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# On the estimation of panel fiscal reaction functions: Heterogeneity or fiscal fatigue?

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## ABSTRACT

This paper investigates whether fiscal fatigue is a robust characteristic of the fiscal reaction function in a panel of OECD countries over the period 1970–2014 or merely an artifact of ignoring important aspects of the panel dimension of the data. More specifically, we test whether the quadratic and cubic debt-to-GDP terms remain significant once a country-specific reaction of the primary balance to lagged debt is allowed for. The results show a significant heterogeneous reaction of the primary balance to lagged debt with fiscal fatigue not being a general characteristic of the fiscal reaction function shared by all countries in our panel. In line with the literature, we further find that fiscal balances tend to deteriorate in contractions without correspondingly improving during expansions.

## 1. Introduction

The European sovereign debt crisis, rising age-related public expenditures and the secular stagnation of output growth have put renewed emphasis on questions about the sustainability of fiscal policy. In a series of papers, [Bohn \(1995, 1998\)](#) developed a stochastic general equilibrium model to evaluate the sustainability question. He argues that plausible indicators such as the average budget deficit and the realized path of the debt-to-GDP ratio can be quite misleading as fiscal sustainability also depends on future economic growth and interest rates. Although historically a growth dividend has covered the entire interest bill on U.S. debt, neither a stable debt-to-GDP ratio nor a balanced primary budget guarantees sustainability when there is a positive probability that future economic growth falls below the interest rate. He further shows that a positive reaction of the primary budget to lagged debt, in contrast, is a sufficient condition for the government to satisfy its intertemporal budget constraint and hence fiscal policy to be sustainable. The essence of Bohn's sustainability test is the estimation of a fiscal reaction function (FRF) to determine whether a build-up of the public debt-to-GDP ratio elicits an increase in the primary balance, controlling for other determinants (the business cycle, inflation, external deficits, etc.). Based on FRF estimates, [Bohn \(1998\)](#) concludes that U.S. fiscal policy has historically been sustainable. [Mendoza and Ostry \(2008\)](#) extend this evidence of fiscal solvency to a large panel of devel-

oped and emerging economies.

Contemporary debt sustainability analysis has evolved from estimating FRFs to using these estimates for stochastic debt simulations. To this end, a reduced form vector autoregressive (VAR) model is estimated to obtain the joint distribution of shocks to a standard set of macroeconomic variables (e.g. output growth, real interest rates and inflation) affecting debt dynamics. Repeatedly drawing shocks from this distribution, letting the primary balance react through the FRF and calculating the implied change in debt then generates stochastic debt trajectories, which are typically summarized by plotting fan charts (see e.g. [Celasun et al., 2007; Medeiros, 2012](#)).

With the FRF at the center of debt sustainability analysis, it is essential that it is correctly specified and estimated. A first key question is whether the FRF is *linear* or *non-linear* in the debt-to-GDP ratio. The most simple rule that ensures sustainability is a linear one. However, in an attempt to stabilize the debt-to-GDP ratio at a reasonable level, fiscal policy may respond more when debt is high and/or rising while being less responsive at lower debt levels. [Bohn \(1998\)](#) indeed shows that U.S. fiscal policy over the period 1916–1995 was unresponsive at low levels of debt but significantly active at higher levels. [Ghosh et al. \(2013\)](#) further argue that it cannot literally be true that the primary balance would always increase with debt because, at sufficiently high levels of debt, this would require primary balances that exceed GDP. Using a panel of 23 advanced countries over the period 1970–2007, they find strong

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support for the existence of a non-linear FRF that exhibits this alleged ‘fiscal fatigue’ characteristic. Specifically, the FRF is well approximated by a cubic function where at low levels of debt there is no relationship between the primary balance and debt while as debt rises, the primary balance becomes more responsive but the reaction eventually weakens and at very high levels of debt the response even becomes negative. This implies that there is a debt level above which the debt dynamics become explosive and the government will necessarily default. A similar result can be found in [Mendoza and Ostry \(2008\)](#) and [Ostry et al. \(2010\)](#) and is now widely accepted as an important characteristic of FRFs and used by different policy institutions to calculate fiscal space, which is the difference between this debt limit and the observed debt-to-GDP ratio, or embedded in their stochastic debt simulations (see e.g. [Fournier and Fall 2015](#); [Berti et al., 2016](#)).

