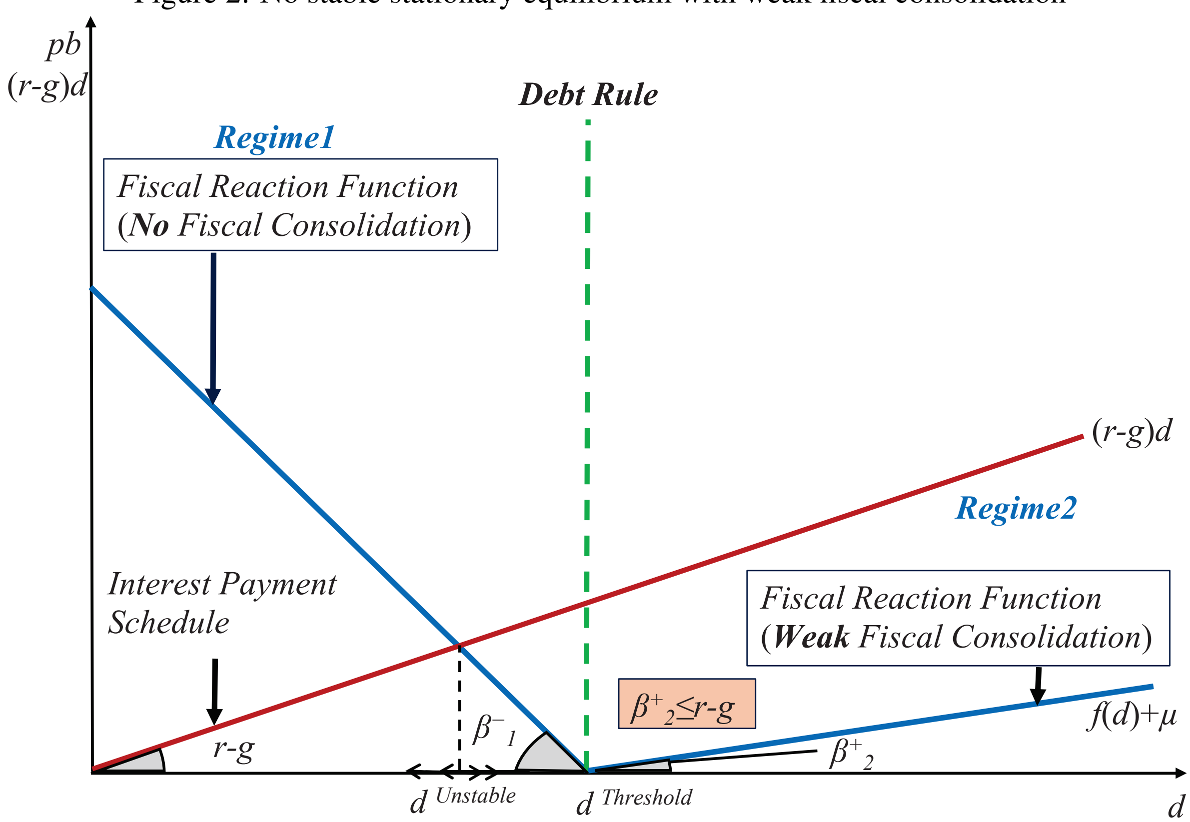


Figure 2: No stable stationary equilibrium with weak fiscal consolidation



Through these two steps, we identify the disparity between *ex ante* and *ex post* behavior of fiscal responses to changes in public debt ,using real-time and revised observations.

4 Data and empirical strategy

4.1 Real-time dataset

We construct a semiannual dataset of revised and real-time observations from the OECD Economic Outlook, which releases projections twice a year. Previous studies such as Beetsma and Giuliodori (2009), Cimadomo (2012), and Aldama and Creel (2022) have primarily constructed annual datasets from the OECD Economic Outlook. A larger sample size is preferable for achieving robust estimation, particularly when employing non-linear regression. Therefore, our dataset offers higher frequency compared to previous studies.

Based on real-time data availability, the dataset includes semiannual data for 13 EU countries from 1996H2 to 2019H2. Data after 2020 are excluded, as EU fiscal rules have been suspended since 2020 due to increased government spending in response to the COVID-19 pandemic. The 13 EU countries included are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, and Sweden.

Following de Castro Fernández et al. (2013), the relationship between real-time and revised observations is defined as follows.

$$Y_{i,t}^{h+8} = Y_{i,t}^{h} + v_{i,t}^{h} \tag{6}$$

Variable for country $i = 1,\ldots, N$ in year $t = 1,\ldots, T$ published on a given date (vintage, h) is denoted as $Y_{i,t}^{h}$. Given the semiannual nature of the OECD Economic Outlook, $Y_{i,t}^{h+8}$ is the revised data after 4 years (i.e., $4\times 2 = 8$). $v_{i,t}^{h}$ is the revision error in the current-vintage estimates.

4.2 Assessing the fiscal sustainability in the neutral state of the economy

Our primary parameter of interest is the response of the primary balance to changes in government debt. Following the literature on fiscal sustainability (Cimadomo (2012), Ghosh et al. (2013), Mauro et al. (2015), and

Mendoza and Ostry (2008)), we begin by assessing fiscal sustainability in the neutral state of the economy, controlling for the business cycle and temporary factors such as rare and extreme spending.[11] This study integrates two approaches from previous studies to exclude the cyclical and temporary factors.

4.2.1 Cyclically-adjusted primary balance and output gap

First, we follow Aldama and Creel (2022) and Cimadomo (2012) which control for two types of fiscal reaction to the cycle: (i) passive (automatic) reaction to the cycle, and (ii) active (discretionary) reaction to the cycle (i.e., the cyclical stance of discretionary fiscal policy) to assess fiscal sustainability given that the neutral state of the economy.

To control for (i) passive reaction, we employ the cyclically-adjusted primary balance estimated by the OECD as an dependent variable ($y_{i,t}$). It identifies which components of government revenue and spending react automatically to the cycle, considering the country specific elasticities.[12] On the revenue side, given the tax rates and definitions of the tax bases, the change in the tax revenue is due to income changes (Galí et al. (2003). On the expenditure side, unemployment compensation changes automatically because of fluctuations in unemployment.[13]

To control for (ii) the active reaction to the cycle, we add the output gap ($OG_{i,t}$) to the explanatory variables. A large body of the literature examines whether the fiscal policy has been counter-or procyclical in OECD and EU countries (Galí et al. (2003), Beetsma and Giuliodori (2009), Aldama and Creel (2022), Cimadomo (2012), and Gootjes and de Haan (2022)). While a countercyclical fiscal policy is contractionary during boom and expansionary during recession to smooth out business cycle fluctuations in output, a procyclical fiscal policy is expansionary during a boom and contractionary during a recession.

It should be noted that the current year's output gap $OG_{i,t}$ could be influenced by fiscal policies imple-

[11] Additionally, we examine whether the intentional fiscal stance of the fiscal consolidation depends on the business cycle or not.

[12] The Stability and Convergence Programs (SGP) adopted in 1997 included a procedure for Excessive Deficit Procedure (EDP) in the case where the 3 percent threshold for government deficit was violated. Under the reformed SGP in 2005, EU member states are requested to report their country-specific "Medium Term Objective (MTO)" which represents that the upper limit of the structural budget deficit, excluding the automatic reaction to the cycle and temporary factors, was set at 1 percent of GDP as a criterion for judging the pace of budget deficit reduction.

[13] However, Bernoth et al. (2015) point out that as government expenditure except for unemployment compensation are assumed to be budgetary elasticity of zero, an automatic stabilizer can operate through expenditure channels other than unemployment compensation. Also, Guajardo et al. (2014) point out that changes in the cyclically-adjusted primary balance often include non-policy changes correlated with other developments that affect output. For instance, a stock market boom improves the cyclically-adjusted primary balance by increasing capital gains and cyclically-adjusted tax revenues.

mented in the same year. Following the approaches of Beetsma and Giuliodori (2009) and Cimadomo (2012), we use instrumental variables to to address the issue of endogeneity (Caner and Hansen (2004)). The instruments for the current year's output gap include the previous year's output gap and the unweighted average of the output gap from the previous year across countries, excluding country i. Additionally, the past year's long-term interest rate, averaged across countries excluding country i, is used as an instrument variable.

4.2.2 Temporary component of the government expenditure

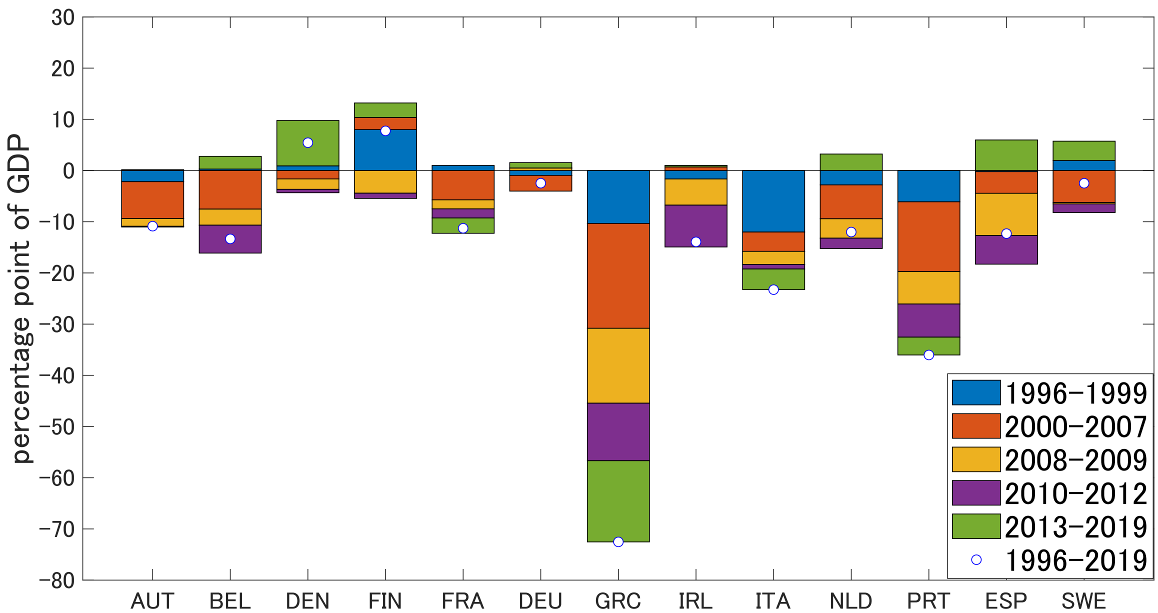
Second, we control for the temporary component of the government expenditure to the GDP ratio by adding the government expenditure gap $GEG_{i,t}$, which captures rare and extreme spending events (e.g., disaster recovery expenses), following the literature on the fiscal reaction function (e.g., Bohn (1998), Ghosh et al. (2013), Mauro et al. (2015), and Mendoza and Ostry (2008)). To decompose total government expenditure, excluding gross interest payments, into trend and temporary components, we apply the trend-cycle decomposition method developed by Hamilton (2018).

