Measuring Fiscal Discipline

A Revealed Preference Approach*

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Abstract

Fiscal rules are essential to limit policy makers' pro-deficit bias, but monitoring the efforts made by policy makers in respecting such rules is difficult as fiscal variables are endogenous variables that are only imperfectly controlled by policy makers. In this paper, we propose a revealed preference approach to measure "fiscal discipline" —policy makers' preference for respecting the fiscal rule—. In times when the fiscal rules conflict with macro stabilization objectives, we can measure fiscal discipline from the way policy makers balance the conflicting objectives; when the policy maker could have done better at satisfying the fiscal rule but chose not to. Fiscal discipline can be measured with minimal structural assumptions on the underlying economic model using only sufficient statistics. We illustrate our approach by studying fiscal discipline in the euro area in the context of the EU Stability and Growth Pact.

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> The Balanced Budget and Emergency Deficit Control Act of 1985 set annual targets for an endogenous variable —the budget deficit— that Congress cannot control any more than King Canute could control the tides.
>
> Blinder (2022)

1 Introduction

Today, fiscal rules are widely used to constrain fiscal policy discretion and limit possible debt-financing biases of policy makers. More than 90 countries have implemented fiscal rules, either at the national or supranational level, with constraints on the public deficit, on public expenditures or on the debt level.[1]

A central, yet rarely studied, feature of fiscal rules is that fiscal variables (the budget deficit, the debt level or even the level of government spending) are endogenous variables, which are affected by factors outside policy makers' immediate control.[2] In that context, how should we establish and quantify policy makers' responsibility in cases of rule violations?

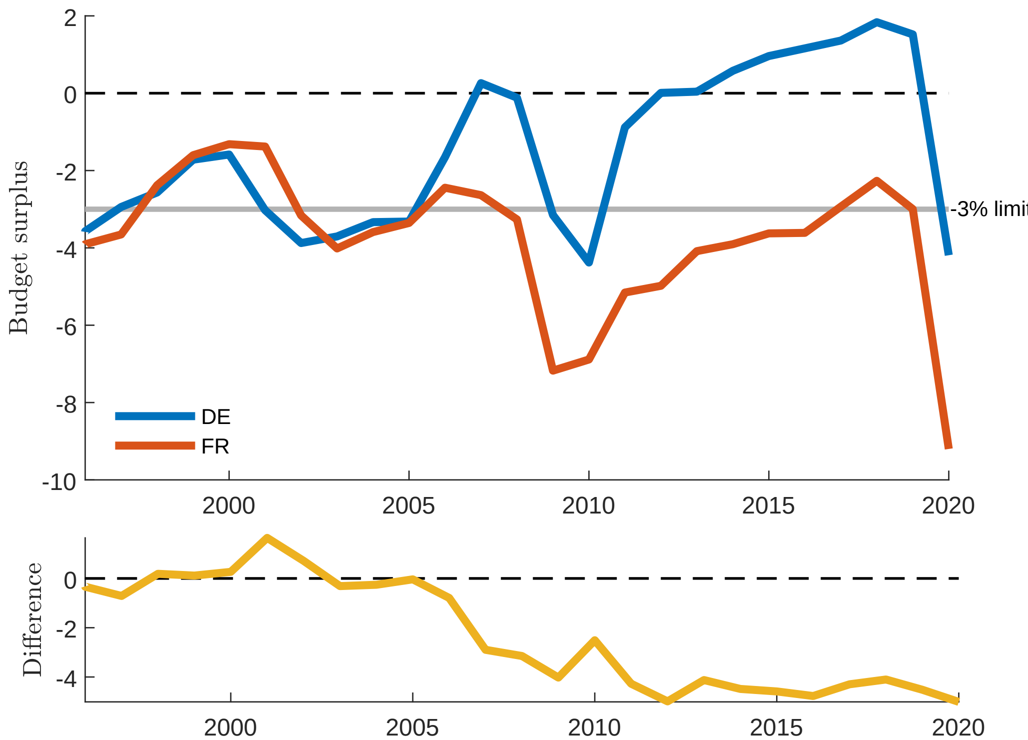
Figure 1 illustrates the problem most vividly with the case of France against Germany, the two largest members of the eurozone, in which countries are bound by a 3 percent ceiling on the budget deficit. Since 2005, France has almost constantly run a budget deficit larger than the 3 percent ceiling. At the same time Germany has almost constantly run a deficit smaller than the 3 percent ceiling. Does this mean that France is a less (fiscally) responsible member of the monetary union than Germany? Is France making less of an "effort" than Germany at respecting the fiscal rules underlying the Euro? Or is it that France suffered larger adverse shocks or tighter financing conditions than Germany and *as a result* ran a larger budget deficit?

Answering these questions is key for the credibility of any fiscal rule. If it is not possible to clearly establish and quantify policy makers' responsibility in cases of rule violations, it will always be difficult to impose sanctions, and rule compliance will remain a vague concept subject to interpretation and political interference. Ultimately, this can lead to frequent rule violation and lack of credibility, as has been the case with many fiscal rules (e.g., Eyraud et al., 2018; Larch and Santacroce, 2020). The necessity of establishing fiscal effort is even more acute for the long-run viability of a monetary union, where free rider problems and "fairness" considerations —all members should make as much effort as respecting the rules— come into play (e.g., Drazen, 2004).

[1] See e.g., Eyraud et al. (2018), Schaechter et al. (2012).

[2] Think for instance of the effects of recessions on unemployment insurance payments and tax receipts through the automatic stabilizers, or on the debt servicing cost through changes in the country's risk premium.

Figure 1: Budget surplus: France vs. Germany



Notes: Top panel: government budget balance in percent of GDP ("budget surplus") for France (FR) and Germany (DE) over 1995-2020. The bottom panel reports the difference between the two series.

In this paper, we propose a revealed-preference approach to measure policy makers' preference for respecting fiscal rules, or "fiscal discipline" for short. Our approach rests on a simple idea: Policy makers have a macro stabilization objective which can conflict with the fiscal rules, and when such conflicts arise, we can measure fiscal discipline from the way policy makers are trading off the macro stabilization objective with the fiscal rule objectives. For instance, following an adverse business cycle shock, a policy maker faces a trade-off between limiting the loss in GDP growth and a deterioration of the budget deficit. We measure fiscal discipline from the way policy makers balance this trade-off, identifying instances when the policy maker *could* have done better at satisfying the fiscal rule but *chose* not to.

When assessing fiscal effort, a central realization is that different policy makers may face different situations at different times —different underlying shocks— and may have different fiscal capacities and hence different abilities to control fiscal variables and respect the rules.[3] Any assessment of fiscal effort should thus be based on (i) what policy makers *could have done* to better respect the fiscal rule and (ii) *at what cost*. Because these two aspects can

[3]Think for instance of countries with a smaller tax base or countries with more tax evasion (e.g., Besley and Persson, 2012; Pappa, Sajedi and Vella, 2015).

differ across time or across countries, measuring fiscal effort directly from the fiscal variable itself (e.g., measuring the magnitude of the breach from a 3% deficit ceiling) cannot be used to compare fiscal effort across time or space.

Instead, our revealed-preference approach measures how much weight a policy maker puts on the fiscal rule objectives relative to a macro stabilization objective, taking into account the "possibility frontier" of the policy maker. Specifically, we consider a class of loss functions that combine the fiscal rules objective with a macro stabilization objective,[4] where the key parameter of interest is the relative weight on the fiscal rule objective: the policy maker's preference for fiscal discipline. Countries putting little weight on the fiscal rule will implement policies that stabilize the economy at the expense of large rule violations. Conversely, fiscally conservative countries will show little deviations from the fiscal rules even during large recessions. To measure the fiscal discipline associated with a policy decision, the idea is then to find the loss function's preference weight that best characterizes the policy decision as an optimal policy.

Importantly, this approach can be implemented without specifying a specific structural macro model nor a specific fiscal policy rule. Instead, we show that for a large class of macro models measuring the fiscal discipline preference parameter only requires two sufficient statistics: (i) sequences of forecasts for the macro objectives and fiscal variables conditional on the policy choice, and (ii) impulse responses of macro objectives and fiscal variables to fiscal policy shocks. The first statistic serves to capture the state of the economy and the nature of the trade-offs facing the policy maker at any point in time, while the second sufficient statistic —the impulse responses to policy shocks— serves to explore what the policy maker *could have done* to better respect the fiscal rule —the possibility frontier—.

The two statistics can be estimated using reduced form econometric models. To construct forecasts, one only needs to compute best predictions conditional on policy paths, and for that purpose we can draw on a variety of methods developed by the forecasting literature (e.g., Elliot and Timmermann, 2016). Similarly, the impulse responses to policy shocks can be estimated from reduced form models in combination with identification restrictions or instrumental variables (e.g., Ramey, 2016).[5]

[4]Although other objectives are present, macro stabilization is the main objective at business cycle frequencies, and it is the central trade-off involved in the implementation fiscal rules (Giavazzi et al., 2021; Arnold et al., 2022).

[5]More specifically, impulse responses can be estimated can be estimated from structural vars or local projections given some appropriate identification strategy, see Blanchard and Perotti (2002); Hall (2009); Owyang, Ramey and Zubairy (2013); Mertens and Ravn (2013); Auerbach and Gorodnichenko (2012, 2013); Ramey and Zubairy (2018); Alesina, Favero and Giavazzi (2019); Barnichon, Debortoli and Matthes (2021); Hall and Thapar (2021) for prominent examples for fiscal policy. These estimates include a broad variety of effects on government spending and tax changes. In addition, specific methods for forecasting fiscal variables are discussed in Favero and Marcellino (2005); Leal et al. (2008); Asimakopoulos, Paredes and Warmedinger (2020), which can complement general macro forecasting tools as discussed in Elliot and Timmermann

To illustrate our method, we measure fiscal discipline in the EU. We characterize the macro stabilization objective with the output gap and the fiscal rule is captured by the difference between the budget deficit and the 3% threshold as originally proposed in the Stability and Growth Pact (SGP). To obtain our sufficient statistics — forecasts and impulse responses —, we constructed a new database containing the economic forecasts provided by each Union member to the EU commission over 1998-2020, as based on the records of the Stability and Growth Pact (SGP). Combining these forecasts with impulse response estimates from Guajardo, Leigh and Pescatori (2014) that capture the effects from fiscal austerity packages, we measure fiscal discipline across all EU countries.

We find substantial variations in fiscal discipline across EU countries: southern EU countries but also France and Belgium put the least weight on the fiscal objectives, i.e., make the least effort to satisfy the SGP constraints. In contrast, Finland, Denmark, Sweden and The Netherlands are most fiscally responsible. Studying fiscal discipline over time, we document a significant drop in fiscal discipline over the 2007-2010 period, spearheaded by the two largest EU economies (France and Germany), though the deterioration in fiscal discipline was relative uniform across countries. After the great financial crisis however fiscal discipline diverged noticeably among EU countries: discipline improved substantially in many countries (notably Germany) all the way throughout the COVID crisis, but remained poor in a selected number of countries, most notably France. In fact, we find that France is among the countries putting the least weight on respecting the SGP.

Relation to literature

Many recent papers have discussed the need for an overhaul of fiscal rules (e.g. Claeys, Darvas and Leandro, 2016; Bénassy-Quéré et al., 2018*b*; Heinemann, 2018; Constâncio, 2020; Blanchard, Leandro and Zettelmeyer, 2020; Arnold et al., 2022). The debate has so far mostly focused on either the most appropriate fiscal instrument to put a cap on, say the budget deficit vs. the growth rate of government spending (e.g., Bénassy-Quéré et al., 2018*b*; Giavazzi et al., 2021; Martin, Pisani-Ferry and Ragot, 2021), on the appropriate level of the fiscal cap, e.g., when r falls below g (e.g., Blanchard, 2019; Furman and Summers, 2020), or more generally on the sustainability of public debt (e.g. Willems and Zettelmeyer, 2022; Reis, 2022).

However, the literature has payed little attention to the difficulty of imposing rules on endogenous variables — how to determine liabilities when the observable policy variables are only imperfectly controlled by the policy maker.[6] Instead, the endogeneity problem has

(2016).

[6]Note the stark difference between fiscal variables and the central banks' policy rate. The latter can be precisely controlled by the central bank (e.g. Kahn, 2010).

been "addressed" through heuristic methods, notably using "cyclically-adjusted" fiscal variables.[7] Unfortunately, there is no clear guidance on the most appropriate cyclical-adjustment method, and because of endogeneity biases it is not clear what this approach actually measures, see also Blanchard (1990).

Our approach to defining and measuring fiscal discipline borrows from the revealed-preference approach that is often used in public finance to measure policy makers' preferences, e.g., measuring preferences for income redistribution from observed tax plans —the inverse optimal-tax method— (e.g., Bourguignon and Spadaro, 2012; Jacobs, Jongen and Zoutman, 2017; Hendren, 2020).

Different from public finance, we do not rely on a specific structural model to learn preferences but instead use a sufficient statistics approach that allows us to make minimal assumptions on the underlying structural model. To do so, we borrow from Barnichon and Mesters (2023)'s sufficient statistics approach for macro policy. Specifically, Barnichon and Mesters (2023) show that the characterization of the optimal policy path can be reduced to the estimation of two sufficient statistics (i) forecasts for the policy objectives conditional on some baseline policy choice, (ii) the impulse responses of the policy objectives to policy shocks. We use this characterization of the optimal policy path to trace out the optimal policies for different weights on the fiscal objectives and subsequently define fiscal discipline as the weight that minimizes the distance from the proposed policy choice to the closest optimal policy choice.

That said, our revealed-preference approach to measuring fiscal discipline could also be implemented using a structural approach, borrowing for instance from the structural models of Galí and Monacelli (2008) or Halac and Yared (2014). After fitting or calibrating such models, one could back the preference parameter that minimizes the distance between the model implied optimal policy and the actual policy choice, as in the public finance literature cited above. Unfortunately, model mis-specification is a central worry among policy makers when evaluating fiscal rules as any assumed model structure may always be too stylized relative to the complexity and unknowns of the macroeconomy (e.g. Blanchard, Leandro and Zettelmeyer, 2020).

