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Real-Time Detection of Hidden Fiscal Unsustainability in the EU

Hideaki Matsuoka

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Abstract

If data revisions lead to the concern about the government solvency, the changes in the market expectation may trigger the crisis. This study investigates how significantly revisions from earlier data have influenced the evaluation of fiscal sustainability in the EU through a novel approach: a heterogeneous panel regression kink with an unknown threshold. The main findings are threefold. First, the fiscal responses to government debt in real time for the peripheral countries of the Euro Area are stronger than the fiscal responses in the revised data. Second, the threshold debt level for the fiscal consolidation occurring in real-time is more optimistic than that in the revised data. Third, the fiscal consolidation in the peripheral countries of the Euro Area with moderate to high debt is procyclical.

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

JEL Codes: E43,H63

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†**Hideaki Matsuoka**, orcid.org/0000-0002-7837-1413. Hitotsubashi University, Graduate School of Economics, Japan. E-mail address: hideaki.matsuoka@r.hit-u.ac.jp Postal address: 2-1 Naka, Kunitachi,Tokyo 186-8601 Japan

"If debt appears to be on an unsustainable path, one must wonder why lenders have not stopped lending already."

-Bohn (2007)

1 Introduction

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 triggered 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. If the data revisions lead to the concern about the government solvency, the changes in the market expectation could be one of triggers of the crisis.

This study addresses the following question:

- How significantly have revisions from earlier data influenced the evaluation of fiscal sustainability in the EU?

To address this, we shed light on the comparison between the *ex ante* and *ex post* information. Theoretically, Bohn (2007) argues two types of fiscal sustainability criteria, namely, (i) a weak criterion and (ii) a stricter

[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.

criterion : (i) if the response of the primary fiscal balance to changes in government debt is at least positive, the intertemporal budget constraint and transversality condition (i.e., no ponzi condition) can be maintained, but with mild explosive paths, and (ii) if this fiscal response exceeds the growth-adjusted interest rate, public debt is expected to converge to a finite proportion of GDP (i.e., a stable stationary equilibrium).[2] We test both types of fiscal sustainability criteria to investigate whether real-time observations hid fiscal unsustainability or not. However, this issue has not been investigated extensively.[3] To the best of our knowledge, only Cimadomo (2012) is similar to our study in terms of the comparison of fiscal responses between the real time and revised data. We take different approaches, as described below.

This study contributes to three strands of the literature on the fiscal sustainability. First, this study makes a methodological contribution towards the heterogeneous Panel Regression Kink with an unknown threshold. We examine how the fiscal reaction in the moderate-to-high-debt countries differs within the EU. While Zhang et al. (2017) extend the regression kink model with an unknown threshold (RKU) into panel data, we further apply this to a panel model with heterogeneity. Ghosh et al. (2013) which is one of the seminal papers employ panel cubic specification to capture the different phases of the fiscal consolidation. The common point between the RKU and cubic function is a continuous function with turning points, and the different point between the RKU and cubic function is that whereas the RKU investigates combinations of straight-lines, the cubic function is always a curved line. One advantage of the RKU is that it easily accommodates heterogeneity, by introducing the slope dummy variables because of the straight-lines rather than curved lines.

Second, we endogenously find the threshold debt level at which the fiscal consolidation occurs, employing Regression Kink with an unknown threshold (RKU) developed by Hansen (2017). We investigate asymmetric government behaviors between low debt and high debt countries. Although the threshold of debt level the fiscal consolidation occurs is expected to be approximately 60 percent under the EU rule, it is 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.[4] (ii) The EU reform (i.e., Six-pack

[2]That is, a weak criterion does not require any assumptions about interest rates.

[3]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.

[4]Previous studies focus on the government deficit, not the government debt. For instance, Caselli and Wingender (2021) show that

regulations) introduced the Euro area member states whose debt exceeds 60 percent of GDP face an Excessive Deficit Procedure (EDP). However, De Jong and Gilbert (2020) and Haan et al. (2016) point out that even after this reform, it has mainly focused on budget balance rules. No previous studies have investigate endogenously this point, whereas Mendoza and Ostry (2008) employ the exogenous threshold (i.e., 60 percent for the gross debt-to-GDP ratio). We find that the threshold of debt level the fiscal consolidation occurs in real time has been more optimistic than that in the revised data.

Third, 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. However, this analytical work hardly existed beyond a few papers. Aldama and Creel (2022) and Larch et al. (2021) investigate this issue, but these two studies reached at disparate conclusions. While Aldama and Creel (2022) show no evidence that fiscal consolidation 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. 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.

The remainder of this paper is organized as follows. Section2 describes the theoretical and empirical connections. Section3 constructs a dataset of real-time observations and describes the panel regression kink with an unknown threshold. Section4 presents the baseline results, the robustness check, and the comparison with other studies. It examines (i) a weak criterion for the fiscal sustainability criteria. Section5 examines (ii) a stricter criterion. Section6 concludes.

2 Connection between theoretical and empirical framework

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

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.

2.1 Theoretical framework

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) .

The nominal government budget constraint is

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

where D_t is one-period public debt, i_t is the implied nominal interest rate on public debt, and PB_t is the primary fiscal balance. Dividing both sides by Y_t (nominal GDP) yields:

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

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

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 (6) 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 is assumed to be

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

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. As for this continuous function, we introduce a kink function, whereas Bohn (1998) and Ghosh et al.

(2013) employ a linear function and cubic function, respectively. Common point between the kink function and the cubic function is a continuous function with turning points. The difference is that whereas the kink function is a combination for straight-lines, the cubic function is always a curved line. The kink function 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 $(d_{t-1} - \gamma d^{Threshold})_- = \min\left[d_{t-1} - d^{Threshold}, 0\right]$ 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 (3) into (2) gives

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

Assuming μ_t is stationary, 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. 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.

2.2 Empirical framework

Based on the theoretical framework, the empirical framework consists of the two steps, as follows:

- Step1 (**Section**3 and **Section**4): Estimate the response of the primary balance to changes in government