4.3 A first look at the data

Figures 3 illustrates the cumulative revision errors in current-year estimates of the cyclically-adjusted primary balance (i.e.,$v_{i,t}$) based on data from the latter half of the year. There is considerable cross-country variation in these revisions, with Greece (GRC) experiencing the most extreme revisions. Greece's total cumulative revision amounts to approximately -73 percentage points of the GDP ratio. Following Greece, the total revisions in Portugal (PRT) and Italy (ITA) are -36 and -23 percentage points of the GDP ratio, respectively. Significant revision errors were present in Greece, Portugal, and Italy even prior to the Global Financial Crisis (i.e., 1996-1999 and 2000-2007). This is consistent with the findings of de Castro Fernández et al. (2013), who document that later data vintages tend to show lower budget balances than earlier data releases on average. In contrast, revision errors in Austria, Denmark, Finland, France, Germany, and Sweden are relatively minor. Overall, the current estimates of the cyclically-adjusted primary balance in peripheral Euro Area countries are more optimistic compared to those in core Euro Area and Nordic countries.

Consequently, such a bias in real-time data may lead to seemingly strong primary fiscal balance response to changes in government debt in real time.

Figure 3: Cumulative revision error on cyclically-adjusted primary balance to GDP ratio



Notes: Data revision is the difference between the revised and real-time data based on the OECD Economic Outlook. AUT:Austria, BEL:Belgium, DEN:Denmark, FIN:Finland, FRA:France, DEU:Germany, GRC: Greece, IRL:Ireland, ITA:Italy, NLD:Netherlands, PRT:Portugal, ESP:Spain, SWE:Sweden.

4.4 Panel Regression Kink Model with Unknown Threshold

We apply a regression kink model with an unknown threshold (RKU) developed by Hansen (2017), whereas Ghosh et al. (2013) employ the panel cubic specification to estimate the response of the primary fiscal balances to changes in government debt. While the RKU investigates the combination of straight-lines, the cubic function is always curved line.

For real-time data, the basic panel regression kink model is as follows:

$$Y_{i,t}^{h} = \alpha_i + \beta_1^{-}(X_{i,t-1}^{h} - \gamma)_{-} + \beta_2^{+}(X_{i,t-1}^{h} - \gamma)_{+} + \phi \mathbf{z_{i,t|t}} + u_{i,t} \tag{7}$$

where $(X_{i,t-1}^{h} - \gamma)_{-}$= $\min\left[X_{i,t-1}^{h} - \gamma, 0\right]$ and $(X_{i,t-1}^{h} - \gamma)_{+}$= $\max\left[X_{i,t-1}^{h} - \gamma, 0\right]$.[14] $Y_{i,t}^{h}$ is the cyclically-adjusted primary balance (percent of GDP) for country $i = 1,\ldots, N$ at a time $t = 1,\ldots, T$ published on a given date (vintage, h), $X_{i,t-1}^{h}$ is lagged public debt (percent of the GDP), and $\mathbf{z_{it}}$ describes control variables including year fixed effects. β_1^{-} and β_2^{+} are expected to be negative and positive, respectively; a phase in which public

[14]For latest revised data, our panel regression kink model is as follows: $Y_{i,t}^{h+8} = \alpha_i + \beta_1^{-}(X_{i,t-1}^{h+8} - \gamma)_{-} + \beta_2^{+}(X_{i,t-1}^{h+8} - \gamma)_{+} + \phi \mathbf{z_{i,t|t}} + u_{i,t}$

debt level is low and fiscal consolidation does not occur, whereas a phase in which debt level is high and fiscal consolidation occurs. Hence, β_1^- is expected to be negative below the unknown kink parameter γ, whereas β_2^+ is expected to be positive above the same kink parameter.

4.5 Estimation

Estimating parameters of the RKU model eliminates the individual effects α_i by removing individual-specific means and then applying non-linear least squares to the transformed model. The transformed dependent variable is $Y_{i,t}^* = Y_{i,t} - \overline{Y_i}$.

The matrix of the transformed explanatory variables is

$$x_{i,t}^*(\gamma) = \left[G_{i,t}^*(\gamma)_- : G_{i,t}^*(\gamma)_+ : \mathbf{z_{i,t}^*}\right]' \tag{8}$$

where $G_{i,t}^*(\gamma)_- = (X_{i,t-1}^h - \gamma)_- - \frac{1}{T}\sum_{t=1}^T (X_{i,t-1}^h - \gamma)_-$, and $G_{i,t}^*(\gamma)_+ = (X_{i,t-1}^h - \gamma)_+ - \frac{1}{T}\sum_{t=1}^T (X_{i,t-1}^h - \gamma)_+$. $\mathbf{z_{i,t}^*} = \mathbf{z_{i,t}^h} - \overline{\mathbf{z_i^h}}$. Given the unknown kink parameter (γ), the parameters $(\beta_1^- : \beta_2^+ : \phi)$ can be estimated by ordinary least squares, which yields:

$$\widehat{\Psi}(\gamma) = \left[\sum_{i=1}^N \sum_{t=1}^T x_{i,t}^*(\gamma) x_{i,t}^*(\gamma)'\right]^{-1} \left[\sum_{i=1}^N \sum_{t=1}^T x_{i,t}^*(\gamma) Y_{i,t}^*\right] \tag{9}$$

where $\widehat{\Psi}(\gamma)$ is conditional to the value (γ). Next, by increasing the number of (γ), the parameter γ is estimated by non-linear least squares as follows:

$$(\hat{\gamma}) = \underset{\{\gamma\}}{ArgMin} \sum_{i=1}^N \sum_{t=1}^T \left[Y_{i,t}^* - \widehat{\Psi}'(\gamma) x^*(\gamma)\right]^2 \tag{10}$$

Consequently , $(\hat{\beta}_1^- : \hat{\beta}_2^+ : \widehat{\phi})' = \widehat{\Psi}(\hat{\gamma})$.

The practical computation involves two steps.

- Step1. The initial value can be obtained by starting a grid search across the parameter γ where grid point is n_γ=30 .
- Step2. We employ the Nelder–Mead simplex algorithm to find a local minimizer of the function non-

linear least squares, using the initial value.[15]

4.6 Other control variables

4.6.1 Government effectiveness ($GEF_{i,t}$)

Following Beetsma et al. (2019) and Beetsma et al. (2023), we obtain a measure of government effectiveness ($GEF_{i,t}$) developed by Kaufmann et al. (2011). Government effectiveness captures perceptions of the quality of public services and civil service and the degree of independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. For example, lack of independence from political pressures causes the budget deficit to worsen through an increase in the government spending or tax reduction.

4.6.2 Lagged fiscal rule index ($FR_{i,t-1}$)

The legal frameworks for fiscal governance in the EU have been strengthened by the so-called "Six-Pack" and "Two-pack".[16] As these reforms could improve the primary balance, we need to control for them comprehensively to avoid omitted variable bias. European Commission (2024) has constructed composite index which reflects five criteria : i) legal base, ii) how binding the rule is, iii) monitoring bodies, iv) correction mechanisms, and v) resilience to shocks.[17] Following Beetsma et al. (2019), we adopt a lagged of the fiscal rule index to avoid a simultaneity bias because the fiscal position affects their fiscal rule.

[15] This algorithm uses a simplex of $n+1$ points for n-dimensional vectors and discards the current worst point to reduce difference between the current best point and other points in simplex at each step in the iteration. See Lagarias et al. (1998) and Miranda and Fackler (2002) for details. Computational codes are based on Fouquau et al. (2008).

[16] On 13th December 2011, Six-pack regulations ensured the expenditure rule. It introduced that Euro area member states whose debt exceeds 60 percent of GDP face an Excessive Deficit Procedure (EDP), if the gap between the corresponding debt level and the 60% reference can not be reduced by 1/20th annually (on average over 3 years) (European Commission (2011)). On 20th February 2013, the Council of the European Union, the European Parliament and the European Commission reached on an agreement on two EU regulations "so called" Two-pack regulations that contribute to strengthening the surveillance mechanisms applicable to all Member States in the Euro Area (European Commission (2013)). One of these regulations requires that countries have independent fiscal institutions (IFIs) in place to monitor compliance with the numerical fiscal rules.

[17] Beetsma et al. (2019) and Beetsma et al. (2023) show that presence of IFIs seems to eliminate optimistic biases in budgetary forecasts and to improve their accuracy by analyzing forecasting errors, using the IMF Fiscal Council dataset (Davoodi et al. (2022)). Moreover, Reuter (2019) show that independent and strong monitoring and the enforcement bodies (with real-time alert mechanism) are significantly associated with a higher probability of compliance with fiscal rules and Chrysanthakopoulos and Tagkalakis (2023) show that individual characteristics of fiscal councils contributed to heighten the probability of starting a fiscal adjustment. De Jong and Gilbert (2020) show that EDP recommendation leads to 0.8-0.9 percent of the GDP of the additional fiscal consolidation plan (i.e., real-time) and 0.6-0.7 percent of actual consolidation (i.e., ex-post).

4.6.3 Lagged Sovereign Default dummy ($Default_{i,t-1}$)

If countries experience sovereign defaults, the fiscal response could become larger for several reasons: (i) debt relief (that is, bondholder haircuts or principal reductions) causes the response to increase automatically, even if the fiscal stance remains unchanged, and ii) The fiscal consolidation can become stringent because of the conditions for the default and the tight monitoring under assistance programs (for example, the European Stability Mechanism). We construct the sovereign default dummy variable from Beers et al. (2023), who develop a comprehensive database of sovereign defaults. Countries that experienced the sovereign defaults in our sample are Greece (2012,2013,2015,2018), Ireland (2013), and Portugal (2013). We control for the lagged event of sovereign defaults.

5 Estimation results

This section presents our findings as followings: (1) headline results; (2) heterogeneity; and (3) robustness checks.

5.1 Headline

Columns (1) and (2), and Columns (3) and (4) of Table 1 present the headline results for the regression kink model with an unknown threshold and the corresponding cases using the instrumental variable approach, respectively. Given that the tests for nonlinearity yield significant p-values, we employ the regression kink model with an unknown threshold and two regime.[18] The estimated unknown kink parameter γ (i.e., the debt level threshold at which fiscal consolidation occurs) is approximately 60 percent, consistent with the EU fiscal rule. We will assess the uncertainty of the kink parameter as part of the robustness check.

The primary parameters of interest are β_1 and β_2.[19] First, as expected, β_1 is negative, indicating no fiscal consolidation occurs when the public debt-to-GDP ratio remains below approximately 60 percent in both the real-time and revised data. Second, in the instrumental variable model (Columns (3) and (4) of Table 1), β_2 shows that the response of the primary fiscal balance to changes in government debt is significantly positive

[18] See Appendix for nonlinearity test.