The remainder of this paper is organized as follows. Section 2 discusses a simple example that highlights why defining and measuring fiscal discipline is difficult using existing approaches and heuristically explains our approach. Section 3 defines the general macro environment in which our study takes place. Section 4 contains the main results for measuring fiscal discipline from revealed preferences. The results from the empirical analysis of fiscal discipline in the EU is discussed in Section 5 and Section 6 discusses extensions.

[7] Cyclical adjustment methodologies are adopted by, among others, the IMF, OECD and European Commission, see Girouard and André (2005); Fedelino, Ivanova and Horton (2009); IMF (2022); Mourre, Astarita and Princen (2014); Mourre, Poissonnier and Lausegger (2019) for exact descriptions of the methodology.

2 An illustrative example

Before formally describing our general framework, we first present a simple example to illustrate (i) how we define fiscal discipline from revealed preferences and (ii) how we measure fiscal discipline using sufficient statistics.

Let y_t denote the output gap and x_t the fiscal variable, which for concreteness we take as the fiscal deficit. The economy is described by

$$y_t = \alpha x_t + \xi_t \qquad \text{and} \qquad x_t = -\beta y_t + p_t \ . \tag{1}$$

The first equation describes how the output gap depends on the fiscal deficit as well as some exogenous shock ξ_t. The second equation separates the fiscal variable into two components: (i) an "external" component outside the policy maker's immediate control: $-\beta y_t$, with $\beta > 0$, and (ii) an "actionable" policy component p_t capturing changes in government spending, transfers or taxation that can be implemented by the policy maker.

The key distinction between the two components of x_t is that the policy maker is only "liable" for the second term: only p_t is chosen by the policy maker. In contrast, the first term —the feedback term βy_t— is given and outside the policy maker's control. One can think of βy_t as capturing the effects of the automatic stabilizers on tax receipts and on unemployment insurance payments, the effects of changes in the risk premium on the debt servicing cost, or other channels outside the policy maker's immediate control (e.g., see Taylor, 2000).

We posit that the policy maker sets p_t according to a rule of the form

$$p_t = \theta \xi_t + \epsilon_t \ , \tag{2}$$

where θ is the reaction to the exogenous shock ξ_t, and ϵ_t is an exogenous (uncorrelated of ξ_t) policy shock. Expression (2) captures how the policy maker systematically uses fiscal policy to smooth ξ_t shocks, while the shock ϵ_t captures exogenous deviations from a reaction coefficient θ. In other words, a policy choice is a pair (θ, ϵ_t).[8]

In sum, both the feedback term and p_t are endogenous variables, but the feedback term βy_t is taken as given by the policy maker (i.e. β is fixed), while p_t is controlled by the policy maker: θ is a choice variable.

Given a policy choice (θ, ϵ_t), we can solve the model and express the endogenous variables $W_t = (y_t, x_t)'$ as functions of the exogenous shocks (ξ_t, ϵ_t). We get

$$W_t = \Gamma \xi_t + \mathcal{R} \epsilon_t \ , \tag{3}$$

[8] While the policy rule (2) does not feature a feedback term —no reaction to the endogenous variable y_t—, this is only done for clarity of exposition. In our general treatment below, the rule for p_t will be generic and allow p_t to respond to all exogenous and endogenous variables in the economy.

with

$$\Gamma = \begin{pmatrix} \Gamma_y \\ \Gamma_x \end{pmatrix} = \begin{pmatrix} \frac{1+\alpha\theta}{1+\alpha\beta} \\ \frac{\theta-\beta}{1+\alpha\beta} \end{pmatrix} \qquad \text{and} \qquad \mathcal{R} = \begin{pmatrix} \mathcal{R}_y \\ \mathcal{R}_x \end{pmatrix} = \begin{pmatrix} \frac{\alpha}{1+\alpha\beta} \\ \frac{1}{1+\alpha\beta} \end{pmatrix} , \tag{4}$$

where $\mathcal{R}$ captures the impulse responses of $(y_t, x_t)'$ to the policy shock ϵ_t, while Γ captures the impulse response of $(y_t, x_t)'$ to a ξ_t shock.

Fiscal policy with and without fiscal constraints

To build up to our definition of fiscal discipline, we first describe the optimal policy with and without fiscal constraints.

Consider first a loss function that only takes into account macro stabilization $\mathcal{L}_t^y = \frac{1}{2}y_t^2$. The optimal allocation is characterized by

$$\min_{y_t,x_t,p_t} \mathcal{L}_t^y \qquad \text{s.t.} \quad (1) \ .$$

This allocation can be implemented by the policy rule

$$p_t = \theta^u \xi_t \qquad \text{with} \qquad \theta^u = -\frac{1}{\alpha} \ , \tag{5}$$

or in other words a policy choice $(\theta, \epsilon_t) = (\theta^u, 0)$.

Consider now a constrained fiscal policy. A legislator would like to restrain discretionary fiscal policy and ensure that the fiscal deficit x_t satisfies the condition $\mathcal{C} = \{x_t \leq \bar{x}\}$.[9]

A planner who takes the fiscal constraints into account now solves

$$\min_{y_t,x_t,p_t} \mathcal{L}_t^y \qquad \text{s.t.} \quad (1) \quad \text{and} \quad \mathcal{C} = \{x_t \leq \bar{x}\} \ .$$

After setting $\bar{x} = 0$ for ease of presentation (and only in this section), we can show that the following rule replicates the optimal allocation

$$p_t = \theta^c \xi_t \qquad \text{with} \qquad \theta^c = \begin{cases} -\frac{1}{\alpha} & \text{if} \quad (\theta^u - \beta)\,\xi_t \leq 0 \\ \beta & \text{if} \quad (\theta^u - \beta)\,\xi_t > 0 \end{cases} . \tag{6}$$

A policy maker following (6) will set the loss of the legislator, say $\mathcal{L}^x = \frac{1}{2}\left(x_t - \bar{x}_t\right)_+^2$ where $(a)_+ = a\mathbf{1}\{a > 0\}$, to zero, at the expense of a non-zero loss $\mathcal{L}_t^y$ whenever the fiscal threshold is exceeded. In other words, respecting the fiscal constraint $\mathcal{C}$ has a cost for the policy maker.

[9] In this paper, we do not take a stand on the reasons underlying this motive, only taking it at a starting point. Such constraints can be justified by deficit bias or financial externalities in a monetary union (e.g Drazen, 2004; Lledó et al., 2017; Eyraud et al., 2018).

Defining fiscal discipline from revealed preferences

Expressions (5) and (6) define two polar cases. In the first case, the policy maker does not pay attention to the fiscal constraint and minimizes her own loss, whereas in the second case the policy maker strictly follows the policy constraint at the cost of a higher macro loss $\mathcal{L}_t^y$. Between these two extremes however, there exists a range of values for $\theta \in [-1/\alpha, \beta]$, each corresponding to a different choice between minimizing $\mathcal{L}_t^y$ and minimizing $\mathcal{L}_t^x$, i.e., to a different preference for abiding by the fiscal constraint.

In fact, we can formalize this choice using a fictitious loss function that captures both the macro and fiscal stabilization objectives:

$$\mathsf{L}_t = \mathcal{L}_t^y + \lambda \mathcal{L}_t^x \ ,$$

where λ defines the weight on the fiscal constraint: the preference for "fiscal discipline" over macro stabilization.

Consider a policy maker solving the problem

$$\min_{p_t} \mathsf{L}_t \qquad \text{s.t.} \quad (1) \ . \tag{7}$$

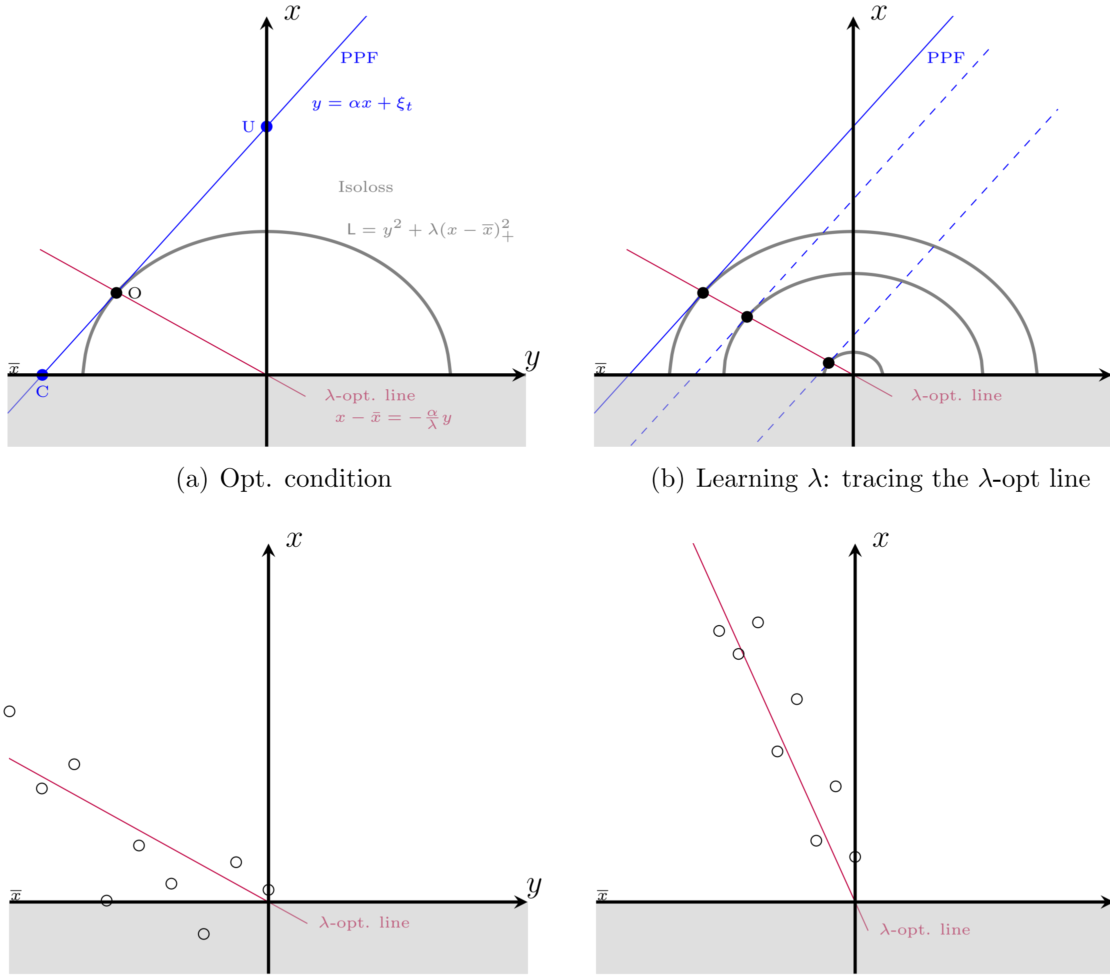
Figure 2(a) illustrates this problem graphically. The loss function is illustrated with an isoloss line (grey line) given by $\mathsf{L}(\lambda) = \mathcal{L}^y + \lambda \mathcal{L}^x$ for some fixed λ. Similar to the familiar bullseye chart encountered in monetary policy, the policy maker aims to to be as close to the center as possible.[10] With a quadratic loss, the isoloss line is an ellipse, whose shape depend on λ: the larger the weight on the fiscal rule, the flatter the ellipse. Specifically, the policy maker's marginal rate of substitution (MRS) between macro stabilization and the fiscal constraint is given by MRS $= -\lambda \frac{(x_t - \bar{x})_+}{y_t}$.

The policy maker's possibility frontier ("PPF", blue line) depicts the "technology" available to a policy maker: how her policy instrument affects the macro variable relative to the fiscal variable. The slope of the PPF is $1/\alpha$: the policy maker's marginal rate of transformation (MRT) between the fiscal deficit and the output gap. The larger the MRT —the flatter the PPF line—, the larger the ability of the policy maker to stabilize output without large movements in the deficit.

The "λ-optimal allocation" —the optimal allocation for the loss function $\mathsf{L}_t(\lambda)$— is such that the PPF is tangent to the isoloss curve: MRT = MRS, marked by the point O in the

[10] A difference is that the fiscal rule only applies for $x_t > \bar{x}$, so that we only depict the isoloss line for positive deficit realizations, and the shaded gray area is the region in which the policy maker faces no trade-off between macro stabilization and fiscal rules.

Figure 2: Illustration of the Revealed-preference approach



(a) Opt. condition

(b) Learning λ: tracing the λ-opt line

(c) High fiscal discipline

(d) Low fiscal discipline

figure. Analytically, this first order condition reads

$$\alpha = \lambda \frac{y_t}{(x_t - \bar{x})_+} \ , \tag{8}$$

which we represent in Figure 2(a) with the "λ-optimality line" in red.[11] The "λ-optimality line" has slope λ/α, and it gives the λ-optimal choice between stabilizing y_t and minimizing deviation from the fiscal constraint $x_t - \bar{x}$.

With some straightforward algebra, we can show that the following policy rule reproduces the λ-optimal allocation:

$$p_t^{\text{opt}}(\lambda) = \theta(\lambda)\xi_t \qquad \text{with} \qquad \theta(\lambda) = \frac{-\alpha + \beta\lambda}{\alpha^2 + \lambda} \ . \tag{9}$$

[11] Readers familiar with the optimal monetary policy literature will recognize (8) as an optimal targeting rule (e.g., Galí, 2015).

The two polar cases (no constraint, and binding constraint) are obtained for $\lambda = 0$ and $\lambda \to \infty$, and they correspond to the optimal policies derived above: a weight of zero on respecting the fiscal constraint (point U) or an infinite weight on respecting the constraint (point C), cf Figure 2(a). Intermediate values for λ correspond to intermediate preference for fiscal discipline, i.e, intermediate weights on the fiscal rule objectives.

In this simple model without policy shocks, there is an exact mapping between the rule coefficient θ and the preference parameter λ. Any reaction function choice θ^0 (with associated policy $p_t^0 = \theta^0 \xi_t$) corresponds to a unique preference parameter λ^0 as we have

$$\lambda^0 = \frac{\theta^0 \alpha^2 - \alpha}{\theta^0 + \beta} \ . \tag{10}$$

Guided by this simple mapping, we will define fiscal discipline as the preference parameter λ^0 that best describes a policy decision $(\theta^0, \varepsilon_t^0)$ as a λ-optimal decision, i.e., as a decision that balances macro stabilization and the fiscal constraint with preference weight λ^0. Formally, we define fiscal discipline as the preference parameter λ^0 given by

$$\lambda^0 = \underset{\lambda \in \mathbb{R}^+}{\operatorname{argmin}} \ \mathbb{E} \| p_t^0 - p_t^{\text{opt}}(\lambda) \|^2 \ . \tag{11}$$

Estimating fiscal discipline using sufficient statistics

Consider first a policy maker following a policy rule with parameter θ^0. How could we estimate her fiscal discipline parameter λ^0?