A second important topic is the *dynamic specification* of the FRF. The highly politicized nature of government budgeting makes it hard to react immediately to changes in debt and other economic conditions. As a result, the primary balance turns out to be a highly persistent series. [Ghosh et al. \(2013\)](#) and [Mendoza and Ostry \(2008\)](#) both consider a static FRF, though, dealing with the resulting strong autocorrelation in the error terms using a somewhat mechanical Generalized Least Squares (GLS) correction. In fact, the underlying assumption of an autoregressive (AR) pattern in the error terms implies that the persistence in the primary balance is assumed to stem from autocorrelation in exogenous shocks that hit the primary balance. This precludes a slow reaction in response to changes in the debt-to-GDP ratio or other economic conditions. Although there are plenty of studies that model slow adjustment by adding the lagged primary balance as an explanatory variable (see e.g. [Égert, 2012](#); [Fatás and Mihov, 2012](#); for recent work), studies combining a dynamic model with non-linearities are rare. One exception is [Ostry et al. \(2010\)](#) who combine a dynamic specification with a non-linear (cubic) reaction in the debt-to-GDP ratio as a robustness test in their [appendix](#).

A third specification issue is potential *slope heterogeneity*. Because debt-to-GDP ratios often show only small variation over time within countries, most of the current literature estimating FRFs relies on panel datasets. Adding a cross-sectional dimension and using a homogeneous panel specification ensures that there is sufficient information in debt-to-GDP ratios - ranging from low levels in countries like Australia, New-Zealand, Denmark, Norway and Sweden to very high levels in countries like Belgium, Greece, Italy and Japan - to identify potential non-linearities in the FRF. However, the fiscal fatigue result of [Ghosh et al. \(2013\)](#) and [Mendoza and Ostry \(2008\)](#) may very well be induced by slope heterogeneity. If some countries react weaker to debt than others (i.e. they have a smaller coefficient on the debt-to-GDP ratio in their FRF), these countries will over time end up with a higher debt level. When estimating a homogeneous FRF, high debt will coincide with a weak reaction in the primary balance not because of fiscal fatigue but because of unmodeled slope heterogeneity in the FRF across countries.

A further specification matter is that an adequate analysis of debt sustainability requires an appropriate modeling of the *link between fiscal policy and the business cycle*. There is quite some literature on this complex link, but it is somewhat detached from the literature on debt sustainability. [Gali and Perotti \(2003\)](#) and [Fatás and Mihov \(2012\)](#) emphasize the role played by automatic stabilizers and discretionary fiscal policy. The degree of automatic stabilization depends on the size of the government and the progressiveness of the tax system, implying that the automatic reaction of fiscal policy to the business cycle is heterogeneous across countries. Large cross-sectional variation in the use of discretionary policy further adds to this heterogeneity. Moreover, there is growing evidence that fiscal variables react asymmetrically to cyclical conditions, i.e. fiscal balances tend to deteriorate in contractions without correspondingly improving in expansions ([Égert, 2012](#); [Balassone et al., 2010](#)). When this asymmetry is not taken into account, the risk of debt increases may be underestimated ([Celasun et al., 2007](#)).

The objective of this paper is to design an appropriately specified panel FRF. More specifically, we will investigate whether fiscal fatigue is a robust characteristic in a panel of OECD countries over the period 1970–2014 or merely an artifact of ignoring important aspects of the panel dimension of the data. The results show a significantly heterogeneous reaction of the primary balance to lagged debt with fiscal fatigue not being a general characteristic of the FRF shared by all countries in our panel. In line with the literature, we further find that fiscal balances tend to deteriorate in contractions without correspondingly improving during expansions.