[19] Following Driscoll and Kraay (1998), standard errors are corrected for serial correlation, heteroskedasticity, and cross-sectional dependence.

in real-time data above this threshold, whereas the corresponding impact in the revised data is insignificant. The marginal impact of public debt on the primary balance in real-time data is approximately 0.03, which is almost three times the effect observed in the revised data. This suggests that bias in the real-time data led to an overstated response of the primary fiscal balance to changes in government debt.

Table 2 compares our estimates with those from other studies that have estimated the marginal impact of public debt on the primary balance using panel data. Our estimated response of the primary fiscal balance to changes in government debt, when the debt-to-GDP ratio exceeds a threshold close to 60 percent in real-time data, is slightly larger than the estimates reported in the existing literature (Cimadomo (2012) and Aldama and Creel (2022)). The reasons for this difference may be as follows: because we employ a novel non-linear model for the EU, whereas these previous studies have focused on OECD. We distinguish a phase where no fiscal consolidation occurs as long as the public debt-to-GDP ratio remains below approximately 60 percent. For the revised data, when debt-to-GDP ratio exceeds the 60 percent, our estimated impact is insignificant, consistent with the findings of Mendoza and Ostry (2008). Consequently, this study bridges the gap between the results based on real-time and revised data. That is, the response of the primary fiscal balance to changes in government debt with real-time data is significantly positive, once the public debt-to-GDP ratio exceeds approximately 60 percent, whereas the corresponding response with revised data is insignificant.

Other control variables also have the significant impacts on the cyclically-adjusted primary balance. First, the output gap is significantly negative in both the revised data and the real-time data. In particular, fiscal policy in the revised data is more procyclical than in real time. Overall, the EU employs a procyclical fiscal policy that is expansionary during boom and contractionary during recession. This result is in line with that of Gootjes and de Haan (2022). Second, the government expenditure gap is significantly negative in both the revised data and the real time. It can control for temporary components such as rare and extreme spending. Third, the government effectiveness is significantly positive, thus contributing to the maintenance of fiscal discipline. Fourth, because the fiscal rule index is significantly positive, the intentional fiscal consolidation may have been contributed by the strengthened fiscal governance in the EU. Fifth, sovereign default dummy variable is positively significant. The experience on the sovereign default could contribute to improving the cyclically-adjusted primary balance due to the condition for the default or the tight monitoring through assistance programs.

Table 1: Headline result

Data type	Revised	Real time	Revised	Real time
Estimation method	RKU (1)	RKU (2)	RKU with IV (3)	RKU with IV (4)
LM_F nonlinearity test	0.00***	0.00***	0.00***	0.00***
Estimated kink point γ	62.9	61.7	61.6	61.6
$(X_{i,t-1}-\gamma)_-$	-0.094***	-0.064***	-0.100***	-0.070***
	(0.02)	(0.02)	(0.02)	(0.02)
$(X_{i,t-1}-\gamma)_+$	0.016**	0.033***	0.011	0.031***
	(0.01)	(0.01)	(0.01)	(0.01)
$OG_{i,t}$	-0.341***	-0.098*	-0.379***	-0.133***
	(0.06)	(0.06)	(0.08)	(0.05)
$GEG_{i,t}$	-0.719***	-0.401***	-0.726***	-0.407***
	(0.11)	(0.12)	(0.10)	(0.13)
$GEF_{i,t}$	1.618**	1.778***	1.698**	1.857***
	(0.81)	(0.58)	(0.86)	(0.58)
$FR_{i,t-1}$	0.524***	0.390**	0.544***	0.405***
	(0.17)	(0.18)	(0.16)	(0.18)
$Default_{i,t-1}$	1.476**	1.627***	1.488***	1.499***
	(0.65)	(0.44)	(0.68)	(0.41)
Country Fixed Effect	YES	YES	YES	YES
Time Fixed Effect	YES	YES	YES	YES
Adj R^2	0.699	0.596	0.683	0.599
DW	0.597	0.779	0.664	0.792
No. of observation	611	611	611	611
No. of countries	13	13	13	13
Sample periods	1996H2-2019H2	1996H2-2019H2	1996H2-2019H2	1996H2-2019H2

Notes: RKU=Regression Kink model with an Unknown threshold. IV=Instrumental Variables. $X_{i,t-1}$ is the lagged public debt to GDP ratio, $OG_{i,t}$ is the output gap, $GEG_{i,t}$ is the government expenditure gap, $GEF_{i,t}$ is the government effectiveness, $FR_{i,t-1}$ is the lagged fiscal rule index and $Default_{i,t-1}$ is the lagged sovereign default dummy. The standard errors proposed by Driscoll and Kraay (1998) are reported in parentheses. ***p<0.01, *p<0.05, *p<0.1

Table 2: Comparison with other studies: Marginal impact of public debt on primary balance

	Percentage point	Levels of public debt to GDP ratio	Countries/Group	Data
This study	-0.06 to -0.03	<60 percent	13 EU	Real-time
	-0.10 to -0.07	<60 percent	13 EU	Revised
	0.03	>60 percent	13 EU	Real-time
	insignificant	>60 percent	13 EU	Revised
	0.00 to 0.03	>60 percent	Individual	Real-time
	0.00 to 0.04	>60 percent	Individual	Revised
Cimadomo (2012)	0.02		19 OECD	Real-time
Aldama and Creel (2022)	0.01 to 0.02		19 OECD	Real-time
Mendoza and Ostry (2008)	0.02	<60 percent	22 AEs	Revised
	insignificant	>60 percent	22 AEs	Revised
Mauro et al. (2015)	0.02		22 AEs	Revised
	0.00 to 0.05		Individual	Revised

5.2 Heterogeneity

5.2.1 Region

Section4 has demonstrated substantial cross-country variation in the revisions. Given that the current estimates of the cyclically-adjusted primary balance in the peripheral countries of the Euro Area are consistently more optimistic than those in the core Euro Area and Nordic countries, there is likely a heterogeneous β_2(i.e., the primary balance response to changes in government debt in moderate-to-high-debt countries, where debt exceeds the estimated threshold).

For the real-time data, our heterogeneous panel regression kink model is as follows:

$$Y_{i,t}^{h} = \alpha_i + \beta_1^{-}(X_{i,t-1}^{h} - \gamma)_{-} + \sum_{k=1}^{2} \beta_{2i} D_k (X_{i,t-1}^{h} - \gamma)_{+} + \phi \mathbf{z_{i,t}^{h}} + u_{i,t} \tag{11}$$

where D_k is a dummy variable for group k. We divide 13 EU countries into three groups: (i) core countries in the Euro Area (Austria, Belgium, France, Germany, and the Netherlands), (ii) Nordic countries (Denmark, Finland, and Sweden), and (iii) peripheral countries in the Euro Area (Greece, Ireland, Italy, Portugal, and Spain). The third group was at the center of the European debt crisis. For the second group (ii), the limited number of observations for the public debt-to-GDP ratio in Nordic countries, which belong to the second regime (i.e., above a level close to 60 percent), makes robust estimation challenging. Therefore, we combine groups (i) and (ii) into a single group but also conduct estimations using all three groups as part of a robustness check.

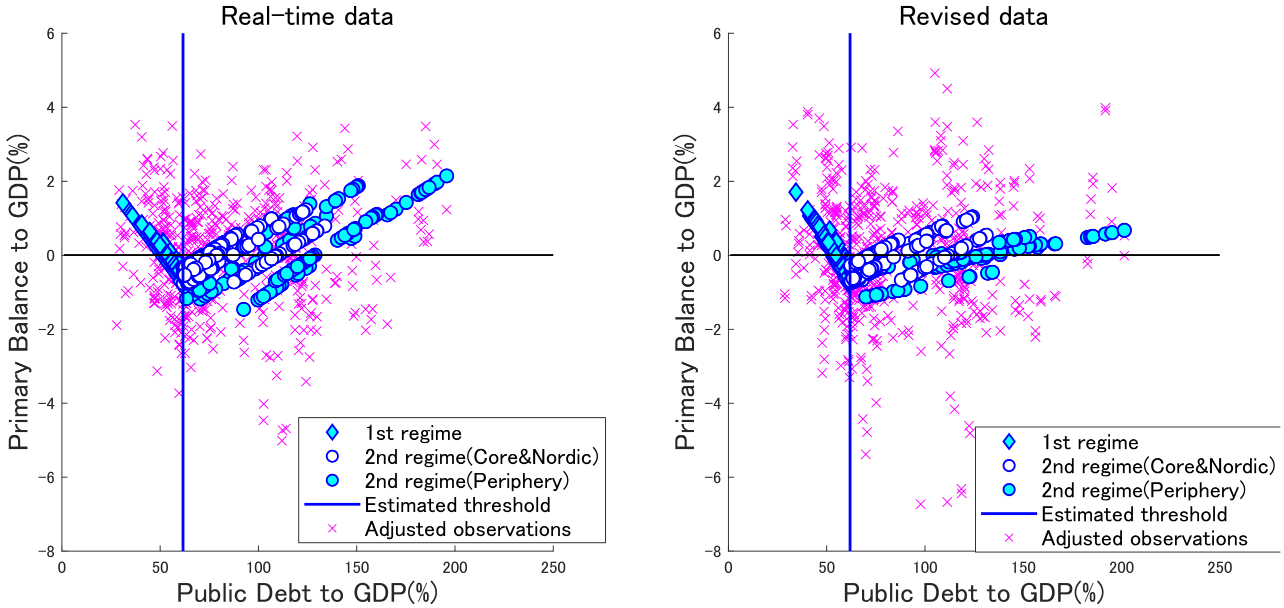
Table 3 shows heterogeneous fiscal responses by estimating $\hat{\beta}_{2i}$. A notable feature is the result for the peripheral countries of the Euro Area. In this group, the response is significantly positive in the real-time data but insignificant in the revised data, suggesting that bias in real-time data may lead to an overestimation of the primary fiscal balance's response to changes in government debt. Figure 4 illustrates the estimated fiscal responses and adjusted observations after controlling for country and year fixed effects, along with other control variables. The slopes for the peripheral countries of the Euro Area differ between the real-time and revised data. In contrast, the reaction of the real-time data for core Euro Area and Nordic countries is similar to that of the revised data (Figure 5). Columns (3) and (4) of Table 3 show that the results for core Euro Area countries remain unchanged even when excluding the Nordic countries.