Figure 1: Stable stationary equilibrium with stringent fiscal consolidation

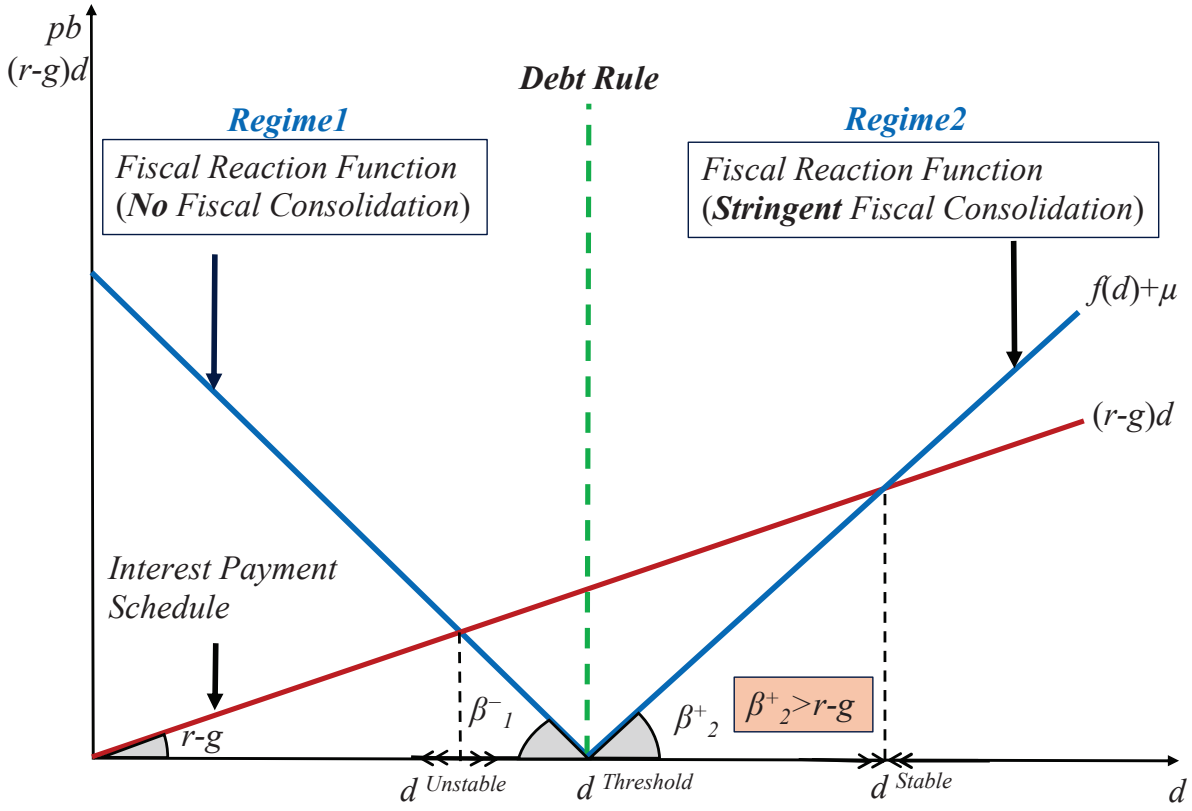
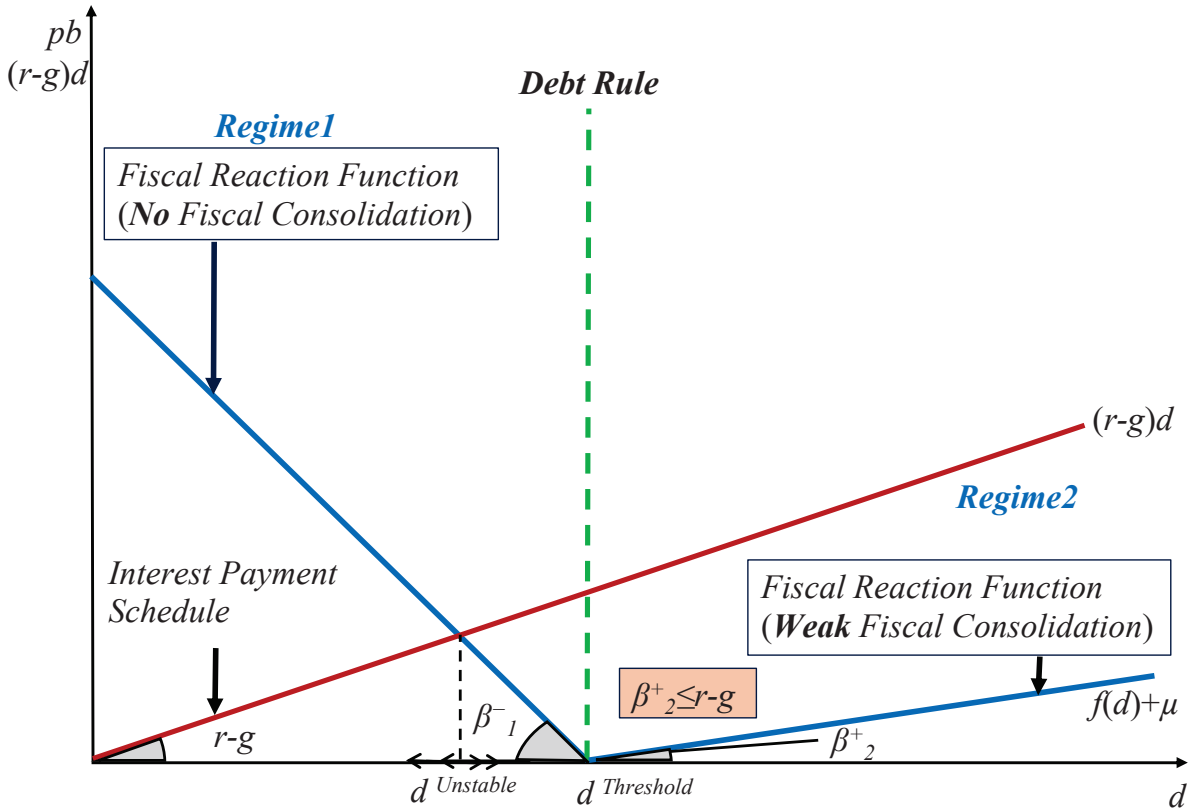


Figure 2: No stable stationary equilibrium with weak fiscal consolidation



debt, incorporating the kink function (4). The main parameters 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).

- Step2 (**Section**5) : 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.

Through these two steps, we investigate how significantly revisions from earlier data have influenced the evaluation of fiscal sustainability in the EU.

3 Data and empirical strategy

3.1 Real-time dataset

We construct a semiannual dataset of revised and real-time observations from the OECD Economic Outlook because it releases their projections twice a year. Previous studies such as Beetsma and Giuliodori (2009), Cimadomo (2012), and Aldama and Creel (2022) construct annual datasets from the OECD Economic Outlook. A larger sample size would be more desirable to achieve a robust estimation, especially because we employ a non-linear regression. Hence, our dataset is more high-frequency than the previous studies.

Based on real-time data availability, the dataset covers semiannual data of 13 EU countries during 1996H2-2019H2. The period after 2020 is excluded in the dataset because the EU fiscal rules have been suspended since 2020 owing to the need for government spending in the wake of COVID-19 pandemic. The 13 EU countries are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, 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.,

4×2 = 8). $v_{i,t}^{h}$ is the revision error in the current-vintage estimates.

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

Our main parameter of interest is the response of the primary balance to changes in government debt. Following the literature on the fiscal sustainability (Cimadomo (2012), Ghosh et al. (2013), Mauro et al. (2015), and Mendoza and Ostry (2008)), we start to assess the fiscal sustainability, given that the neutral state of the economy, controlling the business cycle, and temporary factors such as rare and extreme spending.[5] This study integrates two approaches from previous studies to exclude the cyclical and temporary factors.