The remainder of this paper is organized as follows. Section 2 outlines our empirical specification and estimation methodology. Section 3 presents the estimation results. Section 4 concludes.

## 2. Empirical specification and estimation methodology

In this section we outline our empirical specification of the FRF and the econometric methodology to estimate it. We start with the baseline specification as outlined in [Ghosh et al. \(2013\)](#) and next extend it to allow for persistence in the primary balance, a heterogeneous response to lagged debt and a heterogeneous and asymmetric reaction to the business cycle.

### 2.1. Baseline specification

Our starting point is the static homogeneous non-linear panel FRF proposed by [Ghosh et al. \(2013\)](#)

$$pb_{it} = \alpha_i + \beta_1 d_{i,t-1} + \beta_2 d_{i,t-1}^2 + \beta_3 d_{i,t-1}^3 + \phi gap_{it} + Z_{it} \omega + \varepsilon_{it}, \quad (1)$$

for  $i = 1, \dots, N$  and  $t = 1, \dots, T$  and where  $pb_{it}$  denotes the primary balance of country  $i$  in period  $t$ ,  $d_{i,t-1}$  the one period lagged debt-to-GDP ratio and  $gap_{it}$  the output gap. Following the literature (see e.g. [Gali and Perotti, 2003](#); [Mendoza and Ostry, 2008](#); [Ostry et al., 2010](#); [Ghosh et al., 2013](#)), we add a vector of control variables  $Z_{it}$  including inflation ( $infl_{it}$ ), the implicit interest rate on government debt ( $iir_{it}$ ), the current account balance as a percentage of GDP ( $curac_{it}$ ), trade openness ( $open_{it}$ ), the ratio of elderly ( $old_{it}$ ), the future ratio of elderly ( $Fold_{it}$ ) and three dummy variables capturing whether a country is part of the Euro area in a specific year ( $D_{it}^{euro}$ ), whether elections were held in a certain year ( $D_{it}^{elec}$ ) and whether a country adopted some type of fiscal rule ( $D_{it}^{fisc}$ ). Country-fixed effects  $\alpha_i$  are included to account for country-specific time-invariant factors not included in  $Z_{it}$  that affect the primary balance.

Since unmodeled persistence in the error terms of equation (1) would cause the lagged debt-to-GDP ratio  $d_{i,t-1}$  and its powers to be endogenous and hence induce inconsistency, [Ghosh et al. \(2013\)](#) specify  $\varepsilon_{it}$  as an AR(1) process

$$\varepsilon_{it} = \rho \varepsilon_{i,t-1} + \mu_{it}, \quad (2)$$

and estimate the model in equations (1)–(2) using the (iterated) Prais-Winsten Generalized Least Squares (GLS) estimator.

The fiscal fatigue proposition of a positive but eventually slowing response of the primary balance to rising debt should show up as  $\beta_3 < 0$  (in a cubic specification) or  $\beta_2 < 0$  and  $\beta_3 = 0$  (in a quadratic specification). Using a panel of 23 advanced economies over the period 1970–2007, [Ghosh et al. \(2013\)](#) find  $\beta_1 < 0$ ,  $\beta_2 > 0$  and  $\beta_3 < 0$ . Their coefficient estimates imply that the marginal response of the primary balance to lagged debt is at its maximum for a debt-to-GDP ratio of around 100% of GDP, starts to decline beyond that level and becomes negative for debt-to-GDP ratios exceeding 140%. As a result, the response of the primary balance is at its maximum for a debt-to-GDP ratio of around 140%. However, [Table 1](#) shows that this downward sloping segment of the FRF is identified mainly from the behavior of Japan, and to a lesser extent Belgium and Italy, as over the period 1970–2007 only these countries have episodes where the debt-to-GDP

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