5.2.2 Business cycle

We have begun assessing fiscal sustainability under the assumption of a neutral economic state, controlling for two types of fiscal reaction to the cycle: (i) passive (automatic) reaction to the cycle, and (ii) active (discretionary) reaction to the cycle (that is, the cyclical stance of discretionary fiscal policy). However, the response of the primary balance to changes in government debt may also be influenced by the business cycle. Therefore, we introduce an interaction term between the output gap and lagged moderate-to-high-debt countries, where debt exceeds the estimated threshold. To ensure robustness, we examine the interaction between the dummy variables D_{+gap} and D_{-gap}, representing the output gap and the lagged moderate-to-high-debt countries where D_{+gap} is equal to 1 when the output gap is positive and 0 otherwise and D_{-gap} is equal to 1 when the output gap is negative and 0 otherwise.

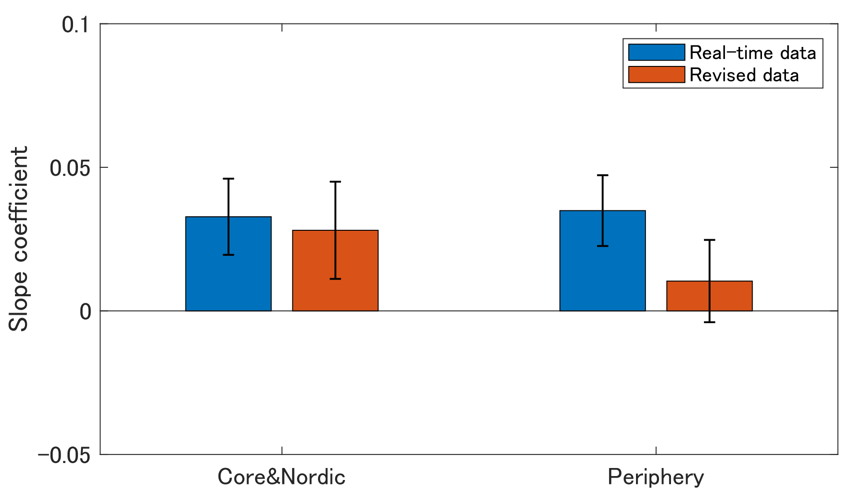
Columns (1) and (2) of Table 4 indicate that fiscal consolidation in peripheral countries of the Euro Area has been procyclical in the presence of moderate-to-high debt. The interaction term between the output gap and lagged moderate-to-high-debt countries in the peripheral countries of the Euro Area is significantly negative in both real-time and revised data. In contrast, the same interaction term for core Euro Area countries and Nordic countries is insignificant in the revised data and only slightly significant in real-time data. Figure 6 demonstrates that the fiscal response in the core countries of the Euro Area and Nordic countries is not sensitive

Figure 4: Fiscal responses and adjusted observations (EA core & Nordic countries vs. EA periphery countries)



Notes: Adjusted observations obtained after controlling for country and year fixed effects, and other control variables. Based on Columns (1) and (2) of Table3.

Figure 5: Heterogeneous fiscal responses (EA core & Nordic countries vs. EA periphery countries)



Notes: Solid bars represent the estimated parameters and the error bars denote the 90 percent confidence intervals. Based on columns (1) and (2) of Table3.

Table 3: Baseline (EA core & Nordic countries vs. EA periphery countries)

Data type	Revised	Real time	Revised	Real time
Estimation method	RKU with IV (1)	RKU with IV (2)	RKU with IV (3)	RKU with IV (4)
LM_F nonlinearity test	0.00***	0.00***	0.00***	0.00***
Estimated kink point	61.9	61.6	61.3	61.0
$(X_{i,t-1}-\gamma)_-$	-0.092***	-0.071***	-0.095***	-0.072***
	(0.02)	(0.02)	(0.03)	(0.02)
$D_{core+nordic}(X_{i,t-1}-\gamma)_+$	0.028***	0.033***		
	(0.01)	(0.01)		
$D_{core}(X_{i,t-1}-\gamma)_+$			0.028***	0.034***
			(0.01)	(0.01)
$D_{Nordic}(X_{i,t-1}-\gamma)_+$			-0.007	0.014
			(0.05)	(0.03)
$D_{periphery}(X_{i,t-1}-\gamma)_+$	0.010	0.035***	0.003	0.031***
	(0.01)	(0.01)	(0.01)	(0.01)
$D_{core+nordic}OG_{i,t}$	-0.551***	-0.365***		
	(0.17)	(0.07)		
$D_{core}OG_{i,t}$			-0.322*	0.440***
			(0.18)	(0.09)
$D_{Nordic}OG_{i,t}$			-0.754***	-0.696***
			(0.20)	(0.13)
$D_{periphery}OG_{i,t}$	-0.362***	-0.073	-0.433***	-0.081
	(0.07)	(0.07)	(0.08)	(0.07)
$GEG_{i,t}$	-0.740***	-0.429***	-0.337	-1.023***
	(0.10)	(0.12)	(0.42)	(0.24)
$GEF_{i,t}$	1.807**	1.497***	1.788**	0.681
	(0.84)	(0.53)	(0.87)	(0.55)
$FR_{i,t-1}$	0.583***	0.402**	0.589***	0.271
	(0.19)	(0.17)	(0.20)	(0.20)
$Default_{i,t-1}$	1.919***	1.793***	1.865***	1.761***
	(0.73)	(0.43)	(0.69)	(0.46)
Country Fixed Effect	YES	YES	YES	YES
Time Fixed Effect	YES	YES	YES	YES
Adj R^2	0.684	0.616	0.685	0.599
DW	0.664	0.808	0.685	0.794
No. of observation	611	611	611	611
No. of countries	13	13	13	13
Sample periods	1996H2-2019H2	1996H2-2019H2	1996H2-2019H2	1996H2-2019H2

Notes: RKU=Regression Kink model with an Unknown threshold. IV=Instrumental Variables. $X_{i,t-1}$ is the lagged public debt to GDP ratio, $OG_{i,t}$ is the output gap, $GEG_{i,t}$ is the government expenditure gap, $GEF_{i,t}$ is the government effectiveness, $FR_{i,t-1}$ is the lagged fiscal rule index and $Default_{i,t-1}$ is the lagged sovereign default dummy. (i) core countries in the Euro Area (Austria, Belgium, France, Germany, and the Netherlands), (ii) Nordic countries (Denmark, Finland, and Sweden), and (iii) peripheral countries in the Euro Area (Greece, Ireland, Italy, Portugal, and Spain). The standard errors proposed by Driscoll and Kraay (1998) are reported in parentheses. ***p<0.01, *p<0.05, *p<0.1

to the business cycle, but becomes significant when the economy is in a neutral state (i.e., when the output gap is approximately zero). As the output gap increases or decreases, the estimated confidence bands widen. In contrast, the fiscal response in the peripheral countries of the Euro Area is highly sensitive to the business cycle, with fiscal consolidations being procyclical in the presence of moderate-to-high debt. Similarly, columns (3) and (4) of Table 4 show that the interaction terms between the dummy variables D_{+gap} and D_{-gap}, representing the output gap and the lagged moderate-to-high-debt in core countries in the Euro Area and Nordic countries are significantly positive. In contrast, the fiscal response in periphery countries of the Euro Area is significantly positive only when the output gap is negative, whereas it is insignificant when the output gap is positive (Figure 7). In other words, they maintained fiscal sustainability during downtown but did not do this during upturns. These findings are consistent with those of Ahmad et al. (2021) and Larch et al. (2021), who found that the degree of procyclicality increases when fiscal space is insufficient (e.g., when debt exceeds a certain exogenous threshold) .

Figure 8 illustrates the country-specific responses, which are calculated using the average country-specific output gap. A notable finding is the result for Greece: the response in Greece is the largest when using real-time data, whereas it becomes insignificant when using the revised data.

5.3 Robustness check

We conduct a wide range of exercises to verify the robustness of our baseline findings, specifically by (1) controlling for asymmetric procyclicality and (2) addressing uncertainties in the kink parameter.

5.3.1 Control for the asymmetric procyclicality

In the baseline, we assume that the cyclical response of fiscal policy is symmetrical throughout the business cycle. Following Gootjes and de Haan (2022), we account for asymmetric procyclicality by interacting the output gap variable with dummy variables, $D_{+gap}OG_{i,t}$ and $D_{-gap}OG_{i,t}$where D_{+gap} is equal to 1 when the output gap is positive and 0 otherwise, and D_{-gap} is equal to 1 when the output gap is negative and 0 otherwise.

This robustness check aligns with the baseline results.[20] In peripheral Euro Area countries, the response in real-time data is significantly positive, whereas it is insignificant in the revised data. Furthermore, the reactions

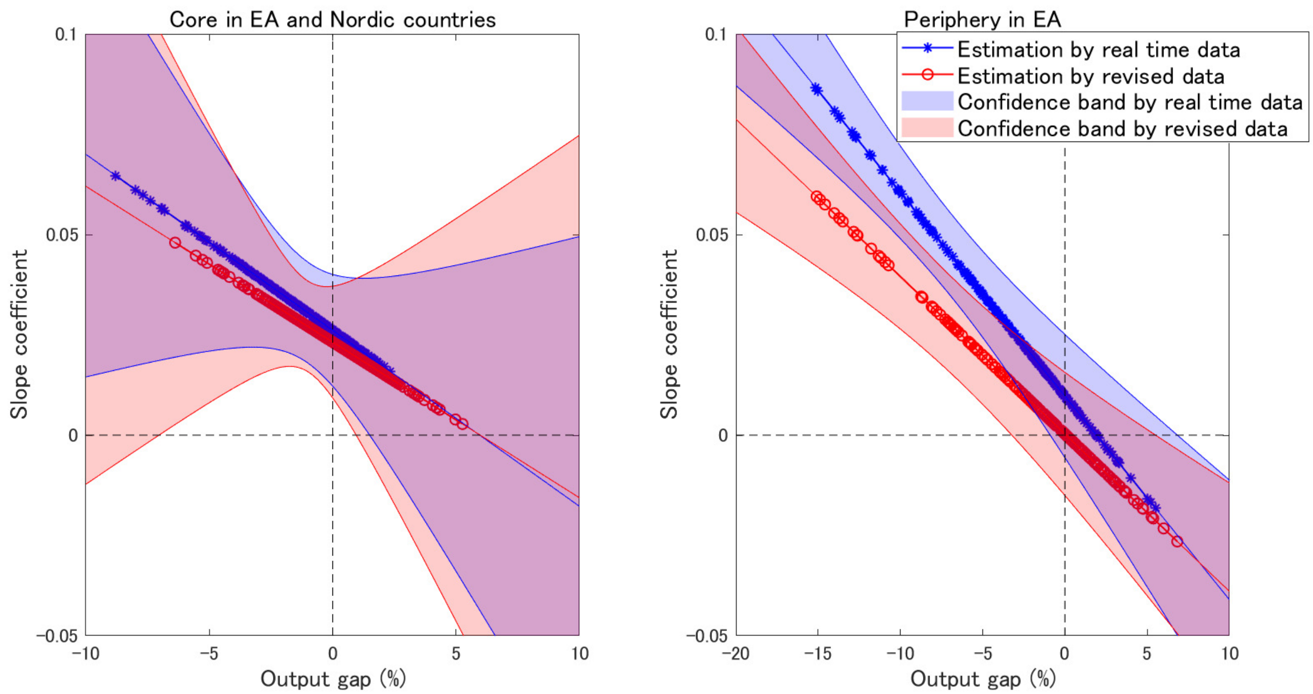
[20]See Appendix for details.

