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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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Is fiscal policy in the euro area Ricardian?*

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Abstract

According to the so-called 'fiscal theory of the price level' (FTPL), under a non-Ricardian regime the price level has to adjust to fulfil the government's budget constraint. In contrast, under a Ricardian regime, government balances adjust in order to preserve government solvency. We empirically determine whether a Ricardian or a non-Ricardian regime is more plausible for the euro area, following the research strategy of Canzoneri, Cumby, and Diba (2001). A Vector AutoRegressive (VAR) model for the primary government balance and the government debt is estimated for the period 1980q2-2013q4. Our model uses dummy interaction terms to account for the breaks due to the introduction of the Euro Convergence Criteria (ECC) and the start of the global financial crisis, respectively. No evidence is found in favour of either regime for the pre-ECC period. In the post-ECC period, a Ricardian regime is more plausible. Some evidence points in the direction of a non-Ricardian regime for the period after the start of the financial crisis.

Keywords: Fiscal Policy, Euro area, Ricardian regime.
JEL classifications: E63, H62, H63.

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1. Introduction

For decades, inflation has been treated as being determined solely by monetary policy actions. Following Friedman (1970), New-Keynesian models assume that "inflation is always and everywhere a monetary phenomenon", and the price level is determined as the unique value that equates money demand and money supply. Consequently, high inflation episodes are being countered by contractionary monetary policy while low inflation episodes are being countered by expansionary monetary policy. Yet, in the aftermath of the recent financial crisis, conventional monetary policy seems to be less effective as interest rates are stuck at the zero lower bound. This situation has led to a revived interest in alternative theories of price determination such as the Fiscal Theory of the Price Level (hereafter: FTPL). Important theoretical contributions by Woodford (1994, 1995), Leeper (1991), and Sims (1994) show that the price level is determined by the government's present value budget constraint and, thus, depends heavily on fiscal policy actions.[1]

According to Woodford (1995), under a 'Ricardian regime' government balances (i.e. government revenues minus expenditures) are determined in such a way that the government budget constraint automatically holds for any price level. In this case, the price level is determined by monetary policy in the same way as traditional monetarist theories describe. However, under a 'non-Ricardian regime' government balances can follow an arbitrary process and the price level adjusts in order to satisfy government solvency. In this case, the equilibrium price level is determined as the unique value that equates the real value of the government debt to the expected present value of future government balances.

Determining the plausibility of Ricardian versus non-Ricardian regimes is particularly important for the euro area as it reveals the ability of the European Central Bank (ECB) to achieve price stability by means of monetary policy. According to the FTPL, evidence in favour of a non-Ricardian regime means that national fiscal policies drive national price levels. Under such circumstances, monetary policy plays a minor role in the determination of prices. Since fiscal policy decisions differ within the euro area, as becomes clear from Figure 1, the existence of a non-Ricardian fiscal regime will lead to price differences amongst euro area countries. Therefore, if fiscal price determination holds, fiscal policy has to play a larger role in achieving a stable aggregate price level.

[1] For a recent critical review of the FTPL, see Buiter (2017).

[Insert Figure 1]

Fiscal policy has to play an even greater role in achieving the price stability objective if monetary policy authorities are facing a zero lower bound, as is the case since the Global Financial Crisis (hereafter: GFC). For example, Sims (2016) argues that if the FTPL holds, for expansionary monetary policy to be effective during periods of low inflation or deflation, fiscal authorities need to use their interest savings (due to the low interest rate) for fiscal expansions. In line with Barro (1979)'s Ricardian equivalence theorem, Sims (2016) further argues that for such a fiscal expansion to be effective in increasing aggregate demand and inflation, consumers have to know that the resulting primary government deficits are to be financed by future inflation, not future taxes or spending cuts. In other words, according to the FTPL fiscal and monetary expansions can only be effective at the zero lower bound if combined with a non-Ricardian fiscal regime. Hence, determining the plausibility of Ricardian versus non-Ricardian regimes in the euro area is particularly relevant as it has implications for the effectiveness of monetary policy in achieving price stability at the current zero lower bound.