One difficulty in implementing the revealed-preference approach sketched above is that neither p_t^0 nor the λ-optimal policy $p_t^{\text{opt}}(\lambda)$ are directly observed. However, we can instead work with the first order condition of (11). With some simple algebra, the optimality condition underlying λ_0 is

$$\frac{\lambda^0}{\alpha} = \frac{Cov(x_{t,+}^0 y_t^0)}{Var(y_t^2)} \tag{12}$$

where $x_{t,+}^0$ and y_t^0 are realizations under the rule θ^0.

Thus, provided we can measure α (the marginal rate of transformation between fiscal deficit and output gap) and observe a sequence for $x_{t,+}^0$ and y_t^0, we can estimate λ from (12). Further, since the MRT can be measured from the impulse responses $\mathcal{R}$, this means that two statistics will be sufficient to estimate the fiscal discipline parameter λ^0: (i) the impulse responses to policy shocks, and (ii) a sequence for x_t^0 and y_t^0.[12]

A simple geometric interpretation helps understand the intuition behind this result. Con-

[12] We will see that this result generalizes to a large class of dynamic model, allowing us to estimate fiscal discipline with sufficient statistics and standard econometrics techniques and with minimal assumptions on the underlying economic model.

sider first a policy maker following a policy rule with parameter θ^0 and without policy shocks ($\varepsilon_t^0 = 0$). As the economy is hit by shocks ξ_t, the PPF will shift around, progressively tracing out the λ-optimality line over time, as sketched in Figure 2(b). Thus, provided we can observe a sequence for x_t and y_t under the policy rule θ^0, we can estimate the slope of the optimality line from $Cov(x_{t,+}, y_t)/Var(y_t)$. With the slope of the optimality line given by λ/α, we can compute λ provided we have some estimate for α.

In the presence of policy shocks —deviations from a reaction coefficient θ^0— the allocation may not always lie on an optimality line, but the parameter λ^0 is the parameter that best describes the observed allocation as minimizing a loss function of the form L_t. Geometrically, this amounts to minimizing the sum-of-squared deviations between the observed allocation and the λ-optimal line — akin to an OLS regression. As sketched in panels (c) and (d), countries with high fiscal discipline will trace out a flat optimality line —low deviations from the fiscal rule despite large negative output gaps—, while countries with low fiscal discipline will trace out a steep optimality line —high fiscal breaches despite mild negative output gap—.

On the "cyclical adjustment" of fiscal variables

Before we generalize our approach to a large class of underlying dynamic macro models, we briefly discuss how the policy practice has dealt with the endogeneity of fiscal variables.

A common heuristic approach to compare policy makers' effort at respecting fiscal rules is to use "cyclically-adjusted" fiscal variables, for instance the cyclically adjusted budget deficit, and to compare how far are these measures from the fiscal rule prescriptions (e.g., Bénassy-Quéré et al., 2018*a*).

The most common cyclical adjustment procedure consists in regressing the fiscal variable x_t on some cyclical indicator like the output gap (here y_t), and assessing fiscal discipline from the distance between the cyclically-adjusted fiscal variable —call it $\widetilde{p}_t$— and the fiscal rule prescription: $\mathbb{E}(\widetilde{p}_t - \bar{x})^2_+$.[13]

Unfortunately, because of a simultaneity bias (y_t and x_t are jointly determined), it is not clear what this regression estimates, not is it clear what the regression residual $\widetilde{p}_t$ actually captures.[14]

That said, through the lens of our simple framework, we could formalize an ideal cyclical adjustment procedure: (i) in a first step, it would isolate p_t from x_t, i.e., it removes the

[13]Given say a fiscal ceiling $\bar{x}$ (e.g., a 3% deficit ceiling as in the EU), the assessment of fiscal discipline is based on the magnitude of the breach of the cyclically-adjusted fiscal variable, what is often called the "structural" structural government balance.

[14]Several works have previously expressed concerns related to the use of cyclically adjusted variables (e.g. Blanchard, 1990), but these methods remain popular due to the lack of alternatives in the literature. The present paper offers an alternative route.

component of x_t for which the policy maker is *not* liable for —e.g., the effect of the automatic stabilizers—, (ii) it would estimate the policy rule for p_t (here the coefficient θ), and (iii) it would map the rule coefficients into revealed-preferences. In this simple model, there is mapping between θ and λ (equation (10)), so that this approach would be equivalent to measuring fiscal discipline: given some observed x_t, what is the policy maker's preference weight on the fiscal rule.

Unfortunately, this ideal approach is difficult to implement in practice. First, measuring p_t requires taking a stand on which component of x_t is the policy maker *liable for*. This is a hard question. Even in this simple example where the only feedback term comes from the automatic stabilizers, this would require detailed data on the underlying tax system to learn the cyclical elasticity (here β) of expenses and revenues implied by the fiscal system (progressivity of the tax code, specificities of the unemployment insurance system, etc.). Moreover, other external factors can influence x_t and would likely need to be removed, for instance the effects of financial market disruptions on the debt servicing cost. Second, estimating a policy rule for p_t suffers from the same endogeneity bias as mentioned above, and instrumental variables (here a proxy for the shocks ξ_t) would be needed. Third, one would need a structural model to map these rule coefficients into revealed-preferences. Overall, these are strong information requirements.[15].

The method that we propose does not suffer from these two issues: it does not require isolating p_t, and it does not require identifying ξ_t. In other words, our sufficient statistics approach to measuring fiscal discipline —assigning responsibilities in case of rule breaches— can be implement with limited information requirements.

3 Economic environment

In this section we describe a generic dynamic macro environment that includes a large class of macro models encountered in the literature but without committing to a particular one.

Generic model

Using a sequence space representation (e.g., Auclert et al., 2021), denote by $\mathbf{X}_t = (x_t', x_{t+1}', \ldots)'$ and $\mathbf{Y}_t = (y_t', y_{t+1}', \ldots)'$ the time t paths of the fiscal and non-fiscal variables where $x_t = (x_{1,t}, \ldots, x_{M_x,t})'$ and $y_t = (y_{1,t}, \ldots, y_{M_y,t})'$ and (respectively) vectors of macro and fiscal variables. The time t expected values of these paths are denoted by $\mathbb{E}_t\mathbf{X}_t$ and $\mathbb{E}_t\mathbf{Y}_t$, where $\mathbb{E}_t(\cdot) = \mathbb{E}(\cdot|\mathcal{F}_t)$, with $\mathcal{F}_t$ the time t information set. A generic model for the economy at

[15] The practice falls short of these requirements (e.g., Girouard and André, 2005)

time t is given by

$$\mathbb{E}_t\mathbf{Y}_t - \mathcal{A}_{yx}\mathbb{E}_t\mathbf{X}_t = \boldsymbol{\Upsilon}_t \qquad \text{and} \qquad \mathbb{E}_t\mathbf{X}_t - \mathcal{A}_{xy}\mathbb{E}_t\mathbf{Y}_t = \mathcal{B}_{xv}\boldsymbol{\Upsilon}_t + \mathbb{E}_t\mathbf{P}_t \ . \tag{13}$$

The first equation (left-hand side) captures the macro block which relates the non-fiscal path $\mathbb{E}_t\mathbf{Y}_t$ to the fiscal path $\mathbb{E}_t\mathbf{X}_t$ and the path of the exogenous and predetermined variables $\boldsymbol{\Upsilon}_t = (v_t', v_{t,t+1}', v_{t,t+2}', \ldots)'$: structural shocks or lagged macro variables. For short, we will refer to the elements of $\boldsymbol{\Upsilon}_t$ as the exogenous inputs. The vector v_t captures the time t vector of exogenous input for y_t, while the terms $v_{t,t+h}$ for $h = 1, 2, \ldots$ are the exogenous inputs for the expected path $\mathbb{E}_t y_{t+h}$. We normalize the exogenous component to be mean zero, but its elements can and will generally be correlated.

The second equation (right-hand side) captures the fiscal block, where the components $\mathcal{A}_{xy}\mathbb{E}_t\mathbf{Y}_t$ and $\mathcal{B}_{pv}\boldsymbol{\Upsilon}_t$ capture the *external* determinants of the fiscal variables (e.g., the effect of the automatic stabilizers on the deficit or the effects of risk premium shocks on the budget deficit). As in the simple example, we treat these determinants —the coefficients $\mathcal{A}_{xy}$ and $\mathcal{B}_{xv}$— as outside of the control of the fiscal policy maker. Instead, the policy maker can choose the path $\mathbb{E}_t\mathbf{P}_t = \mathbb{E}_t(p_t', p_{t+1}', p_{t+2}', \ldots)'$, which we can think of as the "actionable" component of fiscal policy.

Fiscal policy

We write the policy rule for $\mathbb{E}_t\mathbf{P}_t$ as

$$\Theta_{pp}\mathbb{E}_t\mathbf{P}_t = \Theta_{py}\mathbb{E}_t\mathbf{Y}_t + \Theta_{pv}\boldsymbol{\Upsilon}_t + \boldsymbol{\epsilon}_t \ , \tag{14}$$

where we have decomposed the path into (i) a generic response to the state of the economy —as described by $\Theta = (\Theta_{pp}, \Theta_{py}, \Theta_{pv})$— and policy shocks $\boldsymbol{\epsilon}_t$. We impose that Θ_{pp} is lower triangular with positive diagonal elements.

The component $\boldsymbol{\epsilon}_t = (\epsilon_t', \epsilon_{t,t+1}', \epsilon_{t,t+2}', \ldots)'$ captures the path of the policy news shocks, which are mean zero with unit variance and uncorrelated with the exogenous inputs $\boldsymbol{\Upsilon}_t$. Specifically, the vector $\epsilon_t = (\epsilon_{1,t}, \ldots, \epsilon_{M_p,t})'$ includes the contemporaneous policy shocks to the policy instruments and $\epsilon_{t,t+h}$ are policy news shocks: information revealed at time t about policy shocks that realize at time $t + h$.

A policy choice is then defined by a pair $(\Theta, \boldsymbol{\epsilon}_t)$ consisting of the rule parameters Θ and the policy news shocks $\boldsymbol{\epsilon}_t$. We will denote the specific choice of the policy maker by $(\Theta^0, \boldsymbol{\epsilon}_t^0)$and by $\mathbb{E}_t\mathbf{P}_t^0$ and $\mathbb{E}_t\mathbf{Y}_t^0$ the associated paths for the policy instruments and policy objectives.

Note that we can think of the policy shocks as resulting from idiosyncratic deviations from a fixed policy rule. Suppose that a policy maker implements a time-varying reaction function with

$$\Theta_{pp,t}\mathbb{E}_t\mathbf{P}_t = \Theta_{py,t}\mathbb{E}_t\mathbf{Y}_t + \Theta_{pv,t}\boldsymbol{\Upsilon}_t \ , \qquad \Theta_{..,t} = \Theta_{..} + \Delta_{..,t} \ ,$$

where $\Delta_{..,t}$ are iid mean zero maps with independent entries that capture the policy maker's time t deviation from the baseline policy rule. This time-varying can be written as a fixed policy rule, with policy shocks given by $\boldsymbol{\epsilon}_t = -\Delta_{pp,t}\mathbb{E}_t\mathbf{P}_t + \Delta_{py,t}\mathbb{E}_t\mathbf{Y}_t + \Delta_{pv,t}\boldsymbol{\Upsilon}_t$.

Overall, the generic model (13)-(14) includes many specific models that have been adopted for studying fiscal policy, see Benigno and Woodford (2003), Kirsanova et al. (2007) and Galí and Monacelli (2008) for some examples.

Impulse responses and oracle forecasts

We can now define the impulse responses to the structural shocks.

Lemma 1. *Given model* (13)-(14) *and any policy choice* $(\Theta, \boldsymbol{\epsilon}_t)$*, where* Θ *leads to a unique and determinate equilibrium, we have that*

$$\mathbb{E}_t\mathbf{W}_t = \mathcal{D}\boldsymbol{\Upsilon}_t + \mathcal{R}\boldsymbol{\epsilon}_t \tag{15}$$

where $\mathbb{E}_t\mathbf{W}_t = (\mathbb{E}_t\mathbf{Y}_t', \mathbb{E}_t\mathbf{X}_t')'$ *and* $\mathcal{D} = (\mathcal{D}_y', \mathcal{D}_x')'$ *and* $\mathcal{R} = (\mathcal{R}_y', \mathcal{R}_x')'$ *are the impulse responses to the exogenous inputs and the policy news shocks.*

All proofs are collected in the appendix. Note that since the entries of $\boldsymbol{\Upsilon}_t$ are correlated and in general a mix of non-policy shocks and initial conditions $\mathcal{D}$ does not have a structural interpretation. In contrast, $\mathcal{R}$ captures the structural impulse responses of $\mathbb{E}_t\mathbf{Y}_t$ and $\mathbb{E}_t\mathbf{X}_t$ to the fiscal policy shocks $\boldsymbol{\epsilon}_t$. It is instructive to note the similarity between Lemma 1 and the expression obtained in the simple example, i.e. equation (3).

Macro and fiscal objectives

The macro stabilization objective is captured by the loss function

$$\mathcal{L}_t^y = \frac{1}{2}\mathbb{E}_t\mathbf{Y}_t\mathcal{W}_y\mathbf{Y}_t \ , \tag{16}$$

where $\mathcal{W}_y$ is a diagonal map with non-negative entries that select the variables and horizons that correspond to the specific macro stabilization objectives of interest.