3.2.1 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.[6] 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.[7] 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

[5]Furthermore, we investigate whether the intentional fiscal stance of the fiscal consolidation depends on the business cycle or not.

[6]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.

[7]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.

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.

Noted that the output gap $OG_{i,t}$ for the current year could be affected by fiscal policies for the same year. Following Beetsma and Giuliodori (2009) and Cimadomo (2012), we employ the instrumental variables to deal with the endogeneity (Caner and Hansen (2004)). The instrument variables for the output gap for the current year are the previous year's output gap and the past-year output gap (unweighted) average over countries leaving out country i. In addition, the past-year long-term interest-rate is used, again averaged over the countries leaving out country i.

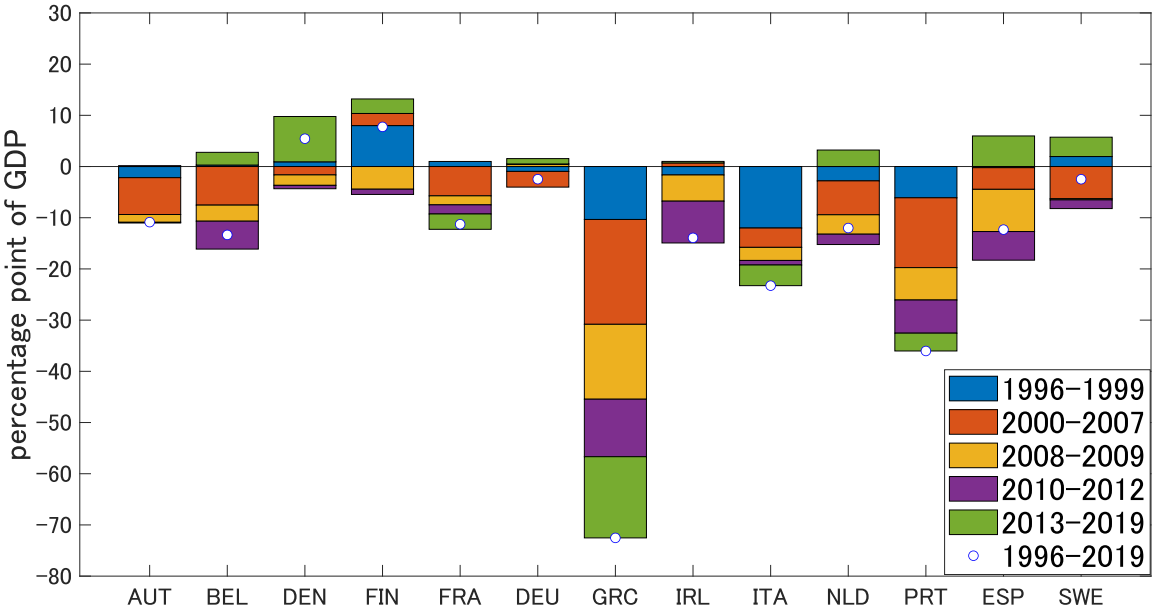
3.2.2 Temporary component of the government expenditure

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 can capture the rare and extreme spending (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 employ the trend-cycle decomposition method developed by Hamilton (2018).

3.3 A first look at the data

Figures 3 shows the cumulative revision errors in current-year estimates of the cyclically-adjusted primary balance (i.e.,$v_{i,t}$) based on the latter half of the year. There has been substantial cross-country dispersion in the revision, with Greece (GRC) at the lower extremes. Greece's total cumulative revision in Greece is -119 percentage point to GDP ratio. Following Greece, total revision in Portugal (PRT) and Spain (ESP) is -62 and -49 percentage point to GDP ratio, respectively. Large revision errors existed in Greece, Portugal, and Spain even before the Global Financial Crisis (i.e., 1996-1999 and 2000-2007). This is consistent with the findings of de Castro Fernández et al. (2013) which document that later vintages of data tend to be lower budget balances than indicated by earlier data releases on average. On the other hand, the revision errors in Austria, Denmark, Finland, France, Germany, and Sweden are relatively small. Overall, the current estimates of cyclically-adjusted primary balance in peripheral countries of the Euro Area are more optimistic than those

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.

of core countries of the 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.

3.4 Panel Regression Kink with Unknown Threshold

We apply a Regression Kink 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. Whereas the common point between the RKU and the cubic function is a continuous function with turning points, the difference is that 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 $(X^h_{i,t-1}-\gamma)_-= \min\left[X^h_{i,t-1}-\gamma, 0\right]$ and $(X^h_{i,t-1}-\gamma)_+= \max\left[X^h_{i,t-1}-\gamma, 0\right]$.[8]

$Y^h_{i,t}$ is the cyclically-adjusted primary balance (percent of GDP) for country i = 1,…, N at a time t = 1,…, T published on a given date (vintage, h), $X^h_{i,t-1}$ 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 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.

3.5 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 $G^*_{i,t}(\gamma)_- = (X^h_{i,t-1}-\gamma)_- - \frac{1}{T}\sum_{t=1}^{T}(X^h_{i,t-1}-\gamma)_-$, and $G^*_{i,t}(\gamma)_+ = (X^h_{i,t-1}-\gamma)_+ - \frac{1}{T}\sum_{t=1}^{T}(X^h_{i,t-1}-\gamma)_+$. $\mathbf{z^*_{i,t}} = \mathbf{z^h_{i,t}} - \overline{\mathbf{z^h_i}}$. 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 , $(\hat{\beta}_1^- : \hat{\beta}_2^+ : \widehat{\phi})' = \widehat{\Psi}(\hat{\gamma})$.

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

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.[9]

3.6 Other control variables

3.6.1 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.

3.6.2 Lagged fiscal rules ($FR_{i,t-1}$)

The legal frameworks for fiscal governance in the EU have been strengthened by the so-called "Six-Pack"[10] and "Two-pack".[11] 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[12], iv) correction

[9]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).

[10]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))

[11]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 (EA) (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.

[12]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)

mechanisms[13], and v) resilience to shocks. 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.

3.6.3 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.

4 Estimation results

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

4.1 Headline

Columns (1) and (2), and Columns (3) and (4) of Table 1 show that the headline result for the Regression Kink with an unknown threshold and the corresponding cases for the instrumental variable approach, respectively. Because the tests for nonlinearity are significant with p-values, the Regression Kink with an unknown threshold with two regimes is employed.[14] The estimated unknown kink parameter γ (i.e., debt level threshold the fiscal consolidation occurs) is approximately the level close to 60 percent. This result is consistent with the EU fiscal rule. We will examine the uncertainty in the kink parameter for the robustness check.

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.

[13] 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).

[14] See Appendix for details.