Even though euro area members are required to comply with the Euro Convergence Criteria (hereafter: ECC) in order to ensure fiscal discipline, this does not necessarily imply a Ricardian regime. Two important requirements of the ECC are that government deficits and debts are not allowed to exceed 3% and 60% of GDP, respectively. These rules are of an asymmetric nature as they only provide upper bounds for deficit and debt ratios. For a Ricardian regime to be in place, government balances need to respond to government debt levels, also in case the ECC rules are not binding. A feedback mechanism between government balances and debt is required to ensure a Ricardian regime (Creel and Le Bihan, 2006). Furthermore, since the start of the GFC, government deficits and debt levels have risen sharply. As a consequence, several countries have failed to comply with the 3% and 60% boundaries (Schuknecht, Moutot, Rother and Stark, 2011).

In this paper, we empirically examine whether fiscal policy in the euro area follows a Ricardian or a non-Ricardian regime. We apply the methodology of Canzoneri, Cumby and Diba (2001), who find a Ricardian regime is more plausible for post-war U.S. fiscal data. Specifically, we estimate a bivariate Vector Autoregressive (VAR) model including the primary government

balance and government debt, both proportional to GDP. Some studies have applied this methodology to individual euro area countries, but this paper analyses the fiscal regime for the euro area as a whole. Examining fiscal regimes at the aggregated level enables us to discuss implications for the euro area price level and possible frictions between monetary policy and the fiscal regime. We extend the methodology used by Canzoneri et al. by including two dummy interaction terms in our VAR model. Verified by statistical break-point tests, the first dummy interaction term accounts for the implementation of the ECC fiscal requirements around 1997q3 and the second accounts for start of the GFC around 2008q3. As a result of the inclusion of the two dummy interaction terms, changes in the fiscal regime can be analysed over time.

After having estimated our VAR model, an (unexpected) shock to the government balance is imposed and the plausibility of Ricardian and non-Ricardian regimes is evaluated by means of impulse response functions. Due to the inclusion of the dummy interaction terms, three periods can be distinguished. The first period covers the years before the introduction of the ECC, the second is the period between the introduction of the ECC and the start of the GFC, and the third covers the post-GFC period. Impulse response functions are analysed for these three periods.

Our results for the first period, i.e. before the introduction of the ECC, are not considered to be favourable for either one of the two regimes since the impulse response functions are insignificant. For both post-ECC periods, our impulse response functions indicate that debt responds negatively to a positive shock to the balance. In order for a non-Ricardian regime to be plausible in such a situation, the correlation between the current balance and future balances needs to be negative. Yet, autocorrelation coefficients are positive for the period before the start of the GFC and, therefore, we conclude that a Ricardian regime is more plausible. For the period after the start of the GFC, negative autocorrelation is found after 5 periods, which provides some evidence in favour of a non-Ricardian regime.

The paper proceeds as follows. Section 2 reviews the relevant literature. Section 3 presents the methodology that we use to examine the plausibility of Ricardian versus non-Ricardian regimes. Section 4 discusses the data. Section 5 reports the results. Section 6 provides a discussion and Section 7 concludes.

2. Literature review

This section first summarizes the fiscal theory of the price level and then discusses some of the empirical literature on the fiscal theory of the price level.

2.1 *The Fiscal Theory of the Price Level*

According to traditional monetarist models, the price level is determined as the unique price level that equates the purchasing power of the money supply to the real money demand (Fisher, 1911). This principle forms the basis for many macroeconomic models and analyses such as the well-known IS-LM framework. According to these models, the government is able to determine the price level by varying the money supply. Yet, the price level might be indeterminate in some special cases. In one such case, namely if the money supply itself depends on the price level, both the money supply and the price level are indeterminate (Sargent and Wallace, 1975).