Turning to the fiscal stabilization objective, we consider a legislator who wants to restrain the policy makers' actions and ensure that some fiscal variables $x_{i,t+h}$ satisfy constraints of the form

$$\mathcal{C} = \{x_{i,t+h} \leq \bar{x}_{i,t+h} \ , \qquad i = 1, \ldots, M_x \ , \qquad h = 0, 1, \ldots\} \ ,$$

where $\bar{x}_{i,t+h}$ is some threshold.[16] We stack the constraints on the fiscal variables in $\bar{\mathbf{X}}_t = (\bar{x}'_t, \bar{x}'_{t+1}, \ldots)'$, with $\bar{x}_t = (\bar{x}_{1,t}, \ldots, \bar{x}_{M_x,t})'$.

We posit that deviating from the fiscal constraint ($\mathbf{X}_t > \bar{\mathbf{X}}_t$) incurs some loss that we capture by the function

$$\mathcal{L}^x_t = \frac{1}{2}\mathbb{E}_t(\mathbf{X}_t - \bar{\mathbf{X}}_t)'_+ \mathcal{W}_x (\mathbf{X}_t - \bar{\mathbf{X}}_t)_+ \ , \tag{17}$$

where $\mathcal{W}_x$ is a diagonal weighting matrix (possibly allowing for discounting) and $(\mathbf{X}_t - \bar{\mathbf{X}}_t)_+$ has elements $(x_{i,t+h} - \bar{x}_{i,t+h})_+ = \mathbf{1}(x_{i,t+h} > \bar{x}_{i,t+h})(x_{i,t+h} - \bar{x}_{i,t+h})$.

4 Measuring fiscal discipline from revealed preferences

In this section we discuss our main results that (i) define fiscal discipline as the weight that the proposed policy choice $(\Theta^0, \boldsymbol{\epsilon}^0_t)$ implicitly places on the fiscal objective and (ii) show that fiscal discipline can be estimated using sufficient statistics: —forecasts and impulse responses—.

4.1 Defining fiscal discipline

To elicit fiscal discipline from policy decisions we define the λ-weighted loss function

$$\mathsf{L}_t = \mathcal{L}^y_t + \lambda \mathcal{L}^x_t \ , \tag{18}$$

where $\lambda > 0$ is the weight on the fiscal stabilization objective. The intuition is the same as in the simple example; with $\lambda = 0$ no weight is placed on the fiscal objectives, whereas with $\lambda \to \infty$ the fiscal rules are perfectly respected. For any given λ we can define an optimal policy path as follows:

Definition 1 (λ-Optimal policy path)**.** *The λ-optimal policy allocation is defined by*

$$\min_{\mathbf{Y}_t, \mathbf{X}_t, \mathbf{P}_t} \ \mathsf{L}_t \qquad s.t. \quad (13) \ , \tag{19}$$

and we denote a λ-optimal policy path by $\mathbb{E}_t \mathbf{P}^{\text{opt}}_t(\lambda)$ if it satisfies (19)*.*

For convenience we make the following assumption.

[16] The thresholds can be time and horizon specific, although in practice fiscal ceilings are constant across time and horizon, for instance a 3% deficit ceiling (e.g. Lledó et al., 2017).

Assumption 1. *The λ-optimal policy path $\mathbb{E}_t\mathbf{P}_t^{\text{opt}}(\lambda)$ is unique for all $\lambda > 0$.*

This assumption is only imposed to make the exposition easier, but it can be easily removed at the expense of more notation.[17]

Consider now a policy maker with policy choice $(\Theta^0, \boldsymbol{\epsilon}_t^0)$ that implies the policy path $\mathbb{E}_t\mathbf{P}_t^0$. We impose the following assumption on this choice.

Assumption 2. *The policy choice $(\Theta^0, \boldsymbol{\epsilon}_t^0)$ underlying the policy path $\mathbb{E}_t\mathbf{P}_t^0$ leads to a unique and determinate equilibrium.*

For any of such policy choices we define the fiscal discipline of a policy maker as follows.

Definition 2 (Fiscal discipline)**.** *Given a policy choice $(\Theta^0, \boldsymbol{\epsilon}_t^0)$, under Assumptions 1-2 the fiscal discipline preference parameter is given by*

$$\lambda^0 = \underset{\lambda>0}{\operatorname{argmin}}\, \mathbb{E}\|\mathbb{E}_t\mathbf{P}_t^0 - \mathbb{E}_t\mathbf{P}_t^{\text{opt}}(\lambda)\|^2 \ . \tag{20}$$

The intuition from the simple example carries over to the more general definition 2: If a policy maker chooses a policy path $\mathbb{E}_t\mathbf{P}_t^0$ that is closest in distance to the optimal path $\mathbb{E}_t\mathbf{P}_t^{\text{opt}}(\lambda^0)$, by revealed-preference this means that the policy maker has a preference parameter λ^0 for fiscal discipline.

4.2 Measuring fiscal discipline

In general, the definition of fiscal discipline does not easily transfer to a measurable quantity unless the specific maps $\mathcal{A}_{..}$ and $\mathcal{B}_{..}$ in the general model are known.[18]

These requirements are strong when there is much uncertainty about the underlying structure of the economy. Fortunately, in generic models of the form (13), it is possible to compute the distance between some baseline policy path and an optimal policy path (optimal for some known loss function) from sufficient statistics alone.

Formally, we establish the following proposition that allows us to measure fiscal discipline from sufficient statistics:

[17] For example, suppose that there are multiple optimal policy paths collected in the set $\mathcal{P}_t^{\text{opt}}$. We could always redefine fiscal discipline from definition 2 as

$$\lambda^0 = \underset{\lambda>0}{\operatorname{argmin}} \min_{\mathbb{E}_t\mathbf{P}_t^{\text{opt}}(\lambda)\in\mathcal{P}_t^{\text{opt}}} \mathbb{E}\|\mathbb{E}_t\mathbf{P}_t^0 - \mathbb{E}_t\mathbf{P}_t^{\text{opt}}(\lambda)\|^2 \ .$$

[18] In such case $\mathbb{E}_t\mathbf{P}_t^{\text{opt}}(\lambda)$ can be determined exactly which can then be compared with $\mathbb{E}_t\mathbf{P}_t^0$, provided that this path is observable.

Proposition 1. *For a policy maker that chooses* $(\Theta^0, \boldsymbol{\epsilon}_t^0)$ *satisfying Assumptions 1-2 the fiscal discipline parameter can be computed from*

$$\lambda^0 = \underset{\lambda>0}{\operatorname{argmin}}\, \mathbb{E}\|\mathcal{H}_\lambda^0 \mathcal{R}^{0\prime}\mathcal{W}_\lambda \mathbb{E}_t \mathbf{W}_t^{0+}\|^2 \ , \tag{21}$$

where

$$\mathcal{H}_\lambda^0 = \mathcal{R}_x^0(\mathcal{R}^{0\prime}\mathcal{W}_\lambda\mathcal{R}^0)^{-1}$$

with $\mathcal{R}^0$ *and* $\mathbb{E}_t\mathbf{W}_t^{0+} = (\mathbb{E}_t\mathbf{Y}_t^{0\prime}, \mathbb{E}_t(\mathbf{X}_t^0 - \bar{\mathbf{X}}_t)'_+)'$ *the impulse responses and forecasts under the policy choice* $(\Theta^0, \boldsymbol{\epsilon}_t^0)$ *as defined in Lemma 1, and* $\mathcal{W}_\lambda = \operatorname{diag}(\mathcal{W}_y, \lambda\mathcal{W}_x)$*.*

Proposition 1 states that even though the two policy paths in (20) are not directly observable, it is still possible to compute their distance. For a linear-quadratic problem the distance between some baseline path and the optimal policy is given by the gradient of the loss function (evaluated at the baseline policy) scaled by the inverse Hessian (e.g., Nocedal and Wright, 2006). A key realization of Barnichon and Mesters (2023) is that that gradient (as well as the Hessian) can be computed from sufficient statistics alone: the impulse responses to policy shocks and the forecasts for the allocation under the policy choice $(\theta^0, \boldsymbol{\epsilon}_t^0)$.

Expression (21) is precisely that scaled gradient with $\nabla_p \mathsf{L}_t(\lambda) = \mathcal{R}^{0\prime}\mathcal{W}_\lambda\mathbb{E}_t\mathbf{W}_t^{0+}$ the gradient of the loss function: $\mathcal{R}^0$ captures the marginal effect of a policy change on the policy objectives, such that a $\mathcal{R}^{0\prime}\mathcal{W}_\lambda\mathbb{E}_t\mathbf{W}_t^{0+}$ captures the marginal effect of a policy change on the loss function $\mathsf{L}_t(\lambda)$.

Inference on fiscal discipline can then be conducted by replacing these population parameters by their sample counterparts and assessing the uncertainty around these parameters. In practice many different methods can be used for estimating impulse responses (Ramey, 2016) and constructing forecasts (Leal et al., 2008; Elliot and Timmermann, 2016).

4.3 Subset fiscal discipline

Measuring fiscal discipline from Proposition 1 requires the entire set $\mathcal{R}^0$ of impulse responses to policy shocks. In practice, computing all impulse responses can be infeasible as identifying shocks to every element of the expected policy path can be hard. Moreover, the policy shocks that we do identify in practice need not correspond to a single news shock, but could instead be a linear combination of multiple policy news shocks (e.g., McKay and Wolf, 2023).

To circumvent this requirement, let $\boldsymbol{\epsilon}_{a,t}$ denote the subset (or linear combination) of policy shocks that can be identified, $\mathcal{R}_a$ the corresponding impulse responses, and $\mathbb{E}_t\mathbf{P}_{a,t}$ the corresponding subset policy path.[19] The paths $\mathbb{E}_t\mathbf{P}_{a,t}^0$ and $\mathbb{E}_t\mathbf{P}_{a,t}^{\mathrm{opt}}$ are then the baseline and optimal subset policy paths. We defined subset fiscal discipline as follows:

[19] Technically, the subset policy path is the subset of $\mathbb{E}_t\mathbf{P}_t$ that is spanned by the shocks $\boldsymbol{\epsilon}_{a,t}$: the projection

Definition 3 (Subset fiscal discipline)**.** *Given a policy choice* $(\Theta^0, \boldsymbol{\epsilon}_t^0)$*, under Assumptions 1-2 the subset fiscal discipline preference parameter is given by*

$$\lambda_a^0 = \underset{\lambda>0}{\operatorname{argmin}}\, \mathbb{E}\|\mathbb{E}_t\mathbf{P}^0_{a,t} - \mathbb{E}_t\mathbf{P}^{\text{opt}}_{a,t}(\lambda)\|^2 \ . \tag{22}$$

The following corollary shows how fiscal discipline can be recovered from sufficient statistics.

Corollary 1. *For a policy maker that chooses* $(\Theta^0, \boldsymbol{\epsilon}_t^0)$ *satisfying Assumptions 1-2 the subset fiscal discipline parameter can be computed from*

$$\lambda_a^0 = \underset{\lambda>0}{\operatorname{argmin}}\, \mathbb{E}\|\mathcal{H}^0_{a,\lambda}\mathcal{R}_a^{0\prime}\mathcal{W}_\lambda\mathbb{E}_t\mathbf{W}_t^{0+}\|^2 \ ,$$

where $\mathcal{H}^0_{a,\lambda} = \mathcal{R}^0_{a,x}(\mathcal{R}_a^{0\prime}\mathcal{W}_{\lambda_a}\mathcal{R}_a^0)^{-1}$ *with* $\mathcal{R}_a^0$ *are the impulse responses corresponding to* $\boldsymbol{\epsilon}_{a,t}$ *under* Θ^0*,* $\mathbb{E}_t\mathbf{W}_t^{0+} = (\mathbb{E}_t\mathbf{Y}_t^{0\prime}, \mathbb{E}_t(\mathbf{X}_t^0 - \bar{\mathbf{X}}_t)'_+)'$ *are the forecasts under* $(\Theta^0, \boldsymbol{\epsilon}_t^0)$ *and* $\mathcal{W}_\lambda = \operatorname{diag}(\mathcal{W}_y, \lambda\mathcal{W}_x)$*.*

The corollary is of practical relevance as it shows that only the subset of impulse responses are needed to identify fiscal discipline for different subsets of policy instruments. Hence, even in situations where not all fiscal policy shocks can be recovered we can still measure fiscal discipline with respect to the policy instruments for which exogenous variations exist.

4.4 Estimating fiscal discipline

We outline how (subset) fiscal discipline can be estimated in practice. Let $\widehat{\mathcal{R}}_a$ and $\widehat{\mathbf{W}}_t^+$ denote the estimate/approximation for the impulse responses $\mathcal{R}_a$ and oracle forecasts $\mathbb{E}_t\mathbf{W}_t^{0+}$, respectively. The impulse responses and forecasts can be obtained using any preferred method, see the introduction for numerous references in the context of fiscal policy. We postulate that the forecasts cover the period $t = 1, \ldots, n$.

Further, suppose that the (approximate) distribution of these quantities is given by

$$\begin{pmatrix} \operatorname{vec}(\widehat{\mathcal{R}}_a - \mathcal{R}_a^0) \\ \widehat{\mathbf{W}}_t^+ - \mathbb{E}_t\mathbf{W}_t^{0+} \end{pmatrix} \overset{a}{\sim} \widehat{F}_t \ .$$

In practice, Bayesian or bootstrap methods are often attractive to obtain the distribution $\hat{F}_t$. To compute the distribution of fiscal discipline the following steps can be followed.

1. for $j = 1, \ldots, S$

of $\mathbb{E}_t\mathbf{P}_t$ on $R_{x,a}$ with $\mathbb{E}_t\mathbf{P}_{a,t} \equiv P_a\mathbb{E}_t\mathbf{P}_t$ where $P_a = \mathcal{R}_{x,a}\left(R'_{x,a}R_{x,a}\right)^{-1}\mathcal{R}'_{x,a}$ and $\mathcal{R}_{x,a}$ denote the impulse responses of $\mathbb{E}_t\mathbf{P}_t$ to the subset shocks $\boldsymbol{\epsilon}_{a,t}$.

(a) simulate $\mathcal{R}_a^{(j)}$, $\mathbf{W}_t^{(j)+}$ and $\mathcal{H}_{a,\lambda}^{(j)}$ from $\widehat{F}_t$ for each period

(b) Compute

$$\lambda_a^{(j)} = \underset{\lambda_a > 0}{\operatorname{argmin}} \frac{1}{n} \sum_{t=1}^{n} \| \mathcal{H}_{a,\lambda}^{(j)} \mathcal{R}_a^{(j)\prime} \mathcal{W}_\lambda \mathbf{W}_t^{(j)+} \|^2$$

2. Report the mean and quantiles of the set $\{\lambda^{(1)}, \ldots, \lambda^{(S)}\}$.

We typically set $S = 1000$ and use a numerical solver to solve the minimization problem.