Table 4: Baseline (Business cycle)

Data type	Revised	Real time	Revised	Real time
Estimation method	RKU with IV (1)	RKU with IV (2)	RKU with IV (3)	RKU with IV (4)
LM_F nonlinearity test	0.00***	0.00***	0.00***	0.00***
Estimated kink point γ	61.3	61.0	61.9	61.7
$(X_{i,t-1}-\gamma)_-$	-0.067***	-0.036***	-0.074***	-0.054***
	(0.02)	(0.01)	(0.02)	(0.02)
$D_{core+nordic}(X_{i,t-1}-\gamma)_+$	0.023**	0.026***		
	(0.01)	(0.01)		
$D_{core+nordic}OG_{i,t}(X_{i,t-1}-\gamma)_+$	-0.004	-0.004*		
	(0.00)	(0.00)		
$D_{periphery}(X_{i,t-1}-\gamma)_+$	0.000	0.010		
	(0.01)	(0.01)		
$D_{periphery}OG_{i,t}(X_{i,t-1}-\gamma)_+$	-0.004***	-0.005***		
	(0.00)	(0.00)		
$D_{core+nordic}D_{-gap}(X_{i,t-1}-\gamma)_+$			0.030***	0.033***
			(0.01)	(0.01)
$D_{core+nordic}D_{+gap}(X_{i,t-1}-\gamma)_+$			0.025**	0.036**
			(0.01)	(0.02)
$D_{periphery}D_{-gap}(X_{i,t-1}-\gamma)_+$			0.027***	0.037***
			(0.01)	(0.01)
$D_{periphery}D_{+gap}(X_{i,t-1}-\gamma)_+$			-0.007	-0.005
			(0.01)	(0.02)
$D_{core+nordic}OG_{i,t}$	-0.416***	-0.239***	-0.514***	-0.332***
	(0.16)	(0.07)	(0.16)	(0.07)
$D_{periphery}OG_{i,t}$	-0.111	0.190***	-0.193***	0.010
	(0.07)	(0.08)	(0.07)	(0.06)
$GEG_{i,t}$	-0.453	-0.951***	-0.191	-0.811***
	(0.35)	(0.23)	(0.33)	(0.23)
$GEF_{i,t}$	1.965**	1.860***	1.608**	1.433***
	(0.82)	(0.52)	(0.81)	(0.51)
$FR_{i,t-1}$	0.705***	0.660***	0.631***	0.372**
	(0.18)	(0.17)	(0.20)	(0.17)
$Default_{i,t-1}$	1.040	0.612	2.226***	1.684***
	(0.74)	(0.44)	(0.82)	(0.40)
Country Fixed Effect	YES	YES	YES	YES
Time Fixed Effect	YES	YES	YES	YES
Adj R^2	0.697	0.652	0.699	0.627
DW	0.700	0.921	0.660	0.843
No. of observation	611	611	611	611
No. of countries	13	13	13	13
Sample periods	1996H2-2019H2	1996H2-2019H2	1996H2-2019H2	1996H2-2019H2

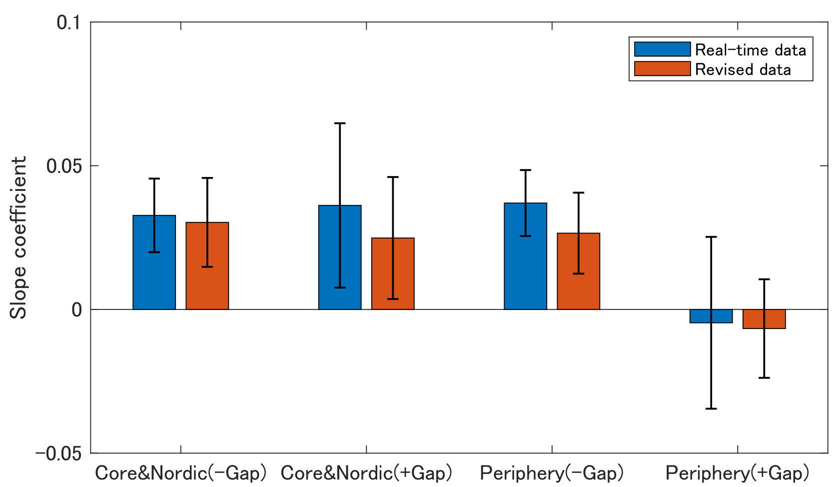
Notes: RKU=Regression Kink model with an Unknown threshold. IV=Instrumental Variables. $X_{i,t-1}$ is the lagged public debt to GDP ratio, $OG_{i,t}$ is the output gap, $GEG_{i,t}$ is the government expenditure gap, $GEF_{i,t}$ is the government effectiveness, $FR_{i,t-1}$ is the lagged fiscal rule index and $Default_{i,t-1}$ is the lagged sovereign default dummy. The standard errors proposed by Driscoll and Kraay (1998) are reported in parentheses. ***p<0.01, *p<0.05, *p<0.1

Figure 6: Fiscal responses and Business cycle



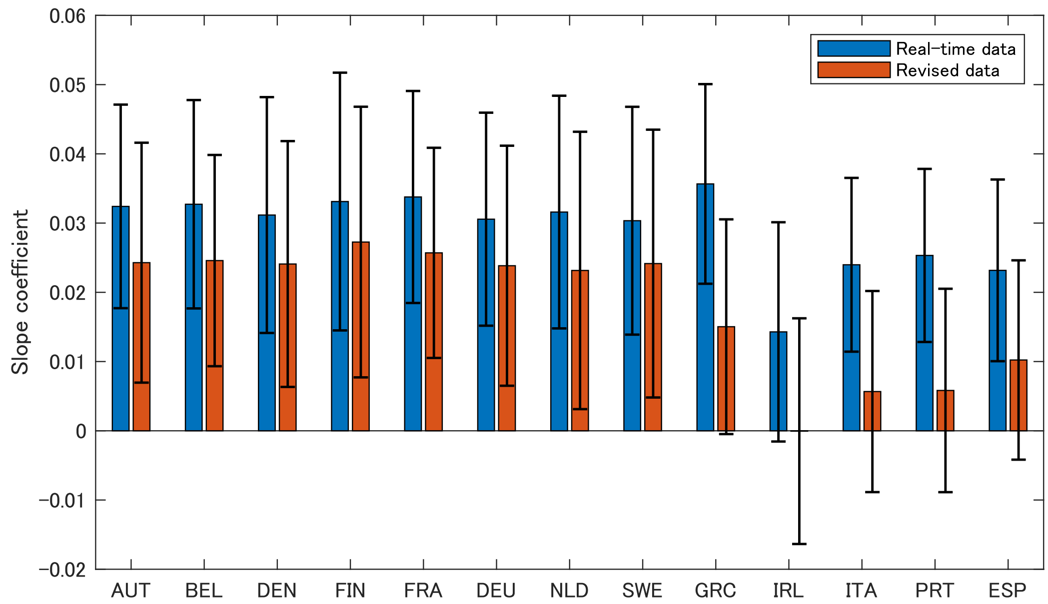
Notes: Shadow area refers to 90 percent confidence interval. Based on columns (1) and (1) of Table4.

Figure 7: Fiscal responses and Business cycle dummy



Notes: Solid bars represent the estimated parameters and the error bars denote the 90 percent confidence intervals. Based on columns (3) and (4) of Table4.

Figure 8: Country specific fiscal responses



Notes: Solid bars represent the estimated parameters and the error bars denote the 90 percent confidence intervals. Country specific responses are calculated by using the average of the country-specific output gap and the estimated parameters and standard errors from columns (1) and (2) of Table4. AUT:Austria, BEL:Belgium, DEN:Denmark, FIN:Finland, FRA:France, DEU:Germany, NLD:Netherlands, SWE:Sweden, GRC: Greece, IRL:Ireland, ITA:Italy, PRT:Portugal, ESP:Spain.

in real-time data for core Euro Area countries and Nordic countries are similar to those observed in the revised data.

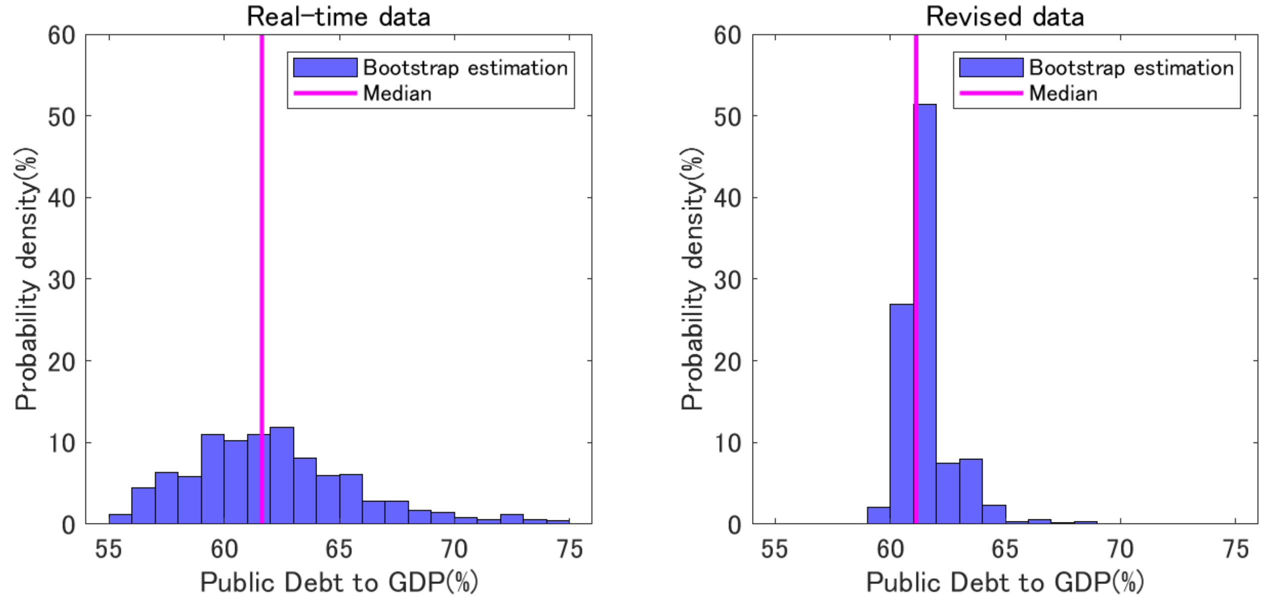
5.3.2 Uncertainty in the kink parameter

Based on various model specifications, we have demonstrated that the estimated unknown kink parameter (i.e., the threshold debt level at which fiscal consolidation occurs), denoted γ is approximately 60 percent. This finding aligns with the EU fiscal rule. To assess robustness, we examine the uncertainty surrounding the kink parameter by employing a standard residual bootstrap with random sampling in the cross-sectional dimension, accounting for heteroscedasticity across countries.[21]

Figure 9 illustrates that the distribution of the kink parameter is wider for real-time data compared to revised data, although the medians are similar between the two. In real-time data, debt threshold estimates below 60 percent are frequently observed, whereas in the revised data, the majority of estimated threshold debt levels exceed 60 percent. In light of the EU fiscal debt rule, we conclude that the planned fiscal consolidation is more

[21] See Appendix for details.