The main parameters of interest are β_1 and β_2.[15] First, as expected, β_1 is negative. This result illustrates that there is no fiscal consolidation as long as public debt-to-GDP ratio is below a level close to 60 percent with both real-time and revised data. In the case of the instrumental variables (Columns (3) and (4) of Table 1), second, for β_2, a response of the primary fiscal balance to changes in government debt in real-time is significantly positive above this level, whereas the corresponding impact of the revised data is insignificant. The marginal impacts of public debt on the primary balances in real-time data are approximately 0.03, which is almost three times in the revised data. It illustrates that bias in the real-time data led to the seemingly strong response of the primary fiscal balance to changes in government debt.

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.

4.2 Heterogeneity

4.2.1 Region

Section2 has illustrated that there has been substantial cross-country dispersion in the revision. As the current estimates of the cyclically-adjusted primary balance in peripheral countries in the Euro Area are consistently more optimistic than the core countries of the Euro Area and Nordic countries, there must be a heterogeneous β_2(that is, the primary balance response to changes in government debt in moderate-to-high-debt countries,

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

Table 1: Headline result

Data type	Revised	Real time	Revised	Real time
Estimation method	RKU	RKU	RKU with IV	RKU with IV
	(1)	(2)	(3)	(4)
LM_F nonlinearity test	0.00***	0.00***	0.00***	0.00***
Estimated kink point	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: The standard errors proposed by Driscoll and Kraay (1998) are reported in parentheses. ***p<0.01, *p<0.05, *p<0.1

where debt is above the estimated threshold).

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

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

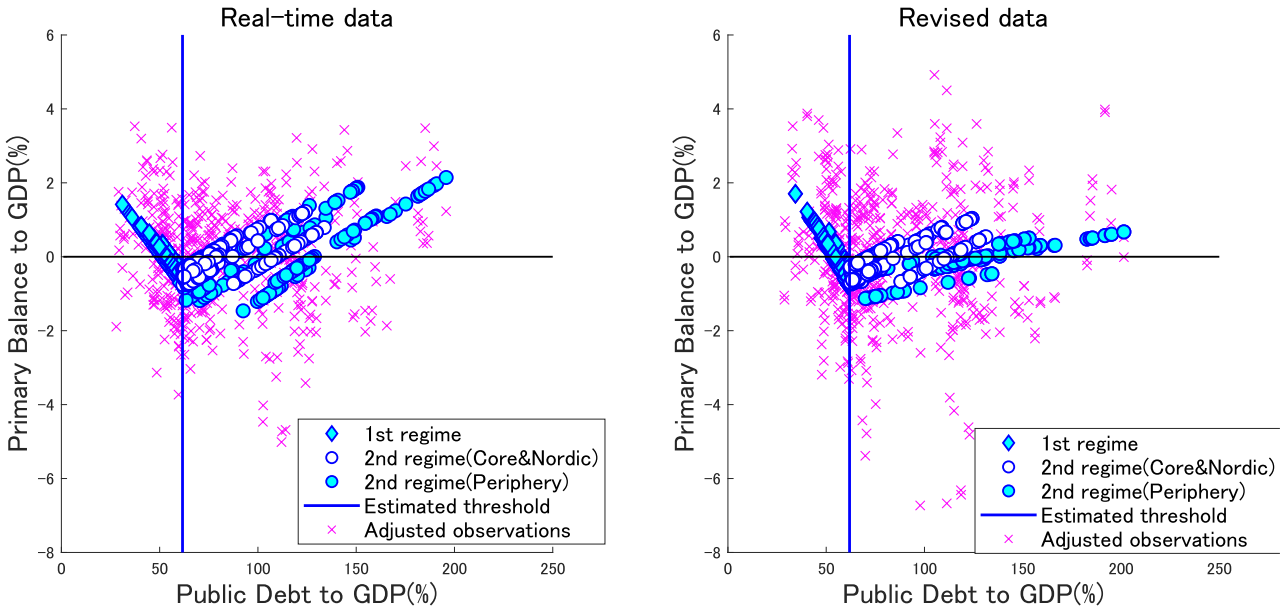
where D_k is a dummy variable for group k. We divide 13 EU countries into three groups; (i) core countries in the Euro Area (Austria, Belgium, France, Germany, and the Netherlands), (ii) Nordic countries (Denmark, Finland, and Sweden), and (iii) peripheral countries in the Euro Area (Greece, Ireland, Italy, Portugal, and Spain). The third group was at the center of the European debt crisis. For the second group (ii), as the number of samples 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) is few, it would be difficult to provide the robust estimation. Hence, we integrate (i) and (ii) into one group, whereas we also examine the estimation by three groups for the robustness check.

Table 2 shows that there are heterogeneous fiscal responses by estimating $\hat{\beta}_{2i}$. First, one striking feature is the result of periphery countries in the Euro Area. The response in this group is significantly positive in the real-time data, while it is insignificant in the revised data. This implies that bias in real-time data can lead to seemingly stronger response of the primary fiscal balance to changes in government debt. Figure 4 illustrates that the estimated fiscal responses and adjusted observations after controlling for country and year fixed effects, and other control variables. The slopes of peripheral countries of the Euro Area differs between the real-time data and the revised data. Second, in contrast, the reaction of real-time data for core countries in the Euro Area and Nordic countries is similar to that of the revised data (Figure 5). Columns (3) and (4) of Table 2 show that even excluding the Nordic countries, the results for core countries in the Euro Area remain unchanged.

4.2.2 Business cycle

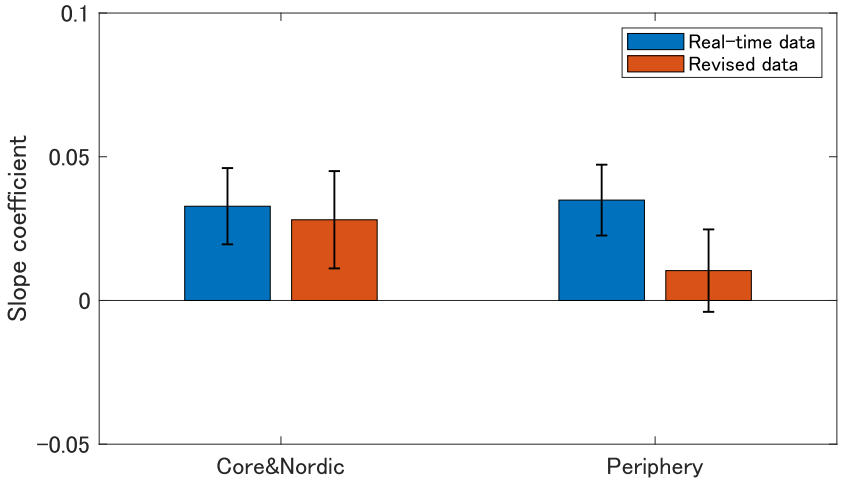
We have started to assess fiscal sustainability given that the neutral state of the economy, controlling for two types of fiscal reaction to the cycle: (i) passive (automatic) reaction to the cycle, and (ii) active (discretionary) reaction to the cycle (that is, the cyclical stance of discretionary fiscal policy). However, the response of the primary balance to changes in government debt may also depend on the business cycle. We introduce the interaction term between the output gap and lagged moderate-to-high-debt countries, where the debt is above the estimated threshold. To ensure the robustness, we examine the interaction term between the dummy

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 Table2.