The FTPL aims at providing a way out of such a situation where the price level is indeterminate. According to this theory, put forward mainly by Woodford (1994, 1995), Leeper (1991), and Sims (1994), it is not monetary policy but fiscal policy that determines the price level. Woodford shows how fiscal policy determines the price level in a simple representative-household model such as that of Sidrauski (1967) and Brock (1975). The defining feature of Woodford's model is the way in which the government's budget constraint is satisfied. In equilibrium, the following present value government budget constraint must hold:

$$w_t = s_t + E_t \sum_{j=t+1}^{+\infty} \left(\prod_{k=t}^{j-1} \alpha_k \right) s_j, \qquad (1)$$

where w_t is the ratio of government debt to nominal GDP at the beginning of period t, s_t is the ratio of the primary government balance to nominal GDP in period t, and α_t is the discount factor for period t. More details on the derivation can be found in Appendix A.[2] Simplified, Eq. (1) states the following:

[2] The definition of the present value budget constraint used here differs slightly from the one used by Woodford (1995) as we chose to follow the empirical strategy used by Canzoneri, Cumby and Diba (2001). Whereas Woodford scales variables by the price level, we chose to scale by nominal GDP, i.e. the product of the price level

$$\frac{W_t}{P_t y_t} = \text{Expected present value of primary balances at time } t, \quad (2)$$

where W_t is the nominal government debt level at the beginning of period t, P_t is the price level in period t, and y_t is real GDP in period t. Even though monetarist models also acknowledge such an equality, the difference between the monetarist view and the FTPL lies in its interpretation. Let us analyse both views in turn.

In the monetarist view, Eq. (1) is a constraint and should hold in order for the government to be solvent. Primary balances are set in such a way that the equality holds no matter what the price level is. The fiscal authority follows a Ricardian regime in this case (Woodford, 1995). Eq. (1) plays no role for price determinacy as, instead, the price level is determined in the money market.

The FTPL interprets Eq. (1) differently, as the price level will adjust in such a way that the equality holds. According to this view, Eq. (1) is merely an equality and the government can choose any arbitrary path for its balances. The price level will adjust in such a way that the equality always holds and the government remains solvent. If the fiscal authority chooses its balances irrespective of Eq. (1) a non-Ricardian regime is in place (Woodford, 1995). Even though the FTPL allows for Ricardian regimes, they are regarded as being exceptional since they require strict theoretical assumptions (Woodford, 1995). Therefore, finding evidence in favour of a non-Ricardian regime is interpreted as evidence in favour of the FTPL.

Different explanations can be given for the price level changes that occur as a result of fiscal policy changes in a non-Ricardian regime. For example, Cochrane (2005) views the valuation of government debt to be similar to the valuation of private stock. Therefore, its real value is determined by the expectations of future balances. If government debt is backed by less future balances, households view it as a less valuable investment. Therefore, they chose to hold fewer bonds and consume more goods and services, which leads to inflationary pressure. On the other hand, Woodford (1995) attributes the price changes to the influence of a real wealth effect. More outstanding government bonds means that there are more net private assets available to

and real GDP. Taking this approach allows for price rigidity and immediate adjustments via real GDP as explained by Woodford (1996).

households. If households know that this higher debt is not backed by higher future taxes, i.e. the government is non-Ricardian, their net wealth increases. As a result of this wealth effect, households consume more goods and services, which leads to inflationary pressure. Similarly, an increase in the government balance induces deflationary pressure.

2.2 *Empirical studies on the FTPL*

The literature shows that the FTPL and the existence of non-Ricardian regimes have been proven difficult to test empirically. At first sight, one might wish to estimate a regression equation such as:

$$P_t = \alpha_1 s_t + \alpha_2 w_t + \boldsymbol{\rho}' \boldsymbol{X}_t + \epsilon_t, \tag{3}$$

where $\boldsymbol{X}_t$ is a vector consisting of a set of other possible determinants of the price level, and ε_t is an error term. Estimates of α_1 and α_2 will tell how much the price level depends on the measures of fiscal policy, i.e. s_t and w_t. In a non-Ricardian regime, a negative estimate for α_1 is expected since a higher government balance induces a lower price level. Unfortunately, finding this negative estimate does not provide convincing evidence for or against a non-Ricardian fiscal regime as a negative relationship between the balance and the price level may exist even in a Ricardian regime. In this case, the causality will run the other way. In a Ricardian regime, if monetary policy induces an increase in the price level, this lowers the real value of outstanding government debt. Taking into account the government budget constraint, balances can be lower. Therefore, a negative relationship exists between the price level and the balance in both a Ricardian and a non-Ricardian regime.