Figure 9: Uncertainty in the kink parameter (threshold of debt level)



Notes: Computed by 1,000 bootstrap replications. Based on columns (1) and (2) of Table3.

optimistic than the actual fiscal consolidation.

6 Empirical test for the stable stationary equilibrium

Finally, we combine the theoretical framework presented in **Section**3 and the empirical framework in **Section**4 and **Section**5 to test the stricter criterion for the fiscal sustainability (that is, if a response of the primary fiscal balance to changes in government debt exceeds the growth-adjusted interest rate, public debt is expected to converge to a finite proportion of the GDP).[22] While a weak criterion does not require any assumptions about interest rates in **Section**4 and **Section**5, a stricter criterion is required to use a growth-adjusted interest rate. First, to assess fiscal sustainability given that the neutral state of the economy, we use the estimated result from columns (1) and (2) of Table 3 and the potential growth rate which captures the long-term growth rate. Second, as a robustness check, we employ the country specific responses calculated using the average of the country-specific output gap and estimated parameters in columns (1) and (2) of Table 4.

[22] Bohn (1999) argue that if the interest rate is below the average growth rate, that leads to a violation of "no ponzi condition" which is consistent with (i) a weak criterion, as previously discussed. Namely, the government may roll over its debt with interest that is, persistent primary budget deficits may be unproblematic (that is, ponzi condition). However, if the low interest rates are due to high risk aversion, policies that exploit the low cost of government debt to run frequently budget deficits impose significant risks on future taxpayers. Sakuragawa and Sakuragawa (2020) examine (ii) a stricter criterion (i.e., a stable stationary equilibrium) when the interest rate is below the average growth rate.

By applying the traditional approach developed by Welch (1938), we test the null hypothesis ($H_0 : \beta_{2i} \leqq r_i - g_i$) and the alternative hypothesis ($H_1 : \beta_{2i} > r_i - g_i$) by comparing the means of these two distributions. The interest rate-growth rate differential $r_i - g_i$ is the difference between the real implied interest rate r_i and the potential growth rate g_i.[23] The average and variance for the interest rate-growth rate differential $r_i - g_i$ in real time are calculated using each year of the OECD Economic Outlook from 1996 to 2019.

Table 5 and Table 6 present the test results for the difference between the fiscal reaction and interest rate-growth rate differential for the neutral state of the economy and the case of the country specific responses, respectively. In both cases, asymmetrical results are observed between the real-time and revised data for Greece and Portugal. The results based on real-time data satisfy the condition for a stable stationary equilibrium, whereas the revised data do not. Therefore, the findings for the revised data are consistent with Figure 2 in **Section**3. This discrepancy arises primarily because fiscal reaction β_{2i} in the revised data becomes smaller than that in the real time data, while the revision of the interest rate-growth differential $r_i - g_i$ from the real-time data is relatively minor.[24] In most countries, excluding Greece, Italy, and Portugal, the null hypothesis ($H_0 : \beta_{2i} \leqq r_i - g_i$) can be rejected for both real-time and revised data, with no evidence of asymmetrical results.

7 Conclusion

This study examines whether unanticipated fiscal shocks have influenced the fiscal sustainability criteria within the EU. To expose such "hidden fiscal unsustainability" in real time, we apply the regression kink model with an unknown threshold (RKU) developed by Hansen (2017) into a panel model with heterogeneity. This novel methodology offers several advantages. One advantage is its ability to examine how the fiscal response varies within the EU. Another advantage is that it enables the endogenous estimation of the threshold debt level at which fiscal consolidation occurs. The main findings are twofold. First, the results suggest that planned consolidations in the peripheral Euro Area countries are consistently more optimistic than the actual outcomes. Primary balance responses to changes in government debt, based on real-time data for these countries, are stronger than those based on revised data, indicating the presence of hidden fiscal unsustainability in real time. Furthermore, when accounting for uncertainty, debt thresholds below 60 percent are frequently observed in

[23] Real implied interest rate is the difference between the ratio of gross interest payments to the lagged public debt and the growth rate of the GDP deflator.

[24] Appendix shows the distributions of the fiscal reaction and the interest rate-growth rate differential.

Table 5: Test for the stable stationary equilibrium: the neutral state of the economy

	Revised	data					Real	time				
Country	$\hat{\beta}_{2i}$ ×100		$\overline{r_i - g_i}$		p-value		$\hat{\beta}_{2i}$ ×100		$\overline{r_i - g_i}$		p-value	
Austria	2.8	(1.0)	0.6	(1.4)	0.00	***	3.3	(0.8)	0.8	(1.6)	0.00	***
Belgium	2.8	(1.0)	0.7	(1.3)	0.00	***	3.3	(0.8)	0.8	(1.3)	0.00	***
Denmark	2.8	(1.0)	1.3	(2.0)	0.02	**	3.3	(0.8)	1.9	(1.8)	0.01	***
Finland	2.8	(1.0)	-0.1	(1.4)	0.00	***	3.3	(0.8)	0.6	(2.4)	0.01	***
France	2.8	(1.0)	0.6	(1.2)	0.00	***	3.3	(0.8)	0.7	(1.3)	0.00	***
Germany	2.8	(1.0)	1.2	(2.1)	0.01	***	3.3	(0.8)	1.1	(1.8)	0.00	***
Greece	1.0	(0.8)	1.4	(3.0)	0.65		3.5	(0.7)	1.5	(2.2)	0.00	***
Ireland	1.0	(0.8)	-4.2	(5.7)	0.00	***	3.5	(0.7)	-1.3	(4.1)	0.00	***
Italy	1.0	(0.8)	1.8	(0.9)	0.98		3.5	(0.7)	2.0	(0.9)	0.00	***
Netherlands	2.8	(1.0)	0.1	(1.8)	0.00	***	3.3	(0.8)	0.7	(1.6)	0.00	***
Portugal	1.0	(0.8)	0.7	(1.7)	0.25		3.5	(0.7)	1.4	(1.3)	0.00	***
Spain	1.0	(0.8)	-0.2	(2.5)	0.06	*	3.5	(0.7)	0.2	(1.8)	0.00	***
Sweden	2.8	(1.0)	-0.5	(2.6)	0.00	***	3.3	(0.8)	-0.1	(2.7)	0.00	***

Table 6: Test for the stable stationary equilibrium: country specific responses

	Revised	data					Real	time				
Country	$\hat{\beta}_{2i}$ ×100		$\overline{r_i - g_i}$		p-value		$\hat{\beta}_{2i}$ ×100		$\overline{r_i - g_i}$		p-value	
Austria	2.4	(1.7)	0.6	(1.4)	0.00	***	3.2	(1.5)	0.8	(1.6)	0.00	***
Belgium	2.5	(1.5)	0.7	(1.3)	0.00	***	3.3	(1.5)	0.8	(1.3)	0.00	***
Denmark	2.4	(1.8)	1.3	(2.0)	0.08	*	3.1	(1.7)	1.9	(1.8)	0.05	**
Finland	2.7	(2.0)	-0.1	(1.4)	0.00	***	3.3	(1.9)	0.6	(2.4)	0.01	***
France	2.6	(1.5)	0.6	(1.2)	0.00	***	3.4	(1.5)	0.7	(1.3)	0.00	***
Germany	2.4	(1.7)	1.2	(2.1)	0.06	*	3.1	(1.5)	1.1	(1.8)	0.00	***
Greece	1.5	(1.6)	1.4	(3.0)	0.45		3.6	(1.4)	1.5	(2.2)	0.00	***
Ireland	0.0	(1.6)	-4.2	(5.7)	0.01	***	1.4	(1.6)	-1.3	(4.1)	0.02	**
Italy	0.6	(1.5)	1.8	(0.9)	0.99		2.4	(1.3)	2.0	(0.9)	0.17	
Netherlands	2.3	(2.0)	0.1	(1.8)	0.00	***	3.2	(1.7)	0.7	(1.6)	0.00	***
Portugal	0.6	(1.5)	0.7	(1.7)	0.56		2.5	(1.3)	1.4	(1.3)	0.01	***
Spain	1.0	(1.4)	-0.2	(2.5)	0.08	*	2.3	(1.3)	0.2	(1.8)	0.00	***
Sweden	2.4	(1.9)	-0.5	(2.6)	0.00	***	3.0	(1.6)	-0.1	(2.7)	0.00	***

Notes: Coefficients for fiscal reaction in Table5 and Table6 are based on columns (1) and (2) of Table3 and columns (1) and (2) of Table4, respectively. Country specific responses in Table6 are calculated by using the average of the country-spefici output gap. The interest rate-growth rate differential is the difference between the real implied interest rate and the potential growth rate. The standard errors are reported in parentheses. ***p<0.01, **p<0.05,, *p<0.10.

real-time data, whereas most estimated thresholds exceed 60 percent in revised data. Second, the peripheral Euro Area countries endeavored to maintain fiscal sustainability during downturns but failed to do so during periods of economic upturn.

Future research could explore the interaction between economic fundamentals and self-fulfilling market sentiments. While this paper provides evidence that updated information about economic fundamentals raises concerns about government solvency, it does not fully examine how these unanticipated changes contribute to shifts in government bond yields. That may be a key factor in driving changes in self-fulfilling market sentiments. Gros and Ji (2013) decompose the surge in the government bond yield in peripheral Eurozone countries during 2010-11 into fundamentals and self-fulfilling market sentiments. However, these two factors interact through the change in the fundamentals. Updated information about the economic fundamentals influencing self-fulfilling market sentiments leads to a surge in government bond yields, subsequently increasing public debt. Consequently, an unanticipated shift in fundamentals may eventually fundamentals themselves. Although this study employs a static model, the future research could utilize a dynamic model to investigate the feedback loop from unanticipated changes in fundamentals to their eventual deterioration through market sentiments.