4.5 Extensions

While we described our main results for the environment described by equations (13)-(14) and (16)-(17), we briefly mention a few extensions for which our results can be generalized.

First, the generic model (13)-(14) is taken as a linear model. This is not necessary: nonlinear features such as state dependence (e.g. Ramey and Zubairy, 2018; Barnichon, Debortoli and Matthes, 2021) and time variation in the coefficients can be easily accommodated. The important restriction is that the coefficients of the macro-fiscal block (13) are independent from the coefficients in the policy reaction function (14), such that the effects of policy on the macro block enter solely via the expected path $\mathbb{E}_t \mathbf{X}_t$ (e.g. Barnichon and Mesters, 2023; McKay and Wolf, 2023).

Second, the loss functions in (16)-(17) are taken as linear quadratic, and we impose no further constraints. Both aspects can be relaxed. We can allow for general strictly convex loss functions, at the expense of needing more sufficient statistics to compute fiscal discipline.[20] Moreover, additional external constraints on the policy path $\mathbb{E}_t \mathbf{P}_t^0$ can also be considered (e.g., constraints on the degree of variability of the policy path – avoiding abrupt changes in policy), can be incorporated by replacing the loss function L_t with a Lagrange function that takes into account the additional constraints.

5 Empirical illustration

In this section we apply our approach to measure fiscal discipline across EU countries since the introduction of the Euro; countries' effort at respecting the Stability and Growth Pact (SGP).

[20] Specifically, we will need density or quantile forecasts instead of merely point forecasts for the conditional expectation.

5.1 Preliminary

Before presenting our results we define the macro stabilization and fiscal objectives that we consider, and we describe how we recovered or estimated the two sets of sufficient statistics.

The loss functions

Since the SGP imposes a 3% ceiling on budget deficits, we consider a loss function capturing two objectives: (i) keeping GDP growth y at potential y^*, and (ii) keeping the budget surplus s above $\bar{s} = -3$ percent:

$$\mathbb{E}_t \mathsf{L} = \sum_{h=0}^{H} \mathbb{E}_t (y_{t+h} - y^*)^2 + \lambda \sum_{h=0}^{H} \mathbb{E}_t (s_{t+h} - \bar{s})_+^2 \tag{23}$$

Since the SGP requires paths for the next 3 years, we will fix the horizon at $H = 3$ years.[21]

In other words, we capture the macro stabilization objective with the output gap, while the fiscal constraint is a constraint on the budget deficit. Clearly more elaborate loss functions could be considered, but we focus on the 3% deficit ceiling since most disputes related to SGP breaches pertained to the budget deficit ceiling.

Data requirements

Conditional forecasts While individual EU countries have been reporting forecasts to EU commission since 1998 as part of the Stability and Growth Pact, there is no dataset aggregating this information. To remedy this limitation, we compiled all SGP records and documents submitted by individual countries since 1998 and created a panel of 1-to-4 year ahead annual country forecasts over 1998-2023. The forecasts cover unemployment, GDP growth, the budget surplus and the debt-to-GDP ratio. The forecasts are conditional on the intended fiscal path. As illustration, Figure 3 displays the forecasts for the budget surplus and the real growth rate submitted by France and Germany.

Since the forecasts reported to the EU commission can (for certain countries) show a high degree of bias, we bias-adjusted all forecasts by removing the horizon specific trend for each country such that the forecasts are unconditionally unbiased. Figure 4 shows the average forecasts before and after bias adjustment. We can see that the France forecasts for the budget surplus are highly biased in the long run, see the bottom panel of Figure 4. The bias is also present for Germany but much less pronounced.

[21] Naturally, more complicated loss functions are possible —including an additional debt-GDP target for instance.

Impulse response to budget deficit shocks As impulse responses to policy shocks, we rely on the set of impulse response estimates from Guajardo, Leigh and Pescatori (2014) that capture the effects of fiscal austerity packages. Given our SGP focus, we only use EU countries in our estimation. Figure 5 plots the estimated impulse responses. After a fiscal consolidation shock, the budget deficit improves by about 1.5ppt while GDP growth is lower by about 0.5ppt for two years.

5.2 Fiscal discipline across EU countries

With the conditional forecasts and impulse responses in hand, we can use Corollary 1 to compute fiscal discipline λ^i for each country i. We first report the estimated λs over the full sample before turning to changes in fiscal discipline over time.

Figure 6 plots the 1998-2023 estimates with the 68 percent confidence intervals, ranking countries from lowest fiscal discipline (lowest weight λ^i on the fiscal objectives) to highest discipline (highest weight λ^i). We cap our λ estimates at 4, as λ is not identified (resp. poorly identified) for countries with no (few) breaches of the 3% deficit ceiling.

Two separate groups clearly stand out in terms of fiscal discipline. Confirming popular opinions, southern countries (Portugal, Spain) put less weight on the fiscal constraint relative to macro stabilization. A new finding however is that France, Belgium and even Austria put just as little weight on keeping the budget deficit under 3%. In other words, once we take into account the "superior" economic outlook of France and Belgium relative to the southern EU countries,[22] France and Belgium are no more fiscally responsible than the southern EU countries. In contrast, the northern countries (Holland, Denmark, Finland, Sweden and to a lesser extent Germany) form a second group with much higher fiscal discipline.

5.3 Fiscal discipline over time

Figure 7 shows the evolution of average fiscal discipline in the EU since the introduction of the Euro in 1999 (black line), along with the interquartile range.

In the initial phase of the Euro (1999-2002), all countries adhered to the fiscal deficit ceiling, and (unsurprisingly) we estimate uniformly high fiscal discipline with λs over 4 for all countries.

Over 2002-2006, fiscal discipline started to deteriorate *ahead* of the great financial crisis (GFC), but the deterioration was concentrated in a subset of countries, see the widening of the interquartile range. In fact, the decline in fiscal discipline was led by the two largest Euro economies —France and Germany—, which we discuss later in more details.

[22] Note that the outlook —the *path* forecasts for y_t and s_t— denotes not only the magnitude of the shocks affecting the economies, but also the nature of the shocks as well as their dynamics.

During the financial crisis, fiscal discipline deteriorated further and this time the decline in λ is noticeable in almost all EU countries, see the narrowing of the inter-quartile range and Figure 8. Subsequently, fiscal discipline improved throughout the union, including during the COVID crisis.

In fact, it is interesting to contrast fiscal discipline in the GFC and in the COVID crises. Figure 8 shows our estimated fiscal discipline parameters for each country in the two periods. During the GFC, fiscal discipline presents a bimodal distribution with (i) a subset of countries with record low levels (significantly below 1) —the southern EU countries, as well France, Belgium and even Germany—, and (ii) another subset with high discipline throughout —the Scandinavian countries (Denmark, Finland and Sweden)—. In comparison, fiscal discipline was both substantially higher and more uniform during the COVID crisis, where all countries had fiscal discipline parameters above 1 (except for Portugal with large error bands).

5.4 France vs. Germany

Going back to our initial motivation in the introduction, it is interesting to study in more details the fiscal discipline of France and Germany, the two largest economies of the EU and as such pillars of the monetary union. This discussion will also help illustrate (i) the workings of our revealed-preference approach to measuring fiscal effort, and (ii) how we can use our revealed-preference approach to assign responsibilities in case of rule violation.

Figure 1 shows the evolution of the budget surpluses of France and Germany over the past 25 years. Germany occasionally deviated from the 3 percent deficit ceiling, but the breaches are short and mild. The situation of Germany contrasts with that of France. While the two surpluses moved in tandem until 2005, since then France has done little fiscal consolidation and has consistently breached the 3% limit.

A natural question is then whether France made less of an effort than Germany in respecting the SGP. This has long been a common suspicion in Germany,[23] though a difficult one to prove: since the fiscal deficit is an endogenous variable, it is difficult to assign responsibility in the case of SGP breaches —the central motivation of this paper. Indeed, confounding factors might explain the larger SGP breach, for instance because a much worse economic situation affected France during and after the GFC, or because the nature or dynamics of the shocks affecting France were different and led France to run a larger deficit than Germany.

To contrast the evolution of fiscal discipline in the two countries over time, Figure 9 plots the sub-sample λ estimates for the two countries along with the EU interquartile range.

Initially both countries showed a comparable (though already larger for France) deteri-

[23] See for instance some German reactions to a recent French proposals to reform the SGP: *France in pre-election push to soften the eurozone's budget rules* DW, May 2021 https://www.dw.com/en/france-in-preelection-push-to-soften-the-eurozones-budget-rules.

oration in fiscal discipline immediately after the introduction of the Euro. Comparing with the interquartile range, we can see that France and Germany "led" the way in undermining the SGP by immediately putting less effort on respecting the fiscal rule. Poor fiscal discipline in France in Germany continued during the GFC, though France again displayed substantially lower fiscal discipline (more than 50% lower) than Germany. In fact, during the GFC France displayed the smallest fiscal discipline parameter across *all* EU countries, a fact that cannot be seen from the magnitude of the budget deficit alone.

Thereafter, things started to diverge noticeably between France and Germany during the European debt crisis. Germany saw a dramatic improvement in fiscal discipline, while France's remained low. A difference that narrowed but persisted during the COVID crisis: while Germany's fiscal discipline deteriorated slightly and France's improved slightly, fiscal discipline in France remained very low relative to the other EU countries. In fact, throughout the entire 2002-2023 period, France is below the inter-quartile range.

Testing fiscal discipline: France vs. Germany

A practical application of measuring fiscal discipline within a currency union is the ability to monitor countries' discipline at respecting common fiscal rules. Indeed, a key hurdle in the implementation of fiscal rules has been the difficulty in assigning responsibilities for rule violation.

Our revealed-preference approach to measuring fiscal discipline offers a way to objectively assign responsibilities by means of a statistical test. We will now illustrate how we can test the null hypothesis that France is making as much fiscal discipline as Germany.

To test whether France made less of a fiscal discipline than Germany, we assign our estimated fiscal discipline parameter for Germany to France ($\lambda^{DE} = 1.2$ over 1998-2023), and we test whether we can reject that France in minimizing Germany's loss function $\mathsf{L}(\lambda^{DE})$. The test statistic is the OPP statistic δ_t^* from Barnichon and Mesters (2023), which measures the distance between $\mathbb{E}_t\mathbf{P}_t^0$ and $\mathbb{E}_t\mathbf{P}_t^{\text{opt}}(\lambda)$. Figure 10 plots the OPP statistic for France over 1998-2023, along with the 95 percent confidence interval. Bands outside of zero indicate cases where we can reject that France made less of an effort than Germany at respecting the deficit ceiling. Both during the GFC and the COVID crisis, we can reject that France made as much effort as Germany. In fact, a joint test over 1998-2023 also rejects (at the 5 percent level) that France made as much effort as Germany over the past 25 years. Answering our motivating question from the introduction, we thus conclude that France *did* make less of an effort as Germany at respecting the SGP.

6 Conclusion

Fiscal rules are essential to limit policy makers' pro-deficit bias, but monitoring the efforts made by policy makers in respecting such rules has proven a formidable task. In the absence of appropriate measures for fiscal discipline, it has been difficult to establishing responsibilities, and ultimately to impose sanctions as and rule compliance has remained a vague concept subject to interpretation and political interference.

In this paper we use a revealed-preference approach to define and measure fiscal discipline. The idea is to estimate the preference weight that policy makers put on the fiscal rule objectives relative to macro stabilization objectives: In situations where the two objectives are in conflict, policy makers had to make a choice and that choice reveals how much policy makers value the fiscal rule objective.

Empirically we apply our approach to estimate fiscal discipline in the EU, both across countries and across time, and we implement a statistical test to (objectively) assess fiscal discipline in real time; the basis for monitoring and enforcing fiscal rules. We show that some countries, most notably France, put a substantially lower preference weight on respecting the Stability and Growth Pact.

While this paper focuses on measuring fiscal discipline, our revealed-preference approach could be used in more general settings where the goal is to measure the underlying preferences of macroeconomic policy makers. For instance, measuring US presidents preference between macro stabilization and fiscal conservatism (e.g., Blinder, 2022), or central bankers' preference between inflation and unemployment —hawks vs. doves— (e.g., Shapiro and Wilson, 2021). There is much speculation about macro policy makers' underlying preferences among the general public or among financial market participants, but to date there is little method to actually measure these preferences. We leave these important questions for future research.

References

Alesina, Alberto, Carlo Favero, and Francesco Giavazzi. 2019. *Austerity: When It Works and When It Doesn't.* Princeton University Press.

Arnold, Nathaniel G, Ravi Balakrishnan, Bergljot B Barkbu, Hamid R Davoodi, Andresa Lagerborg, Waikei R Lam, Paulo A Medas, Julia Otten, Louise Rabier, Christiane Roehler, Asghar Shahmoradi, Mariano Spector, Sebastian Weber, and Jeromin Zettelmeyer. 2022. "Reforming the EU Fiscal Framework: Strengthening the Fiscal Rules and Institutions." IMF working paper: DP/2022/014.

Asimakopoulos, Stylianos, Joan Paredes, and Thomas Warmedinger. 2020. "Real-Time Fiscal Forecasting Using Mixed-Frequency Data*." *The Scandinavian Journal of Economics*, 122(1): 369–390.

Auclert, Adrien, Bence Bardóczy, Matthew Rognlie, and Ludwig Straub. 2021. "Using the Sequence-Space Jacobian to Solve and Estimate Heterogeneous-Agent Models." *Econometrica*, 89(5): 2375–2408.

Auerbach, Alan J., and Yuriy Gorodnichenko. 2012. "Measuring the Output Responses to Fiscal Policy." *American Economic Journal: Economic Policy*, 4: 1–27.

Auerbach, Alan J., and Yuriy Gorodnichenko. 2013. "Output Spillovers from Fiscal Policy." *American Economic Review*, 103(3): 141–46.

Barnichon, Regis, and Geert Mesters. 2023. "A Sufficient Statistics Approach for Macroeconomic Policy." *American Economic Review.* forthcoming.