Hence, to determine whether fiscal policy is able to determine the equilibrium price level, one needs to focus on fiscal behaviour. According to the FTPL, the fiscal regime determines whether the equilibrium price level is determined by monetary or fiscal policy. In the case of a Ricardian regime, balances are set in such a way that the present value government budget constraint is satisfied. In the case of a non-Ricardian regime, which is assumed by the FTPL, balances are able to move in an arbitrary way since the price level adjusts in order to satisfy the present value government budget constraint anyway. Therefore, investigating whether balances are set in a way that guarantees government solvency may provide evidence in favour of a Ricardian or a non-Ricardian regime. Many papers attempt to estimate an equation such as Eq.

(1) directly, but this approach is heavily criticized by Bohn (1995) as it needs strong assumptions on future discount factors. Instead, Bohn (1998) presents another approach that estimates a fiscal policy rule such as:

$$s_t = \alpha w_t + \boldsymbol{\rho}' \boldsymbol{X_t} + \epsilon_t, \quad (4)$$

where s_t and w_t, are defined as above, and $\boldsymbol{X_t}$ is a vector consisting of a set of control variables. Bohn (2005) demonstrates that a positive α is sufficient to satisfy the present value government budget constraint. He finds empirical evidence suggesting that the budget balance responds positively to the beginning-of-period debt in the U.S. during the period 1948-1989. Consequently, the author concludes that U.S. government debt is sustainable for his sample. Bohn's approach has been applied widely. Greiner, Köller and Semmler (2007) estimate a fiscal policy rule for four euro area countries and find evidence in favour of debt sustainability in all cases. This result has often been interpreted as empirical evidence in favour of a Ricardian regime: balances respond to the initial debt level in order for the government to be solvent.

However, Cochrane (1998) points at an 'observational equivalence' problem with Bohn's approach, because both regimes may accept Eq. (1) as an equilibrium condition. Therefore, the positive relation that Bohn finds is inconclusive evidence for a Ricardian regime. The reasoning is as follows. Causality runs in opposite ways for both regimes. In a Ricardian regime, the balance responds positively to beginning-of-period debt in order for the government to be solvent. Hence, the price level is not affected, as s_t responds to w_t in order for Eq. (1) to hold. In a non-Ricardian regime, however, if an increase in s_t causes the right-hand side of Eq. (1) to rise, the price level will decrease so that the left-hand side of Eq. (1) increases as well. Therefore, a positive relation between s_t and w_t can also be found in the case of a non-Ricardian regime.

Canzoneri, Cumby and Diba (2001; hereafter CCD) try to circumvent the observational equivalence problem by choosing a short-run dynamic approach. They analyse the responses of balances and debt after an (unexpected) shock to the balance, thereby determining how both variables are interrelated. Specifically, CCD test whether a Ricardian or a non-Ricardian regime is present in the post-war period for the U.S. by estimating a Vector Autoregression (VAR) model. Their model includes two variables: primary government balances and government liabilities, both proportional to nominal GDP. Government liabilities are defined as government

debt plus the monetary base. CCD present the responses of both variables after a shock to the balance. Impulse response functions show that the debt ratio decreases for several periods after a positive shock to the balance. Ricardian regimes provide an intuitive interpretation of this: if government balances unexpectedly increase, debt is paid off. A non-Ricardian interpretation for this outcome exists as well, but the authors regard this as less plausible for the following reason. For a non-Ricardian regime to hold in this case, the decrease in the debt ratio has to result from a decrease in the expected present value of future balances (the right hand side of Eq. (1)). This would mean that there has to be a negative correlation between the current balance and future balances. The increase in the current balance has to trigger a decrease in future balances which in turn lowers the debt ratio in case of a non-Ricardian regime. Since the authors do not find this negative correlation, they conclude that a Ricardian regime is more plausible for their data.