Appendix

A.1 Linearity test

Testing the null hypothesis $H_0 : \beta_1 = \beta_2$ can inform us on the linearity in the regression kink model with unknown threshold (RKU). However, this test is not standard since, under H_0, the RKU model contains unidentified nuisance parameters (Hansen (1996)).

To test the null hypothesis is $H_0 : \beta_1 = \beta_2$ the approximate likelihood ratio of H_0 is based on

$$LM_F = TN(SSR_0 - SSR_1)/SSR_0 \tag{12}$$

where SSR_0 is the sum of squared residuals of the linear model $Y_{i,t} = \beta_0 X_{i,t-1} + \phi \mathbf{z_{i,t}} + u_{i,t}$ and SSR_1 is that of the RKU model with two regimes.

If a p-value associated with LM_F leads us to reject the null hypothesis, we then examine whether three regimes exist.

$$LM_F = TN(SSR_1 - SSR_2)/SSR_1 \tag{13}$$

where SSR_2 is the sum of squared residuals of the linear model $Y_{i,t} = \beta_0 X_{i,t-1} + \sum_{j=1}^{2}\left[\beta_j (X_{i,t-1} - \gamma_j)_+\right] + \phi \mathbf{z_{i,t}} + u_{i,t}$ and SSR_1 is that of the RKU model with two regimes.

A.2 Uncertainty in the kink parameter: Bootstrap

To incorporate the uncertainties into the kink parameter γ , we employ a standard residual bootstrap with the random sampling in the cross-sectional dimension, considering the heteroscedasticity across countries. Following Candelon et al. (2013), Hansen (1999) and Wooldridge (2010), the practical computation is as follows:

- Step1. We group the regression residuals $\hat{u}_{i,t}$ by country i: $\hat{\mathbf{u}}_\mathbf{i}$($T \times 1$ vector) and use these errors to create the bootstrap errors $\mathbf{u}_\mathbf{i}^{(b)}(T \times 1)$ for all countries.
- Step2. We generate the dependent variable by using the estimated parameters from the regression kink model with unknown threshold and the bootstrap errors $\mathbf{u}_i^{(b)}$ from Step 1. We compute 1,000 bootstrap replications.

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Table A.1: Sources and description of the data

Variable	Variable Names	Description	Sources
$Y_{i,t}$	Cyclically-adjusted primary balance to GDP ratio	Current-vintage estimates and revised data after 4 years	OECD *Economic Outlook*
$X_{i,t}$	Public debt to GDP ratio	Current-vintage estimates and revised data after 4 years	OECD *Economic Outlook*
$OG_{i,t}$	Output gap	Current-vintage estimates and revised data after 4 years	OECD *Economic Outlook*
$GEG_{i,t}$	Government expenditure gap	Decompose total government expenditure to GDP ratio excluding the gross interest payments to GDP ratio into trend and temporary component by Hamilton (2018). Current-vintage estimates and revised data after 4 years	OECD *Economic Outlook*
$r_{i,t}$	Real implied interest rate	Difference between the ratio of gross interest payments to the lagged public debt and the growth rate of the GDP deflator. Current-vintage estimates and revised data after 4 years	OECD *Economic Outlook*
$g_{i,t}$	Potential growth rate	Current-vintage estimates and revised data after 4 years	OECD *Economic Outlook*
$GEF_{i,t}$	Government effectiveness index	Perceptions of the quality of public services the quality of the civil service the degree of its independence from political pressures the quality of policy formulation and implementation the credibility of the government's commitment to such policies	Kaufmann et al. (2011)
$FR_{i,t}$	Fiscal Rule index	Composite of the five criteria: i) the legal base ii) how binding the rule is iii) monitoring bodies iv) correction mechanisms v) resilience to shocks	European Commission (2024)
$Default_{i,t}$	Sovereign default dummy	Construct the dummy variables from BoC–BoE Sovereign Default Database	Beers et al. (2023)

Table A.2: Robustness check (EA core & Nordic countries vs. EA periphery countries)

Data type	Revised	Real time	Revised	Real time
Estimation method	RKU with IV (1)	RKU with IV (2)	RKU with IV (3)	RKU with IV (4)
LM_F nonlinearity test p-value	0.00***	0.00***	0.00***	0.00***
Estimated kink point γ	62.9	61.6	61.9	61.1
$(X_{i,t-1}-\gamma)_-$	-0.085***	-0.064***	-0.083***	-0.063***
	(0.02)	(0.01)	(0.02)	(0.02)
$D_{core+nordic}(X_{i,t-1}-\gamma)_+$	0.030***	0.036***		
	(0.01)	(0.01)		
$D_{core}(X_{i,t-1}-\gamma)_+$			0.032***	0.037***
			(0.01)	(0.01)
$D_{nordic}(X_{i,t-1}-\gamma)_+$			-0.006	0.014
			(0.03)	(0.02)
$D_{EAperiphery}(X_{i,t-1}-\gamma)_+$	0.013	0.043***	0.014	0.043***
	(0.01)	(0.01)	(0.01)	(0.01)
$D_{core+nordic}D_{-gap}OG_{i,t}$	-0.348***	0.033		
	(0.07)	(0.07)		
$D_{core+nordic}D_{+gap}OG_{i,t}$	-0.864***	-0.051		
	(0.24)	(0.21)		
$D_{core}D_{-gap}OG_{i,t}$			-0.696**	-0.399***
			(0.19)	(0.08)
$D_{core}D_{+gap}OG_{i,t}$			-0.450	-0.379
			(0.21)	(0.35)
$D_{nordic}D_{-gap}OG_{i,t}$			-0.666***	-0.348***
			(0.16)	(0.08)
$D_{nordic}D_{+gap}OG_{i,t}$			-0.522***	-0.760***
			(0.14)	(0.30)
$D_{periphery}D_{-gap}OG_{i,t}$	-0.724***	-0.413***	-0.334***	0.032
	(0.07)	(0.11)	(0.07)	(0.07)
$D_{periphery}D_{+gap}OG_{i,t}$	-1.598***	0.705***	-0.861***	-0.045
	(1.09)	(0.38)	(0.24)	(0.21)
$GEG_{i,t}$	-0.860***	-1.020***	-0.844**	-0.992***
	(0.49)	(0.36)	(0.50)	(0.35)
$GEF_{i,t}$	1.451*	1.181**	1.408*	1.206**
	(0.55)	(0.40)	(0.55)	(0.42)
$FR_{i,t-1}$	0.595***	0.335**	0.556***	0.309*
	(0.18)	(0.15)	(0.19)	(0.15)
$Default_{i,t-1}$	1.889**	2.065***	1.892***	2.086***
	(0.58)	(0.50)	(0.58)	(0.50)
Country Fixed Effect	YES	YES	YES	YES
Time Fixed Effect	YES	YES	YES	YES
Adj R^2	0.686	0.614	0.686	0.614
DW	0.677	0.837	0.668	0.841
No. of observation	611	658	611	611
No. of countries	13	14	13	13
Sample periods	1996H2-2019H2	1996H2-2019H2	1996H2-2019H2	1996H2-2019H2

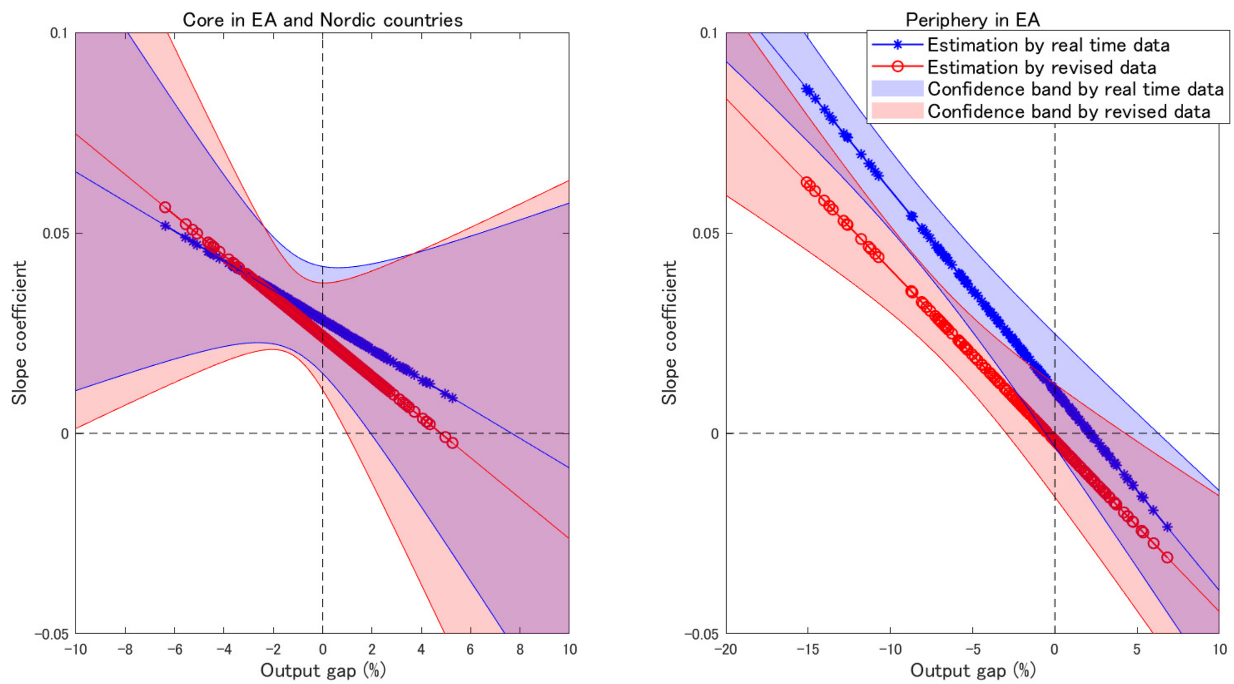
Notes: The standard errors proposed by Driscoll and Kraay(1998) are reported in parentheses. ***p<0.01, *p<0.05, *p<0.1

Table A.3: Robustness check (Business cycle)