Barnichon, Regis, Davide Debortoli, and Christian Matthes. 2021. "Understanding the Size of the Government Spending Multiplier: Its in the Sign." *The Review of Economic Studies*, 89(1): 87–117.

Bénassy-Quéré, Agnès, Benoit Coeuré, Pierre Jacquet, and Jean Pisani-Ferry. 2018*a*. *Economic Policy: Theory and Practice. Second edition.* Oxford University Press.

Bénassy-Quéré, A, M. Brunnermeier, H. Enderlein, E. Farhi, M. Fratzscher, C. Fuest, P-O Gourinchas, P. Martin, J. Pisani-Ferry, H. Rey, I. Schnabel, N. Veron, B. Weder di Mauro, and J. Zettelmeyer. 2018*b*. "Reconciling risk sharing with market discipline: A constructive approach to euro area reform." CEPR Policy Insight No 91.

Benigno, Pierpaolo, and Michael Woodford. 2003. "Optimal Monetary and Fiscal Policy: A Linear-Quadratic Approach." *NBER Macroeconomics Annual*, 18: 271–333.

Besley, Tim, and Torsten Persson. 2012. "Public finance and development." *Draft Chapter for the Handbook of Public Economics.*

Blanchard, O. 1990. "Suggestions for a New Set of Fiscal Indicators." OECD Economics Department Working Papers, No 79.

Blanchard, Olivier. 2019. "Public debt and low interest rates." *American Economic Review*, 109(4): 1197–1229.

Blanchard, Olivier, Alvaro Leandro, and Jeromin Zettelmeyer. 2020. "Redesigning EU fiscal rules: From rules to standards." *Economic Policy*.

Blanchard, Olivier, and Roberto Perotti. 2002. "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output." *The Quarterly Journal of Economics*, 117: 1329–1368.

Blinder, Alan S. 2022. *A monetary and fiscal history of the United States, 1961–2021.* Princeton University Press.

Bourguignon, F., and A. Spadaro. 2012. "Tax-benefit revealed social preferences." *Journal of Economic Inequality*, 10: 75–108.

Claeys, G., Z. Darvas, and Á. Leandro. 2016. "A Proposal to Revive the European Fiscal Framework." Bruegel Policy Contribution.

Constâncio, Vítor. 2020. "The Return of Fiscal Policy and the Euro Area Fiscal Rule." *Comparative Economic Studies*, 62: 358372.

Drazen, Allan. 2004. "Fiscal rules from a political economy perspective." In *Rules-based fiscal policy in emerging markets.* 15–29. Springer.

Elliot, Graham, and Allan Timmermann. 2016. *Economic Forecasting.* Princeton University Press.

Eyraud, Luc, Xavier Debrun, Andrew Hodge, Victor Lledó, and Catherine Pattillo. 2018. *Second-generation fiscal rules: Balancing simplicity, flexibility, and enforceability.* Vol. 2018, International Monetary Fund.

Favero, Carlo A., and Massimiliano Marcellino. 2005. "Modelling and Forecasting Fiscal Variables for the Euro Area." *Oxford Bulletin of Economics and Statistics*, 67(s1): 755–783.

Fedelino, Annalisa, Anna Ivanova, and Mark A. Horton. 2009. "Computing Cyclically-Adjusted Balances and Automatic Stabilizers." IMF, Fiscal Affairs Department, Technical Notes and Manuals.

Furman, Jason, and Lawrence Summers. 2020. "A Reconsideration of Fiscal Policy in the Era of Low Interest Rates." *Discussion Draft, Harvard University.*

Galí, Jordi. 2015. *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and its Applications.* Princeton University Press.

Galí, Jordi, and Tommaso Monacelli. 2008. "Optimal monetary and fiscal policy in a currency union." *Journal of International Economics*, 76(1): 116 – 132.

Giavazzi, Francesco, Veronica Guerrieri, Guido Lorenzoni, and Charles-Henri Weymuller. 2021. "Revising the European Fiscal Framework."

Girouard, Nathalie, and Christophe André. 2005. "Measuring Cyclically-adjusted Budget Balances for OECD Countries." OECD Economics Department Working Papers, No 434.

Guajardo, Jaime, Daniel Leigh, and Andrea Pescatori. 2014. "Expansionary austerity? International evidence." *Journal of the European Economic Association*, 12(4): 949–968.

Halac, Marina, and Pierre Yared. 2014. "Fiscal rules and discretion under persistent shocks." *Econometrica*, 82(5): 1557–1614.

Hall, Matthew, and Aditi Thapar. 2021. "The economic effects of government spending: using expectations data to control for information." *Macroeconomic Dynamics*, 1–30.

Hall, R. E. 2009. "By how much does gdp rise if the government buys more output?" *Brookings Papers on Economic Activity*, 40(2): 183–249.

Heinemann, Friedrich. 2018. "How could the Stability and Growth Pact be simplified?" Report written at the request of the European Parliaments Committee on Economic and Monetary Affairs.

Hendren, Nathaniel. 2020. "Measuring economic efficiency using inverse-optimum weights." *Journal of Public Economics*, 187: 104198.

IMF, International Monetary Fund. 2022. "Fiscal Monitor: Helping People Bounce Back." IMF, Fiscal Monitor, October.

Jacobs, Bas, Egbert L.W. Jongen, and Floris T. Zoutman. 2017. "Revealed social preferences of Dutch political parties." *Journal of Public Economics*, 156: 81–100.

Kahn, George A. 2010. "Monetary policy under a corridor operating framework." *Economic Review-Federal Reserve Bank of Kansas City*, 5.

Kirsanova, Tatiana, Mathan Satchi, David Vines, and Simon Wren-Lewis. 2007. "Optimal Fiscal Policy Rules in a Monetary Union." *Journal of Money, Credit and Banking*, 39(7): 1759–1784.

Larch, Martin, and Stefano Santacroce. 2020. "Numerical compliance with EU fiscal rules: The compliance database of the Secretariat of the European Fiscal Board." European Commission.

Leal, Teresa, Javier J. Prez, Mika Tujula, and Jean-Pierre Vidal. 2008. "Fiscal Forecasting: Lessons from the Literature and Challenges." *Fiscal Studies*, 29(3): 347–386.

Lledó, Victor, Sungwook Yoon, Xiangming Fang, Samba Mbaye, and Young Kim. 2017. "Fiscal Rules at a Glance." International Monetary Fund.

Martin, Philippe, Jean Pisani-Ferry, and Xavier Ragot. 2021. "Reforming the European fiscal framework." *Les notes du conseil danalyse économique*, 63.

McKay, Alisdair, and Christian Wolf. 2023. "What Can Time-Series Regressions Tell Us About Policy Counterfactuals?" *Econometrica.* forthcoming.

Mertens, Karel, and Morten O. Ravn. 2013. "The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States." *American Economic Review*, 103(4): 1212–1247.

Mourre, G., A. Poissonnier, and M. Lausegger. 2019. "The Semi-Elasticities Underlying the Cyclically-Adjusted Budget Balance: An Update and Further Analysis." European Economy Economic Papers, No 098.

Mourre, G., C. Astarita, and S. Princen. 2014. "Adjusting the budget balance for the business cycle: the EU methodology." European Economy Economic Papers, No 536.

Nocedal, Jorge, and Stephen Wright. 2006. *Numerical optimization.* Springer Science & Business Media.

Owyang, Michael T., Valerie A. Ramey, and Sarah Zubairy. 2013. "Are Government Spending Multipliers Greater during Periods of Slack? Evidence from Twentieth-Century Historical Data." *American Economic Review*, 103(3): 129–34.

Pappa, Evi, Rana Sajedi, and Eugenia Vella. 2015. "Fiscal consolidation with tax evasion and corruption." *Journal of International Economics*, 96: S56–S75.

Ramey, Valerie. 2016. "Macroeconomic Shocks and Their Propagation." In *Handbook of Macroeconomics.* , ed. J. B. Taylor and H. Uhlig. Amsterdam, North Holland:Elsevier.

Ramey, Valerie A., and Sarah Zubairy. 2018. "Government Spending Multipliers in Good Times and in Bad: Evidence from U.S. Historical Data." *Journal of Political Economy*, 126.

Reis, Ricardo. 2022. "Debt Revenue and the Sustainability of Public Debt." *Journal of Economic Perspectives*, 36(4): 103–24.

Schaechter, Andrea, Tidiane Kinda, Nina T Budina, and Anke Weber. 2012. "Fiscal rules in response to the crisis-toward the'next-generation'rules: A new dataset."

Shapiro, Adam Hale, and Daniel J Wilson. 2021. "Taking the Fed at its Word: A New Approach to Estimating Central Bank Objectives using Text Analysis." *The Review of Economic Studies.*

Taylor, John B. 2000. "Reassessing Discretionary Fiscal Policy." *Journal of Economic Perspectives*, 14(3): 21–36.

Willems, Tim, and Jeromin Zettelmeyer. 2022. "Sovereign Debt Sustainability and Central Bank Credibility." *Annual Review of Financial Economics*, 14(1): 75–93.

Appendix

A1: Proofs

Proof of Lemma 1. First note that by combining model (13) and the reaction function (14) we obtain

$$\tilde{\mathcal{A}}_{xx}\mathbb{E}_t\mathbf{X}_t - \tilde{\mathcal{A}}_{xy}\mathbb{E}_t\mathbf{Y}_t = \tilde{\mathcal{B}}_{xv}\boldsymbol{\Upsilon}_t + \boldsymbol{\epsilon}_t \qquad \text{and} \qquad \mathbb{E}_t\mathbf{Y}_t - \mathcal{A}_{yx}\mathbb{E}_t\mathbf{X}_t = \boldsymbol{\Upsilon}_t \ ,$$

where $\tilde{\mathcal{A}}_{xx} = \Theta_{pp}$, $\tilde{\mathcal{A}}_{xy} = \Theta_{pp}\mathcal{A}_{xy} + \Theta_{py}$ and $\tilde{\mathcal{B}}_{xv} = \Theta_{pp}\mathcal{B}_{xv} + \Theta_{pv}$. Stacking the two equations according to $\mathbf{W}_t = (\mathbf{Y}_t', \mathbf{X}_t')'$ gives

$$\mathcal{A}\mathbb{E}_t\mathbf{W}_t = \mathcal{B}\boldsymbol{\Upsilon}_t + \mathbf{J}\boldsymbol{\epsilon}_t \ ,$$

where

$$\mathcal{A} = \begin{bmatrix} \mathbf{I} & -\mathcal{A}_{yx} \\ -\tilde{\mathcal{A}}_{xy} & \tilde{\mathcal{A}}_{xx} \end{bmatrix} , \qquad \mathcal{B} = \begin{bmatrix} \mathbf{I} \\ \tilde{\mathcal{B}}_{xv} \end{bmatrix} \qquad \text{and} \qquad \mathbf{J} = \begin{bmatrix} \mathbf{0} \\ \mathbf{I} \end{bmatrix} .$$

Since, Θ is assumed to lead to a unique and determinate equilibrium we have that the inverse map of $\mathcal{A}$ exists. It follows that

$$\mathbb{E}_t\mathbf{W}_t = \underbrace{\mathcal{A}^{-1}\mathcal{B}}_{\mathcal{D}}\boldsymbol{\Upsilon}_t + \underbrace{\mathcal{A}^{-1}\mathbf{J}}_{\mathcal{R}}\boldsymbol{\epsilon}_t \ .$$

We note that the maps $\mathcal{D}$ and $\mathcal{R}$ can be partitioned to confirm with $\mathbb{E}_t\mathbf{Y}_t$ and $\mathbb{E}_t\mathbf{X}_t$. $\square$

Proof of Proposition 1. We first characterize the λ-optimal policy as given in Definition 1, that is

$$\min_{\mathbf{Y}_t, \mathbf{X}_t, \mathbf{P}_t} \mathsf{L}_t \qquad \text{s.t.} \qquad (13) \ . \tag{24}$$

Using $\mathcal{W}_\lambda = \text{diag}(\mathcal{W}_y, \lambda\mathcal{W}_x)$ and $\mathbf{W}_t^+ = (\mathbf{Y}_t', (\mathbf{X}_t - \bar{\mathbf{X}}_t)_+')'$ Lagrange function for this problem is given by

$$\begin{aligned} L_t = & \mathbb{E}_t\left\{\frac{1}{2}\mathbf{W}_t^{+\prime}\mathcal{W}_\lambda\mathbf{W}_t^+ + \boldsymbol{\mu}_1'(\mathbf{Y}_t - \mathcal{A}_{yx}\mathbf{X}_t - \boldsymbol{\Upsilon}_t)\right. \\ & \left. + \boldsymbol{\mu}_2'(\mathbf{X}_t - \mathcal{A}_{xy}\mathbf{Y}_t - \mathcal{B}_{xv}\boldsymbol{\Upsilon}_t - \mathbf{P}_t)\right\} \ , \end{aligned}$$

where $\boldsymbol{\mu}_1$ and $\boldsymbol{\mu}_2$ denote the Lagrange multipliers. The first order conditions for $\mathbf{Y}_t, \mathbf{X}_t, \mathbf{P}_t$ are given by

$$\begin{aligned} \mathbf{0} &= \mathcal{W}_y\mathbb{E}_t\mathbf{Y}_t + \boldsymbol{\mu}_1 - \mathcal{A}_{xy}'\boldsymbol{\mu}_2 \\ \mathbf{0} &= \lambda\mathcal{W}_x\mathbb{E}_t(\mathbf{X}_t - \bar{\mathbf{X}}_t)_+ + \boldsymbol{\mu}_2 - \mathcal{A}_{yx}'\boldsymbol{\mu}_1 \\ \mathbf{0} &= \boldsymbol{\mu}_2 \ , \end{aligned}$$

and from Assumption 1 it follows that this system of equations implies a unique solution $\mathbb{E}_t\mathbf{P}_t^{\text{opt}}(\lambda)$.