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



Notes: Bar charts refer to 90 percent confidence interval. Based on columns (1) and (2) of Table2.

Table 2: Baseline (EA core & Nordic countries vs. EA periphery countries)

Data type	Revised	Real time	Revised	Real time
Estimation method	RKU with IV	RKU with IV	RKU with IV	RKU with IV
	(1)	(2)	(3)	(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: The standard errors proposed by Driscoll and Kraay (1998) are reported in parentheses. ***p<0.01, *p<0.05, *p<0.1

variables D_{+gap} and D_{-gap} for 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 3 show that the fiscal consolidation in peripheral countries of the Euro Area has been procyclical when facing moderate-to-high-debt. Interaction term between the output gap and lagged moderate-to-high-debt countries in peripheral countries of the Euro Area is significantly negative in real time and the revised data, whereas that in core countries in the Euro Area and Nordic countries is insignificant in the revised data and slightly significant in the real time. Figure 6 shows the fiscal response in the core countries in the Euro Area and Nordic countries is not sensitive to business cycle, and is significant in the neutral state of the economy (i.e., output gap is around 0). When the output gap becomes large or small, the estimated confidence bands become large. Contrary, the fiscal response at periphery of the Euro Area is prominently sensitive to the business cycle. Their fiscal consolidations are procyclical when facing the moderate-to-high-debt. Similarly, columns (3) and (4) of Table 3 show that the interaction terms between dummy variables D_{+gap} and D_{-gap} for 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, and did not do this during upturns. These results are consistent with those of Larch et al. (2021) which find that the degree of procyclicality increases if debt exceeds a certain exogenous threshold.

Figure 8 illustrates the country specific responses which are calculated by using the average country-specific output gap. One striking feature is the result for Greece. The response in Greece is the largest for the real-time data, whereas it is insignificant for the revised data.

4.3 Robustness check

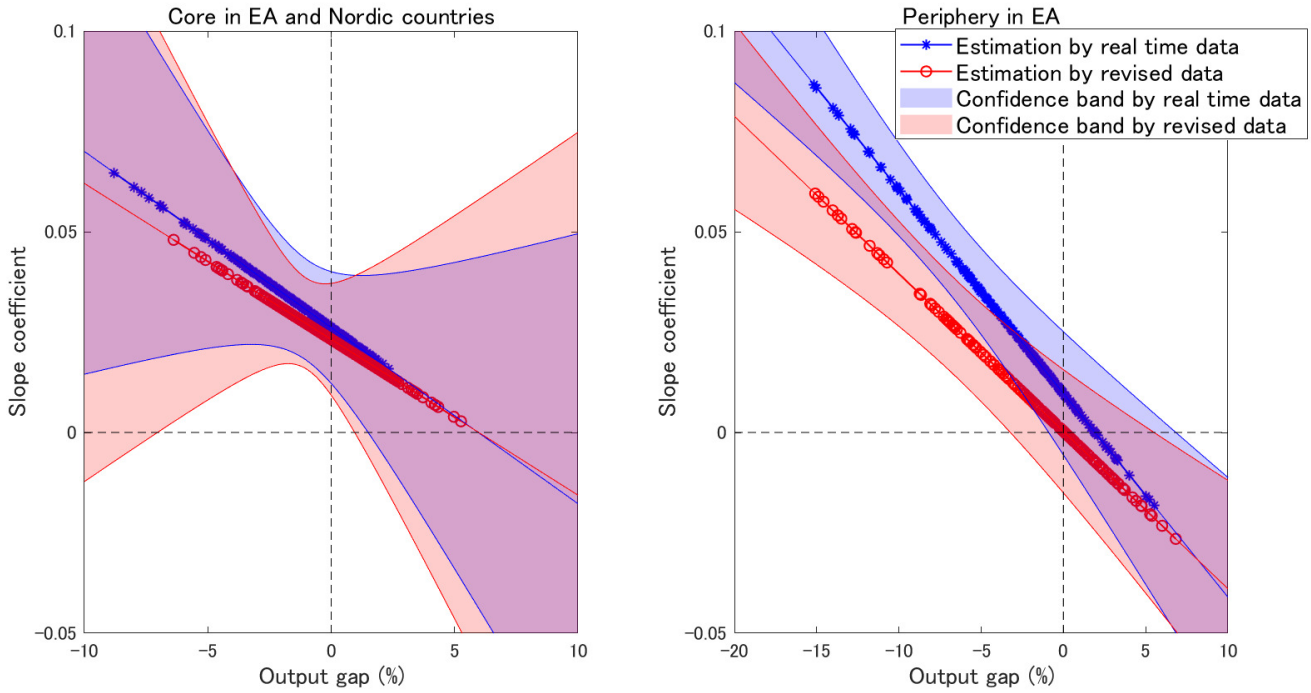
We consider a wide range of exercises to verify the robustness of our baseline findings with the following: (1) control for the asymmetric procyclicality; (2) uncertainties in the kink parameter; and (3) comparison with other studies.

Table 3: Baseline (Business cycle)

Data type	Revised	Real time	Revised	Real time
Estimation method	RKU with IV	RKU with IV	RKU with IV	RKU with IV
	(1)	(2)	(3)	(4)
LM_F nonlinearity test	0.00***	0.00***	0.00***	0.00***
Estimated kink point	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

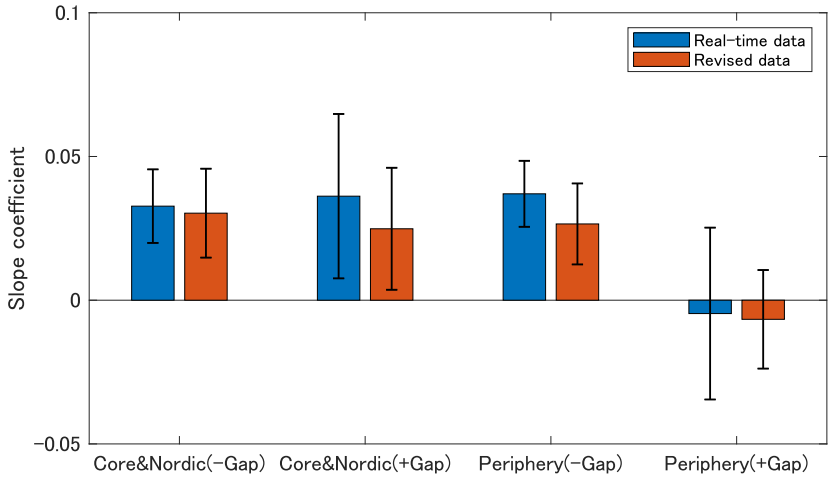
Notes: The standard errors proposed by Driscoll and Kraay (1998) are reported in parentheses. ***p<0.01, *p<0.05, *p<0.1