Data type	Revised	Real time	Revised	Real time
Estimation method	RKU with IV (1)	RKU with IV (2)	RKU with IV (3)	RKU with IV (4)
LM_F nonlinearity test p-value	0.00***	0.00***	0.00***	0.00***
Estimated kink point γ	61.6	61.6	62.9	61.7
$(X_{i,t-1}-\gamma)_-$	-0.066***	-0.034**	-0.068***	-0.049***
	(0.02)	(0.01)	(0.02)	(0.02)
$D_{core+nordic}(X_{i,t-1}-\gamma)_+$	0.024**	0.028***		
	(0.01)	(0.01)		
$D_{core+nordic}OG_{i,t}(X_{i,t-1}-\gamma)_+$	-0.005	-0.004		
	(0.00)	(0.00)		
$D_{EAperiphery}(X_{i,t-1}-\gamma)_+$	-0.002	0.011		
	(0.01)	(0.01)		
$D_{EAperiphery}OG_{i,t}(X_{i,t-1}-\gamma)_+$	-0.004***	-0.005***		
	(0.00)	(0.00)		
$D_{core+nordic}D_{-gap}(X_{i,t-1}-\gamma)_+$			0.036***	0.035***
			(0.01)	(0.01)
$D_{core+nordic}D_{+gap}(X_{i,t-1}-\gamma)_+$			0.023*	0.029***
			(0.01)	(0.02)
$D_{periphery}D_{-gap}(X_{i,t-1}-\gamma)_+$			0.025***	0.038***
			(0.01)	(0.01)
$D_{periphery}D_{+gap}(X_{i,t-1}-\gamma)_+$			-0.011	-0.004
			(0.01)	(0.01)
$D_{core+nordic}D_{-gap}OG_{i,t}$	-0.647***	-0.275***	-0.848***	-0.401***
	(0.25)	(0.06)	(0.26)	(0.07)
$D_{core+nordic}D_{+gap}OG_{i,t}$	-0.603***	-0.475*	-0.599***	-0.484*
	(0.22)	(0.29)	(0.22)	(0.28)
$D_{periphery}D_{-gap}OG_{i,t}$	-0.074	0.272***	-0.254***	0.039
	(0.08)	(0.07)	(0.06)	(0.07)
$D_{periphery}D_{+gap}OG_{i,t}$	-0.735***	0.176	-0.676***	0.079
	(0.26)	(0.19)	(0.25)	(0.22)
$GEG_{i,t}$	-0.414	-1.032***	-0.270	-0.975***
	(0.33)	(0.20)	(0.42)	(0.22)
$GEF_{i,t}$	1.718**	1.744***	1.524*	1.290***
	(0.79)	(0.49)	(0.80)	(0.49)
$FR_{i,t-1}$	0.760***	0.613***	0.661***	0.361**
	(0.18)	(0.16)	(0.20)	(0.16)
$Default_{i,t-1}$	0.925	0.653	2.117***	1.733***
	(0.77)	(0.49)	(0.77)	(0.44)
Country Fixed Effect	YES	YES	YES	YES
Time Fixed Effect	YES	YES	YES	YES
Adj R^2	0.707	0.659	0.709	0.629
DW	0.713	0.946	0.666	0.870
No. of observation	611	658	611	611
No. of countries	13	14	13	13
Sample periods	1996H2-2019H2	1996H2-2019H2	1996H2-2019H2	1996H2-2019H2

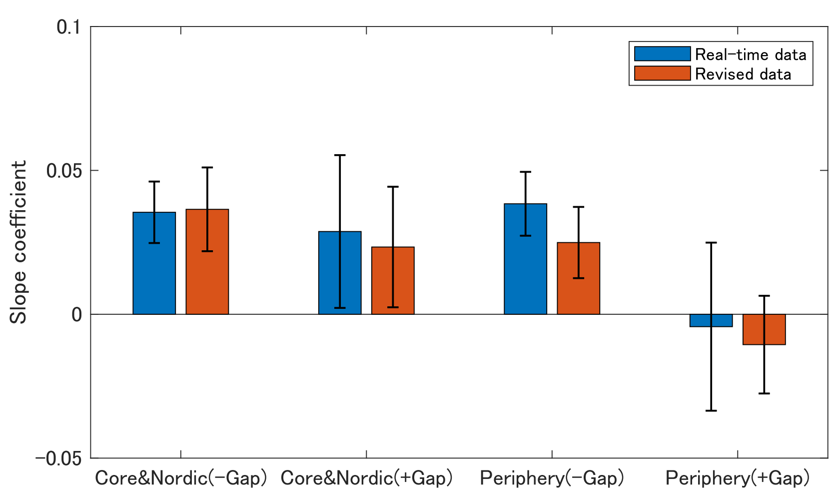
Notes: The standard errors proposed by Driscoll and Kraay(1998) are reported in parentheses. ***p<0.01, *p<0.05, *p<0.1

Figure A.1: Robustness check (Fiscal responses and Business cycle)



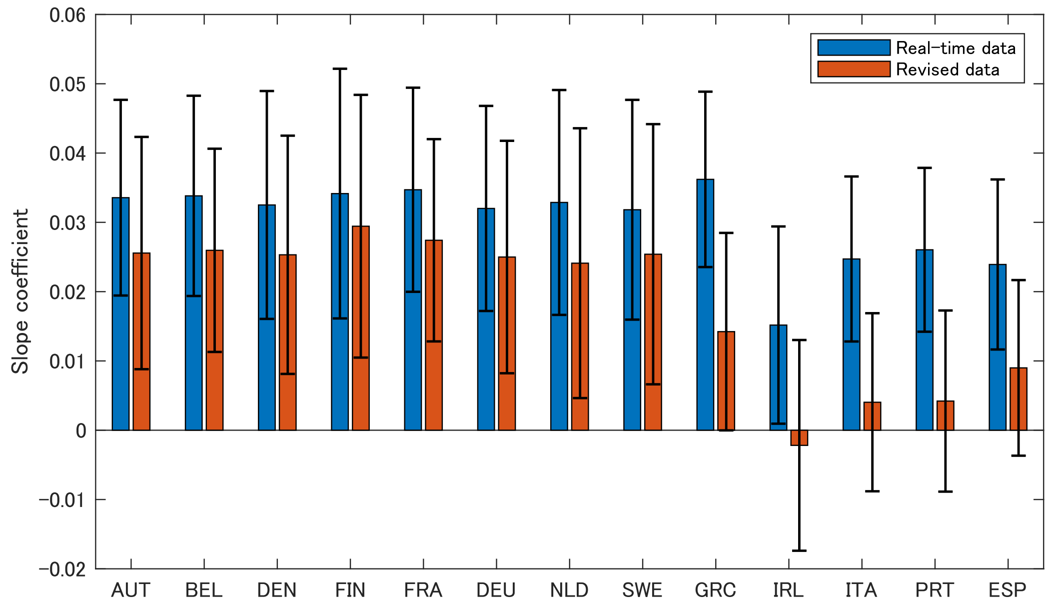
Notes: Shadow area refers to 90 percent confidence interval. Based on columns (1) and (2) of Table A.3.

Figure A.2: Robustness check (Fiscal responses and Business cycle dummy)



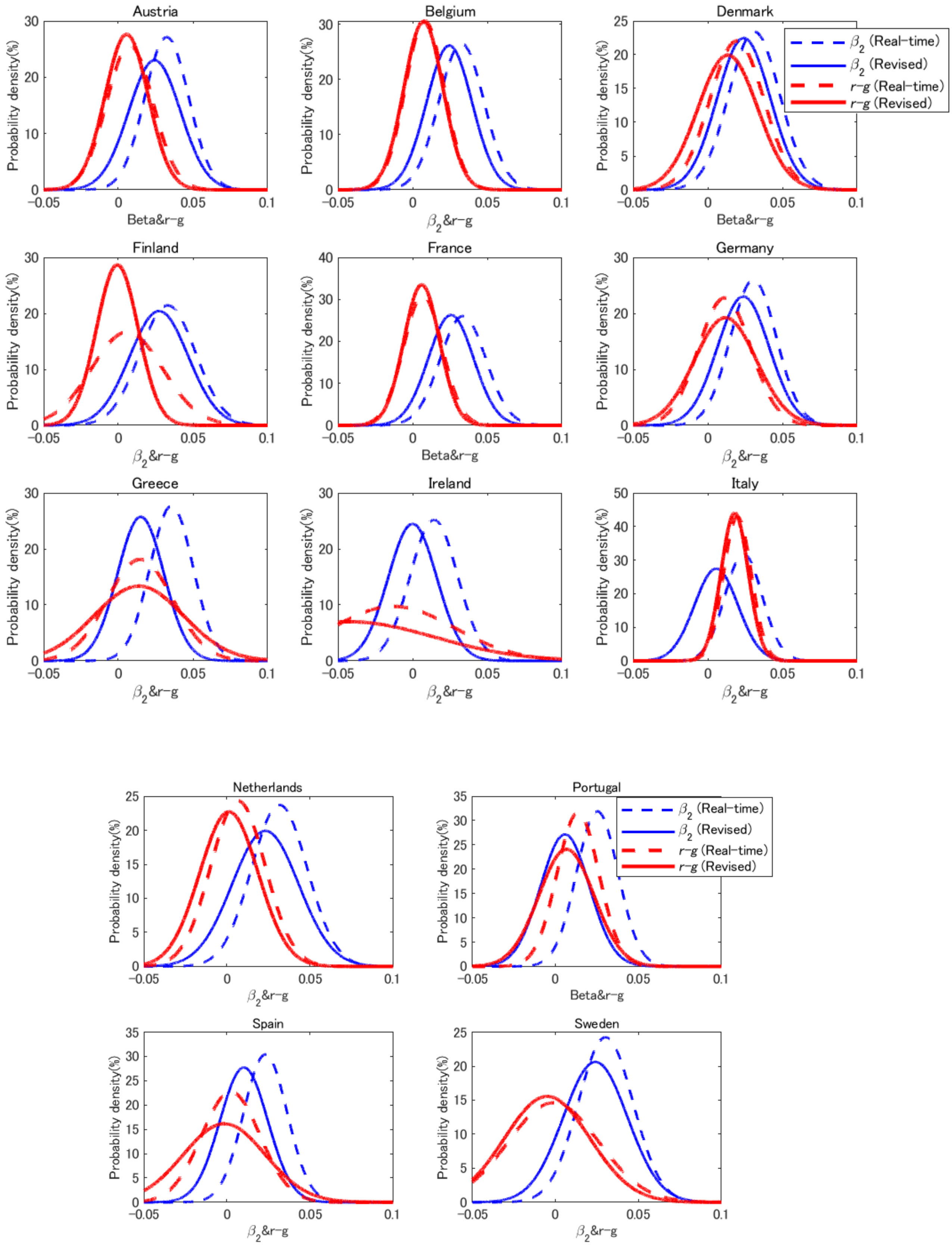
Notes: Solid bars represent the estimated parameters and the error bars denote the 90 percent confidence intervals. Based on columns (3) and (4) of Table A.3.

Figure A.3: Robustness check (Country specific fiscal responses)



Notes: Solid bars represent the estimated parameters and the error bars denote the 90 percent confidence intervals. Country specific responses are calculated by the average of the country-specific output gap and the estimated parameters and standard errors from columns (1) and (2) of Table A.2. AUT:Austria, BEL:Belgium, DEN:Denmark, FIN:Finland, FRA:France, DEU:Germany, NLD:Netherlands, SWE:Sweden, GRC: Greece, IRL:Ireland, ITA:Italy, PRT:Portugal, ESP:Spain.

Figure A.4: Distributions of the fiscal reaction and the interest rate-growth rate differential



Notes: Based on Table5.