Next, we measure the distance between the proposed policy and the λ-optimal policy. To do so consider the fictitious policy problem of a policy maker considering deviating from the proposed reaction $(\Theta^0, \boldsymbol{\epsilon}_t^0)$ with some fixed sequence of perturbations $\boldsymbol{\delta}_t$.

$$\min_{\mathbf{Y}_t,\mathbf{X}_t,\mathbf{P}_t,\boldsymbol{\delta}_t} \mathcal{L}_t \qquad \text{s.t.} \qquad (13) \quad \text{and} \quad (14)\ . \tag{25}$$

The Lagrange function for this problem is given by

$$\begin{aligned} L_t^f =& \mathbb{E}_t \Big\{ \frac{1}{2} \mathbf{W}_t^{+'} \mathcal{W}_\lambda \mathbf{W}_t^+ + \boldsymbol{\mu}_1'(\mathbf{Y}_t - \mathcal{A}_{yx}\mathbf{X}_t - \boldsymbol{\Upsilon}_t) \\ & +\boldsymbol{\mu}_2'(\mathbf{X}_t - \mathcal{A}_{xy}\mathbf{Y}_t - \mathcal{B}_{xv}\boldsymbol{\Upsilon}_t - \mathbf{P}_t) \\ & +\boldsymbol{\mu}_3'(\Theta_{pp}^0\mathbf{P}_t - \Theta_{py}^0\mathbf{Y}_t - \Theta_{pv}^0\boldsymbol{\Upsilon}_t - \boldsymbol{\epsilon}_t^0 - \boldsymbol{\delta}_t) \Big\}\ , \end{aligned}$$

which leads to the first order conditions for $\mathbf{Y}_t, \mathbf{X}_t, \mathbf{P}_t, \boldsymbol{\delta}_t$ given by

$$\begin{aligned} \mathbf{0} &= \mathcal{W}_y \mathbb{E}_t \mathbf{Y}_t + \boldsymbol{\mu}_1 - \mathcal{A}_{xy}' \boldsymbol{\mu}_2 - \Theta_{py}^{0'} \boldsymbol{\mu}_3 \\ \mathbf{0} &= \lambda \mathcal{W}_x \mathbb{E}_t (\mathbf{X}_t - \bar{\mathbf{X}}_t)_+ + \boldsymbol{\mu}_2 - \mathcal{A}_{yx}' \boldsymbol{\mu}_1 \\ \mathbf{0} &= \boldsymbol{\mu}_2 + \Theta_{pp}^{0'} \boldsymbol{\mu}_3 \\ \mathbf{0} &= \boldsymbol{\mu}_3\ . \end{aligned}$$

Since $\boldsymbol{\mu}_3 = \mathbf{0}$, it is easy to verify that the first order conditions of the fictitious policy problem (25) are identical to the first order conditions of the original policy problem (24). Hence they have the same solution $\mathbb{E}_t \mathbf{P}_t^{\text{opt}}$.

Next, using that Θ^0 leads to a unique equilibrium we can use the steps from Lemma 1 to write

$$\mathbb{E}_t \mathbf{W}_t = \mathbb{E}_t \mathbf{W}_t^0 + \mathcal{R}^0 \boldsymbol{\delta}_t\ , \tag{26}$$

where $\mathbb{E}_t \mathbf{W}_t^0 = \mathcal{D}^0 \boldsymbol{\Upsilon}_t + \mathcal{R}^0 \boldsymbol{\epsilon}_t^0$, with $\mathcal{D}^0$ and $\mathcal{R}^0$ the responses under Θ^0. With this we can rewrite the fictitious policy problem (by substituting out the variables $\mathbf{W}_t, \mathbf{P}_t$ in terms of $\boldsymbol{\delta}_t$ and the news shocks and initial conditions) as

$$\min_{\boldsymbol{\delta}_t} \mathsf{L}_t \qquad \text{s.t.} \qquad \mathbb{E}_t \mathbf{W}_t = \mathbb{E}_t \mathbf{W}_t^0 + \mathcal{R}^0 \boldsymbol{\delta}_t\ . \tag{27}$$

The solution to this minimization problem is given by

$$\boldsymbol{\delta}_t^* = -(\mathcal{R}^{0'} \mathcal{W}_\lambda \mathcal{R}^0)^{-1} \mathcal{R}^{0'} \mathcal{W}_\lambda \mathbb{E}_t \mathbf{W}_t^{0+}\ .$$

This implies that the distance between the proposed policy and the λ-optimal policy is given by $\mathcal{R}_x^0 \boldsymbol{\delta}_t^*$. □

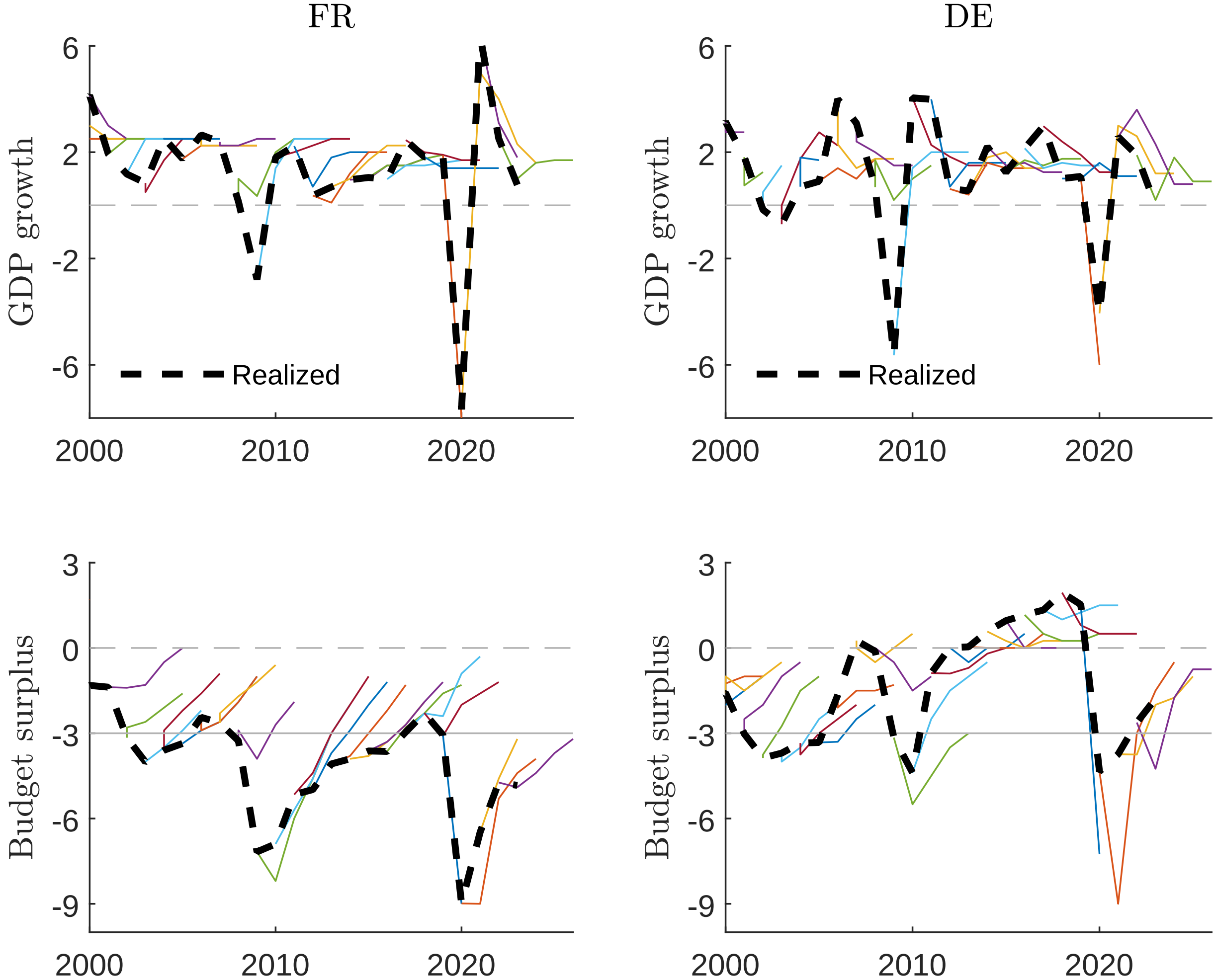
Proof of Corollary 1. The proof is similar when compared to the proof of proposition 1, the only difference is that optimality is only computed in the direction of the identified policy shocks $\boldsymbol{\epsilon}_{a,t}$. Specifically, starting from (26) we can write

$$\mathbb{E}_t \mathbf{W}_t = \mathbb{E}_t \mathbf{W}_t^0 + \mathcal{R}_a^0 \boldsymbol{\delta}_{a,t} + \mathcal{R}_{-a}^0 \boldsymbol{\delta}_{-a,t}$$

where we have decomposed the sequence of adjustments into the part corresponding to $\boldsymbol{\epsilon}_{a,t}$ and the remained $\boldsymbol{\epsilon}_{-a,t}$. Now optimizing the loss function with respect to $\boldsymbol{\delta}_{a,t}$ allows to measure the distance between $\mathbb{E}_t \mathbf{P}_{a,t}^0$ and $\mathbb{E}_t \mathbf{P}_{a,t}^{\text{opt}}$.

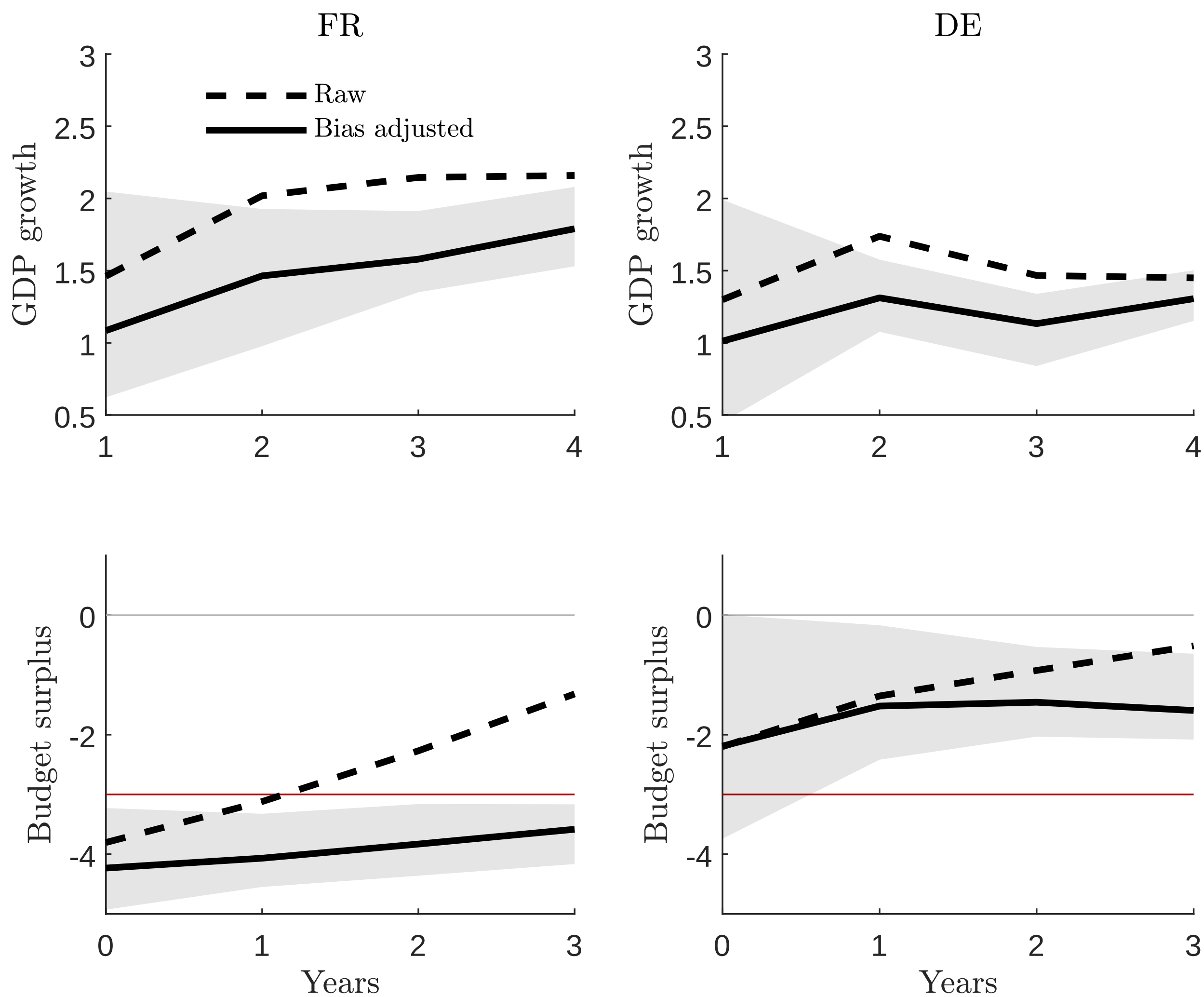
$\square$

Figure 3: SGP forecasts: France vs. Germany



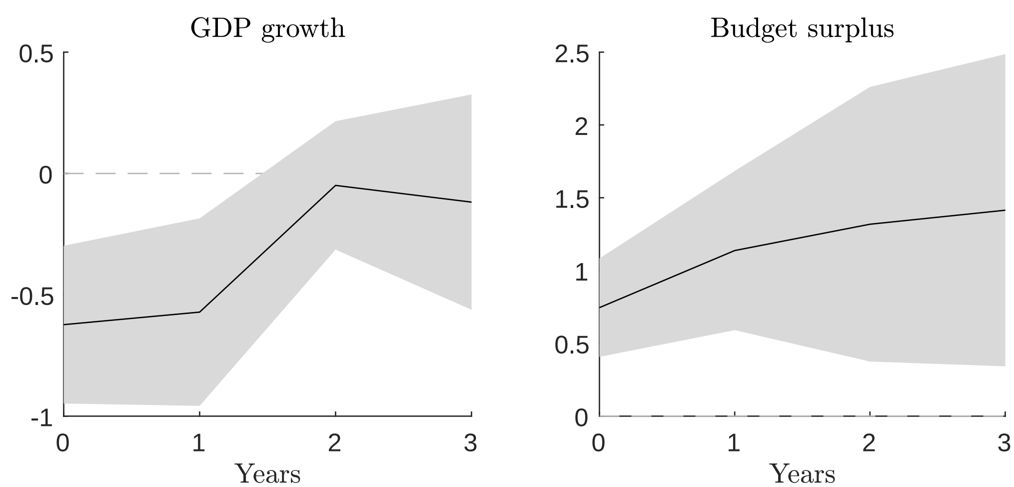
Notes: The panels report the realized values (dashed-thick lines) for GDP growth and the budget surplus for France (FR, left column) and Germany (DE, right column), along with the forecasts by France and Germany to the EU commission as partof the SGP over 1998-2023 (colored lines).