Semmler and Zhang (2004) perform a VAR analysis similar to CCD for France during the period 1967 until 1998 and for Germany for the period 1970 until 1998. In contrast to CCD, Semmler and Zhang exclude the monetary base; their endogenous variables are primary balance and government debt, both proportional to GDP. Excluding the monetary base excludes the possibility of fiscal price determination occurring as a result of monetary phenomena such as seigniorage (Sargent and Wallace, 1981). The exclusion of the monetary base fully disentangles monetary and fiscal price determination, which is also stressed by Creel and Le Bihan (2006). The impulse responses of Semmler and Zhang also indicate that the debt ratio decreases for several periods after an increase in the balance. As explained above, this can occur in both a Ricardian and a non-Ricardian regime. Contrary to CCD, Semmler and Zhang analyse a debt shock in order to differentiate between a Ricardian and a non-Ricardian regime in case debt responds negatively to a surplus shock. The impulse responses indicate that the balance decreases after a positive shock to the debt ratio. In a Ricardian regime, a positive response of the balance is expected after a positive shock to debt. Since the authors do not find this positive response, they conclude that a non-Ricardian regime is more plausible for France and Germany. Nevertheless, in a non-Ricardian regime no predictions can be made about the response of the balance after a debt shock. Therefore, we apply the methodology of CCD and examine the correlation structure of balances in case we find a negative response of debt after a positive shock to the balance. However, we follow Semmler and Zhang in excluding the monetary base.

3. Method

We test the empirical plausibility of Ricardian and non-Ricardian regimes using the approach of CCD. Specifically, we estimate a VAR model and analyze the dynamics between government debt and the primary balance. This section first explains how to estimate a VAR model when there are breaks in the data and then discusses the analytical framework we use to determine whether a Ricardian or a non-Ricardian regime is more plausible.

3.1 *VAR modelling with breaks*

The estimated VAR model includes two variables: the government's primary balance in period *t*, s_t, and the government debt at the beginning of period *t*, w_t. Both are proportional to GDP. More details on the construction of the respective variables and the data that is used will follow in Section 4. As will be shown in Section 4, two breaks are present during our sample period, the first due to the introduction of the ECC and the second after the start of the Global Financial Crisis (GFC) in 2008. We use time dummies to address such breaks and estimate a VAR model including two dummy interaction terms. Splitting the sample in three sub-periods and estimation of three VARs is no option because of the resulting loss of observations. Therefore, dummy interaction terms are introduced and the model is estimated for the whole sample period. The first dummy interaction term accounts for the implementation of the Euro Convergence Criteria (D_{ECC}) and the second accounts for the start of the GFC (D_{GFC}). The reduced-form model, including *p* lags, looks as follows:

$$s_t = \alpha_s + \beta_s D_{ECC} + \gamma_s D_{GFC} + \delta_{ss}(L)s_{t-1} + \delta_{sw}(L)\, w_{t-1} + \eta_{ss}(L)s_{t-1}D_{ECC} + \eta_{sw}(L)w_{t-1}D_{ECC} + \theta_{ss}(L)s_{t-1}D_{GFC} + \theta_{sw}(L)w_{t-1}D_{GFC} + e_t^s \quad (5)$$

$$w_t = \alpha_w + \beta_w D_{ECC} + \gamma_s D_{GFC} + \delta_{ws}(L)s_{t-1} + \delta_{ww}(L)w_{t-1} + \eta_{ws}(L)s_{t-1}D_{ECC} + \eta_{ww}(L)w_{t-1}D_{ECC} + \theta_{ws}(L)s_{t-1}D_{GFC} + \theta_{ww}(L)w_{t-1}D_{GFC} + e_t^w, \quad (6)$$

where $\delta_{ij}(L) = \delta_{1.ij} + \delta_{2.ij}L + \cdots + \delta_{p.ij}L^{p-1}$ for *i*,*j* = *s*, *w*, and $\eta_{ij}(L)$ and $\theta_{ij}(L)$ are similar polynomials. In short-hand matrix notation:

$$Z_t = \alpha + \beta D_{ECC} + \gamma D_{GFC} + \delta(L)Z_{t-1} + \eta(L)Z_{t-1}D_{ECC} + \theta(L)Z_{t-1}D_{GFC} + e_t \quad (7)$$