Figure 6: Fiscal responses and Business cycle



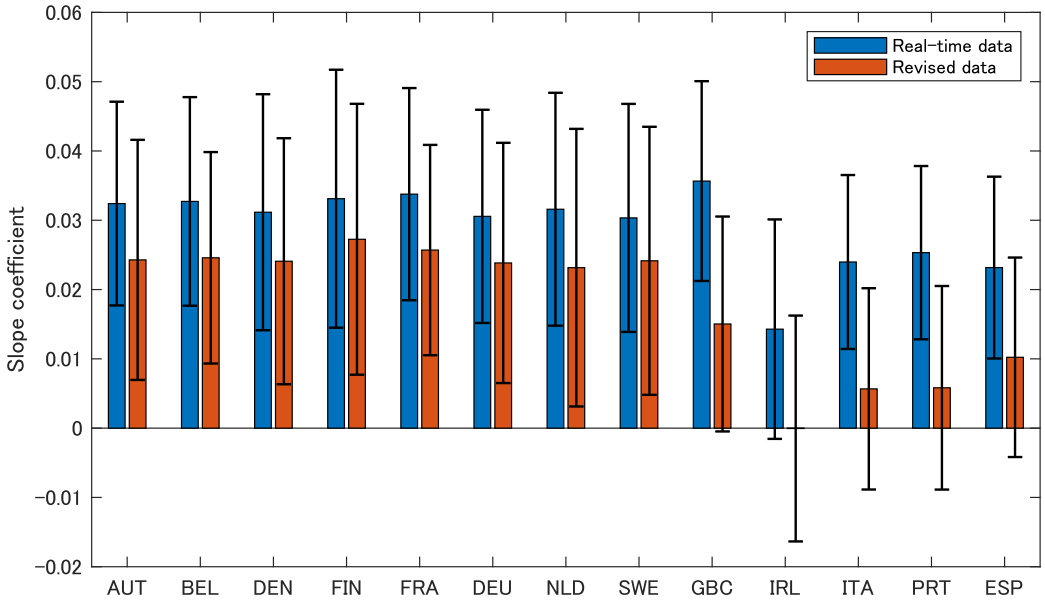
Notes: Shadow area refers to 90 percent confidence interval. Based on columns (1) and (1) of Table3.

Figure 7: Fiscal responses and Business cycle dummy



Notes: Bar chart refers to 90 percent confidence interval. Based on columns (3) and (4) of Table3.

Figure 8: Country specific fiscal responses



Notes:Bar chart refers to 90 percent confidence interval. 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 Table3. 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.

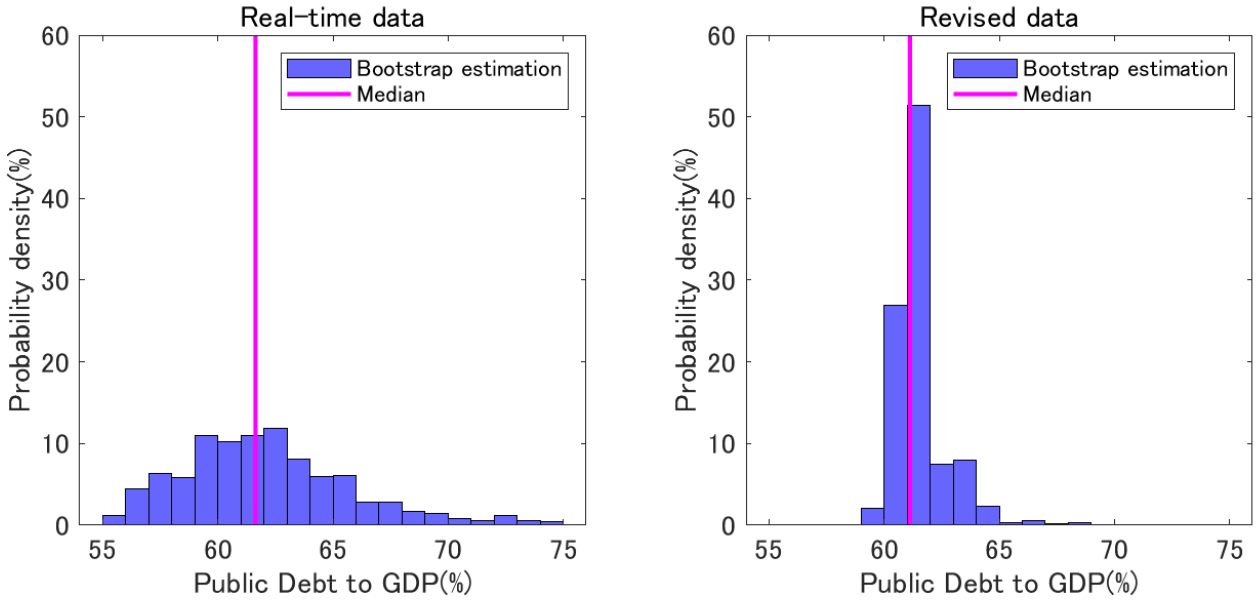
4.3.1 Control for the asymmetric procyclicality

For the baseline, we have assumed that the cyclical reaction of fiscal policy symmetrical over the entire business cycle. Following Gootjes and de Haan (2022), we control for the asymmetric procyclicality. The output gap variable interacts 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 is consistent with the baseline result.[16] The response in peripheral countries of the Euro Area is significantly positive in the real-time data, whereas it is insignificant in the revised data. In addition, the reactions of real-time data for core countries in the Euro Area and Nordic countries are similar to those of the revised data.

[16]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.

4.3.2 Uncertainty in the kink parameter

Based on the several specifications, we have shown that the estimated unknown kink parameter (that is, the threshold debt level at which the fiscal consolidation occurs) γ is approximately a level close to 60 percent. This result is consistent with the EU fiscal rule. For the robustness, we examine the uncertainty of the kink parameter, by employing the standard residual bootstrap with the random sampling in the cross-sectional dimension, considering the heteroscedasticity across countries.[17]

Figure 9 shows that there is wider distribution of the kink parameter in real time than that of the revised data, whereas the median in real time and that in the revised data are similar. The estimated debt threshold values below 60 percent are frequently observed in real time. In contrast, the majority of the estimated threshold debt levels exceed 60 percent in the revised data. Consequently, the threshold debt level at which the fiscal consolidation occurs in real time is more optimistic than in the revised data.

4.3.3 Comparison with other studies

Table 4 compares our estimates with those of other studies which have been devoted to estimating the marginal impact of public debt on primary balance, using the panel data.

[17] See Appendix for details.

Table 4: 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

First, for the real-time data, when the debt-to-GDP ratio exceeds 60 percent, our estimated impact is approximately 0.03. This is slightly larger than the existing literature (Cimadomo (2012) and Aldama and Creel (2022)). The reasons for this difference may be as follows: because we focus on the EU and employ a nonlinear model, whereas these previous studies have focused on OECD and employed the linear models. We differentiate the phase, in which there is no fiscal consolidation as long as the public debt-to-GDP ratio is below a level close to 60 percent with both the real-time and revised data.