Figure 4: SGP forecasts and bias correction: France vs. Germany



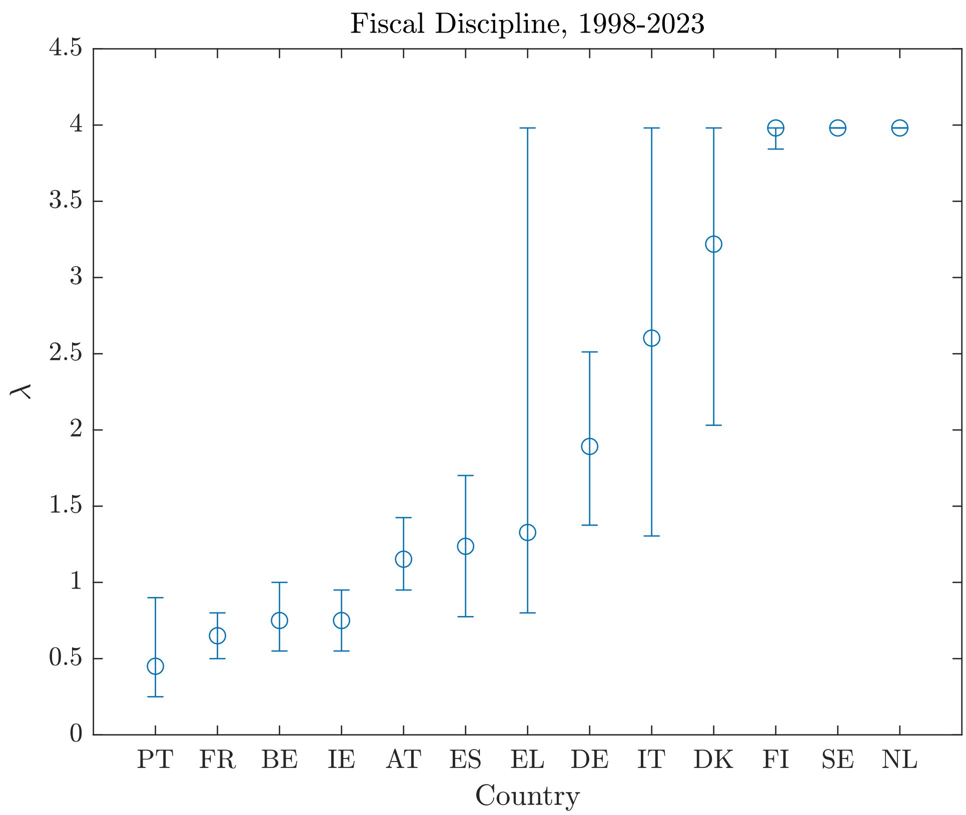
Notes: The top (bottom) panels report the average forecasts for GDP growth (budget surplus) reported by France (FR, left column) and Germany (DE, right column) to the EU commission over 1998-2023. The shaded areas display with the inter-quartile range (shaded area). The dashed lines depict the raw forecasts and the plain lines depict the bias-adjusted forecasts.

Figure 5: Impulse responses to a fiscal austerity shock



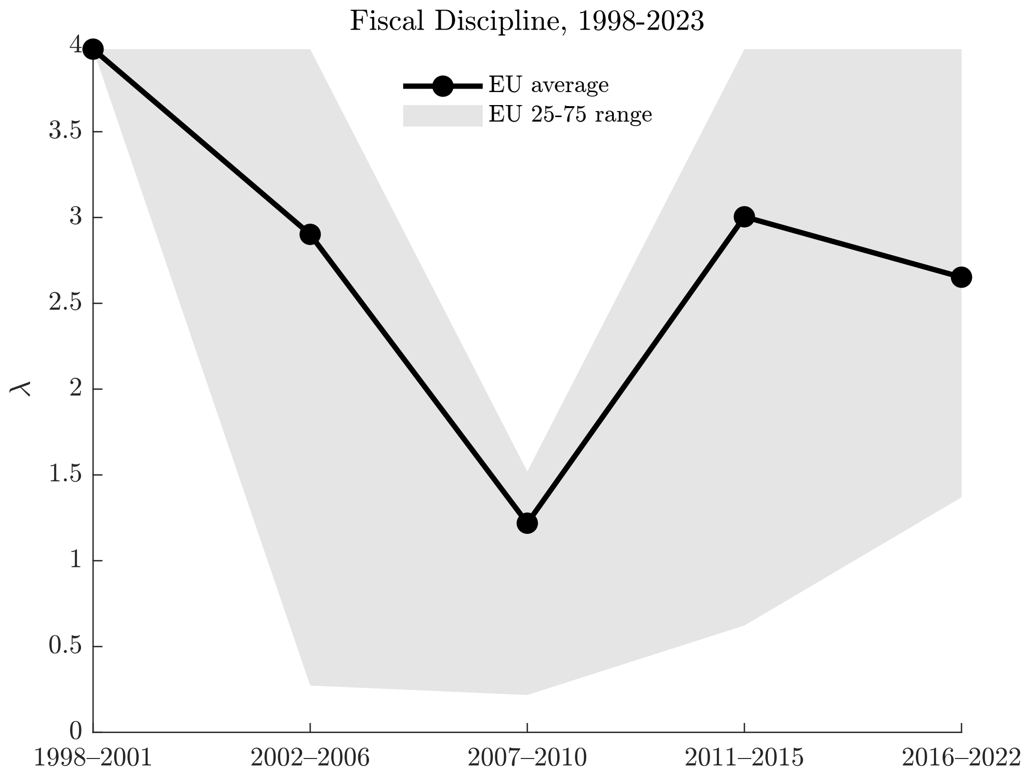
Notes: Impulse responses to fiscal austerity shock, estimation based on Guajardo, Leigh and Pescatori (2014) narratively identified shocks.

Figure 6: Fiscal Discipline in the EU, 1998-2023



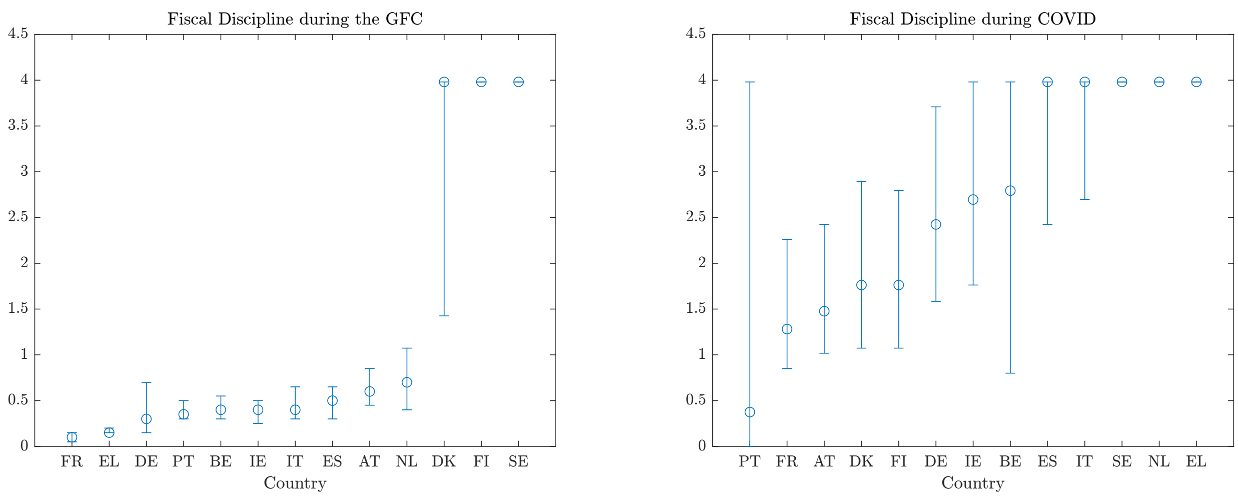
Notes: Each marker reports the fiscal discipline parameter λ^i for an EU country together with the 68 percent confidence intervals. Country codes are AT (Austria), BE (Belgium), DE (Germany), DK (Denmark), ES (Spain), FI (Finland), FR (France), IE (Ireland), IR (Italy), PT (Portugal), SE (Sweden), NL (Holland) and EL (Greece).

Figure 7: Fiscal discipline over time



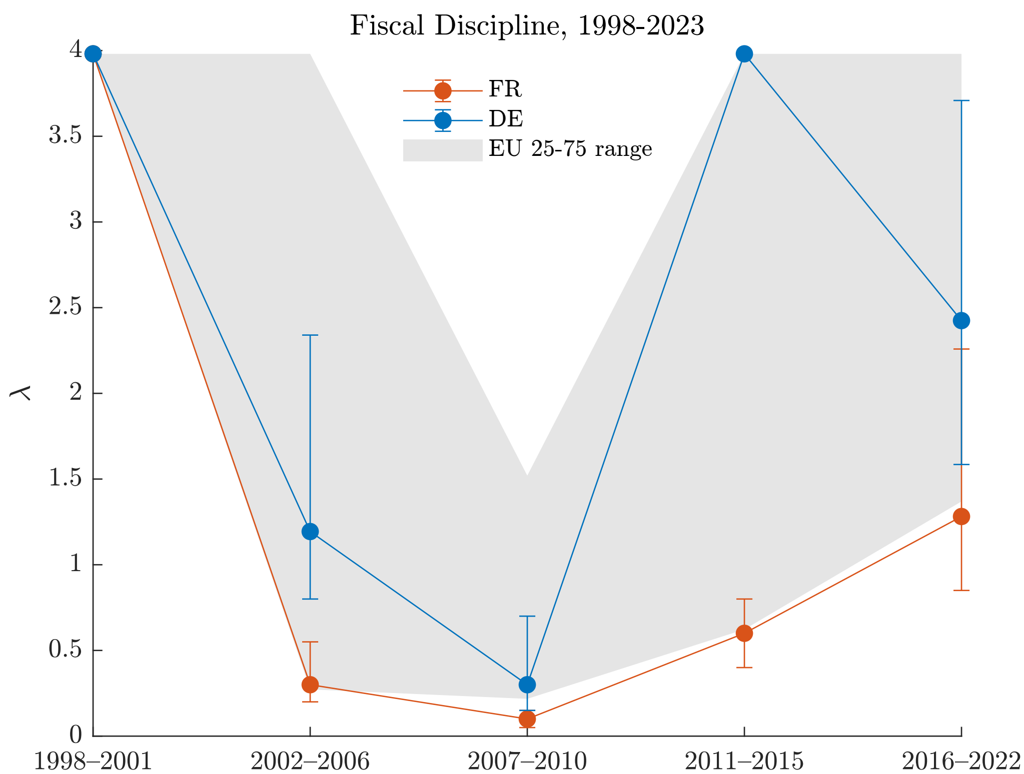
Notes: We show the evolution of average fiscal discipline λ in the EU.

Figure 8: Fiscal discipline: GFC vs COVID



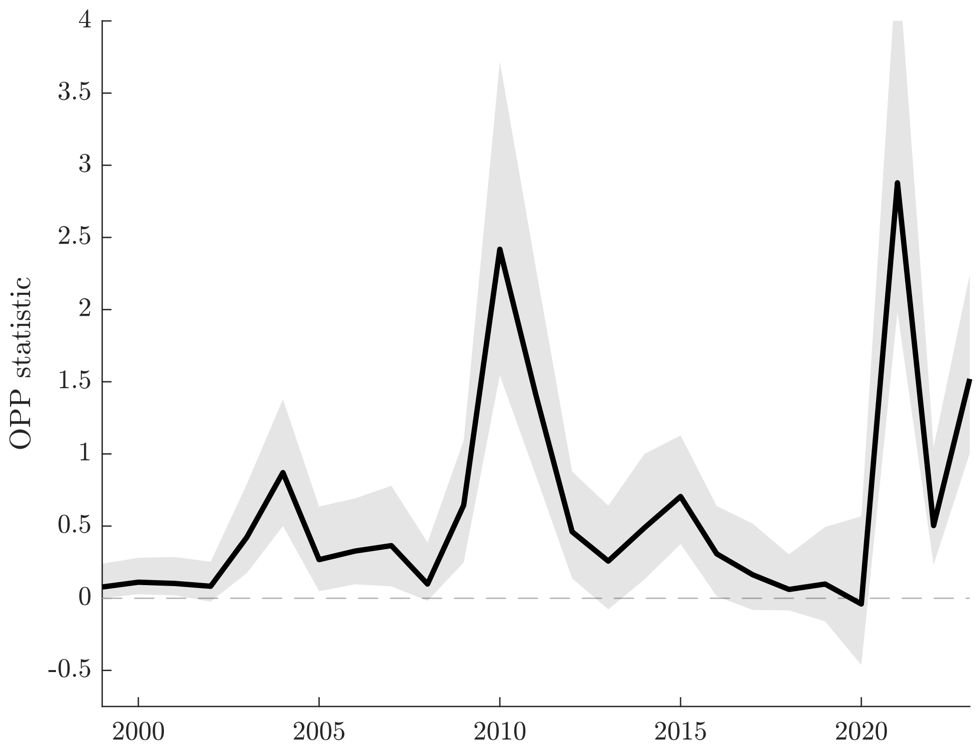
Notes: Each marker reports the fiscal discipline parameter λ^i for the EU countries for two period: financial crises (left) and COVID crises (right). Whiskers indicate the 68 percent confidence intervals.

Figure 9: Fiscal discipline: France vs Germany



Notes: Each marker reports the fiscal discipline parameter λ^i for France (FR) and Germany (DE) along with the EU interquartile range.

Figure 10: Fiscal discipline test, 1998-2023



Notes: OPP statistic with 95 confidence band for France using a preference parameter $\lambda^{DE} = 1.2$ estimated for Germany over 1998-2023. A non-zero value for the OPP statistic indicates a rejection of the null $\lambda^{FR} = \lambda^{DE}$, i.e., that France put as much weight on fiscal discipline as Germany.