Second, 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). Combining the first and second points, this study fills the gap between the results of the real-time data and those of the revised data. That is, the response of the primary fiscal balance to changes in government debt with real-time data is significantly positive when the public debt-to-GDP ratio is above a level close to 60 percent, whereas the corresponding response with revised data is insignificant.

5 Empirical test for the stable stationary equilibrium

Finally, we combine the theoretical framework presented in **Section**2 and the empirical framework in **Section**3 and **Section**4 to test the stricter criterion for the fiscal sustainability (that is, if a response of the primary fiscal

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 Table2 and columns (1) and (2) of Table3, 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.

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).[18] While a weak criterion does not require any assumptions about interest rates in **Section**3 and **Section**4, 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 3.

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).[19] 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, there are asymmetrical results between the real-time and the revised data in Greece and Portugal. The results for real-time data satisfy the condition of the stable stationary equilibrium, but not for the revised data. Hence, the result for revised data is in line with Figure 2 in **Section**2. This is mainly because fiscal reaction β_{2i} in the revised data becomes smaller than that in the real time data. In contrast, the revision of $r_i - g_i$ from the real-time is relatively negligible.[20] In most countries except Greece, Italy, and Portugal, the null hypothesis ($H_0 : \beta_{2i} \leqq r_i - g_i$) can be rejected for the real time and revised data and there are no asymmetrical results.

[18] 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.

[19] 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.

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

6 Conclusion

This study examines how significantly revisions from earlier data have influenced the evaluation of fiscal sustainability in the EU through a novel approach: a heterogeneous panel regression kink with an unknown threshold. To address this, we shed light on the comparison between the *ex ante* and *ex post* information. The main findings are threefold. First, primary balance responses to changes in government debt with real-time data for peripheral countries of the Euro Area are stronger than the corresponding responses with revised data, illustrating that hidden fiscal unsustainability exists in real-time. Second, we endogenously find the threshold of debt level at which the fiscal consolidation occurs in the EU. By incorporating the uncertainty, the phenomenon of the debt threshold below 60 percent is frequently observed in real time. By contrast, the majority of the estimated threshold debt levels exceed 60 percent in the revised data. Consequently, the threshold of debt level the fiscal consolidation occurs in the real time could be more optimistic than that in the revised data. Third, fiscal consolidation in the Eurozone's peripheral countries is more procyclical than others when facing the moderate-to-high-debt, finding evidence that they have attempted to maintain fiscal sustainability during downtown and did not do so during upturns. Hence, combining our findings and that of Jordá and Taylor (2016) may address the question why the negative impact of the fiscal consolidation on growth in the Eurozone was larger than that of other advanced economies.

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 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 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	RKU with IV	RKU with IV	RKU with IV
	(1)	(2)	(3)	(4)
LM_F nonlinearity test p-value	0.00***	0.00***	0.00***	0.00***
Estimated kink point	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

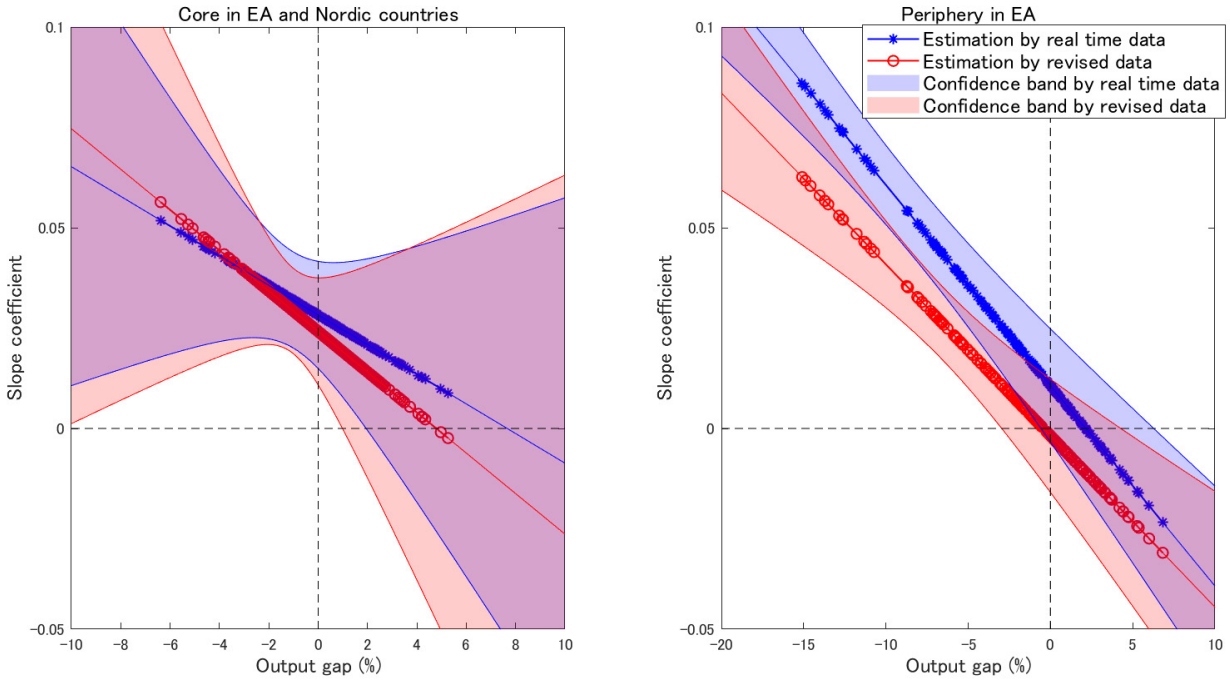
Notes: The standard errors proposed by Driscoll and Kraay(1998) are reported in parentheses. ***p<0.01, *p<0.05, *p<0.1

Table A.3: Robustness check (Business cycle)

Data type	Revised	Real time	Revised	Real time
Estimation method	RKU with IV	RKU with IV	RKU with IV	RKU with IV
	(1)	(2)	(3)	(4)
LM_F nonlinearity test p-value	0.00***	0.00***	0.00***	0.00***
Estimated kink point	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

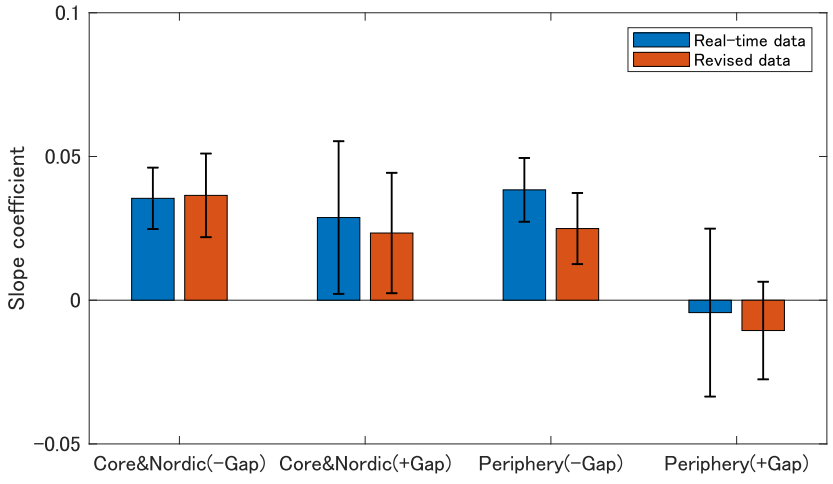
Notes: The standard errors proposed by Driscoll and Kraay(1998) are reported in parentheses. ***p<0.01, *p<0.05, *p<0.1

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



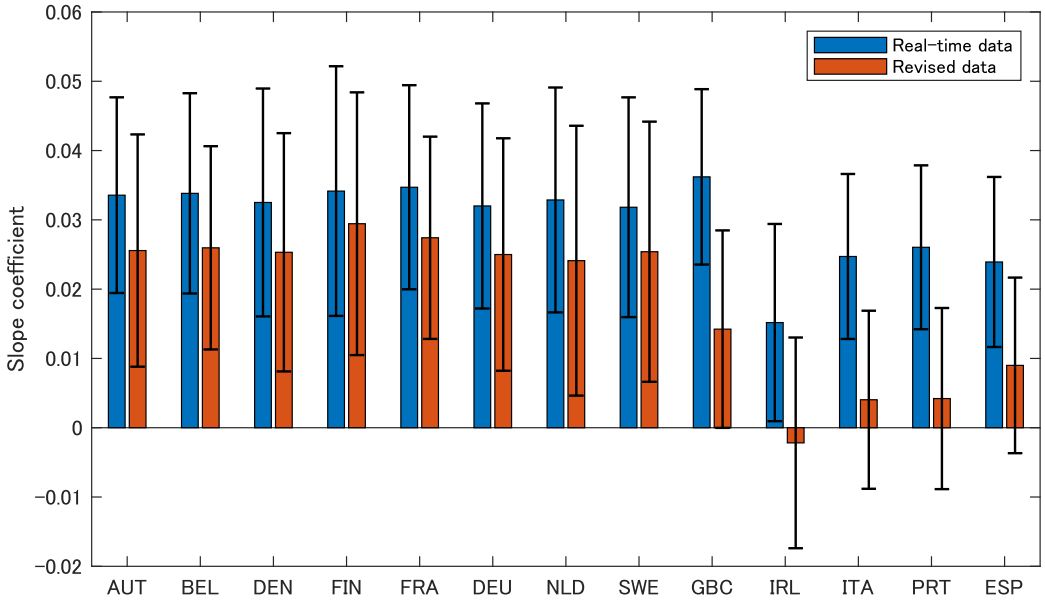
Notes: Shadow area refers to 90 percent confidence interval. Based on columns (1) and (2) of Table A.2.

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



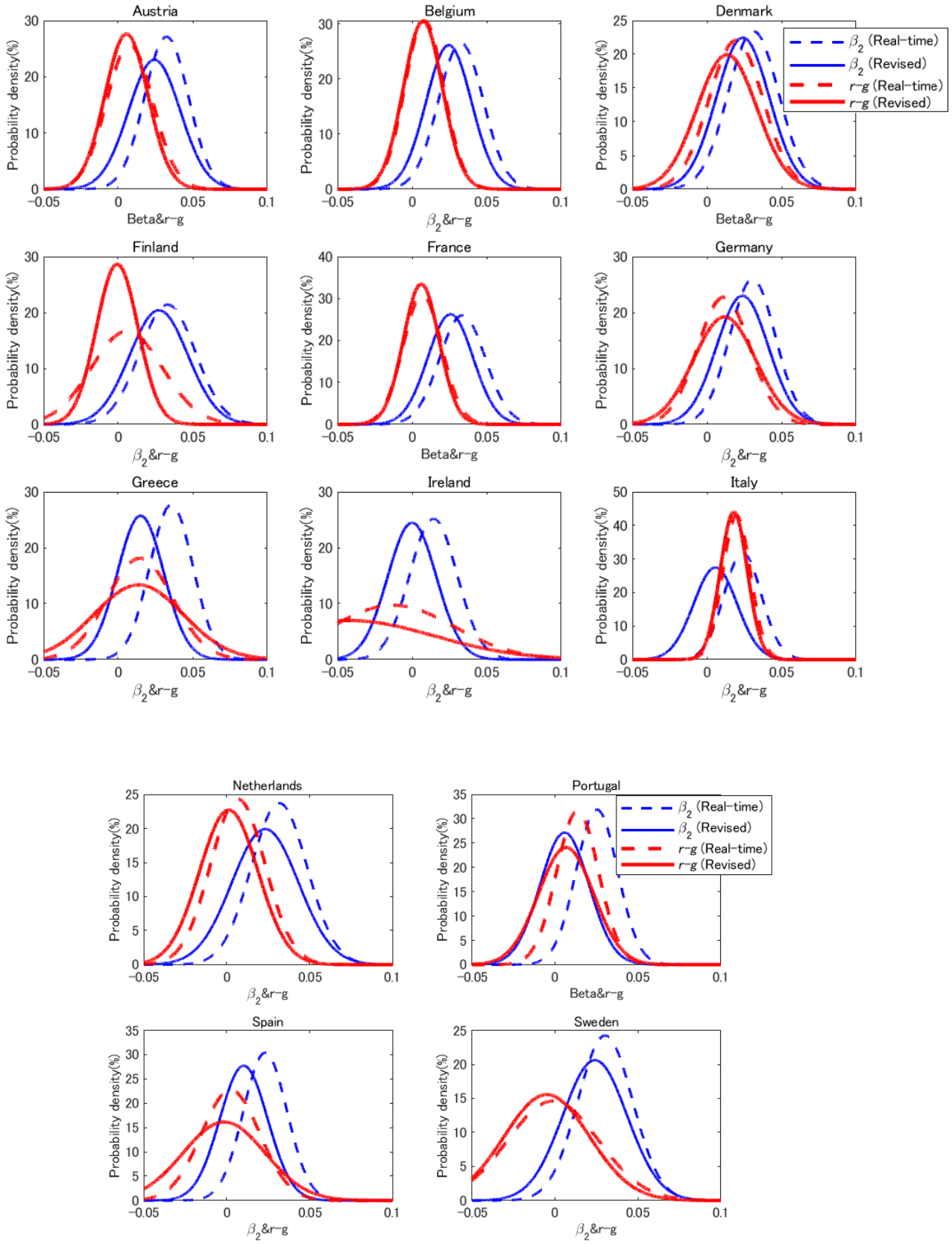
Notes: Bar chart refers to 90 percent confidence interval. Based on columns (3) and (4) of Table A.2.

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



Notes:Bar chart refers to 90 percent confidence interval. 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 Table6.