Hence, each endogenous variable is explained by a constant, a constant interacted with both dummy variables, lagged values for both endogenous variables, lagged values interacted with both dummy variables, and an error term. The error term is assumed to be serially and mutually uncorrelated. Eq. (7) can be estimated by means of Ordinary Least Squares (OLS), since both equations contain the same set of lagged variables. The inclusion of the dummy variables as exogenous variables enables us to determine whether the constant in the regression equations changes after the breaks. Moreover, the dummy interaction terms are added as endogenous variables in order to determine whether the slopes of the regression equations change after the occurrence of the breaks.

After estimating the above VAR model, three VAR models are created from the estimated coefficients. Each of the three separate models represents a different period. When both dummy terms are equal to zero, i.e. when considering the first period, the estimated VAR is equal to a simple bivariate VAR model. The coefficients for the dummy interaction terms are neglected. When considering the second period, the estimated coefficients of the VAR model are found by adding the respective coefficients of the endogenous variables to the estimated coefficients of the first dummy interaction term. For example, the constant in the estimated equation for s_t is found by adding the estimates for α_s and β_s. Similarly, the estimated coefficients for the VAR of the last period are found by adding the respective coefficients of the second dummy interaction coefficients. For example, the constant in the estimated equation for s_t is found by adding the estimates for α_s, β_s and γ_s.

The IRFs are calculated by imposing a recursive ordering as in Sims (1980). The primary balance is ordered before debt. In other words, the balance affects debt contemporaneously. In order to obtain standard errors for the estimated coefficients and confidence intervals for the IRFs of the VAR model including the dummy interaction terms, the bootstrap methodology of Runkle (2002) is used. This methodology is a parametric bootstrap method that is suitable for time series data since it preserves the temporal dependence of the data in generating bootstrap samples.[3] The method proceeds as follows:

[3] The original bootstrap methodology of Efron (1982) cannot be used as this assumes that all observations in the sample are assumed to be independently distributed. This is too restrictive for time series data.

1. Estimate the reduced-form model in Eq. (7) using OLS. This gives the estimates: $\widehat{\alpha}$, $\hat{\beta}$, $\hat{\gamma}$ $\widehat{\delta(L)}$, $\widehat{\eta(L)}$, $\widehat{\theta(L)}$ and $\widehat{e_t}$.

2. Using the estimated coefficients and residuals of the fitted model, estimate the linear predictions for the endogenous variables. Using the reduced-form model specified above, the linear predictions are calculated as: $\widehat{Z_t} = \hat{\alpha} + \hat{\beta} D_{ECC} + \hat{\gamma} D_{GFC} + \widehat{\delta(L)} Z_{t-1} + \widehat{\eta(L)} Z_{t-1} D_{ECC} + \widehat{\theta(L)} Z_{t-1} D_{GFC}$ for $t = (1+p), \ldots, N$, where p is the number of lags and N is the total number of observations.

3. Using the linear predictions $\widehat{Z_t}$, create bootstrapped time-series, Z_t^*, for $t = (1+p), \ldots, N$, as follows: $Z_t^* = \widehat{Z_t} + e_t^*$, where e_t^* is a random draw from the empirical distribution of the residuals.

4. Estimate the reduced-form VAR as in Eq. (7) using the bootstrapped time-series in Z_t^* as dependent variables.

5. Compute impulse response functions for both endogenous variables using the coefficients given by the estimated VAR of the bootstrapped series of step 4.

6. Repeat steps 3-5 for a fixed number of times. The number of iterations we used is 1,000.

Confidence bands are obtained by taking the 5th and the 95th percentile impulse responses.

3.2 *Analytical framework*

To investigate whether a Ricardian regime or a non-Ricardian regime is more plausible, we analyse the effects of a one-period increase in s_t. Impulse Response Functions (IRFs) show how the balance and debt ratio respond in the current period and future periods. Figure 2 summarizes our analytical framework, which is adopted from CCD.

[Insert Figure 2]

In a Ricardian regime, a negative response of w_{t+1} should always follow a positive shock in s_t since in this case the higher balance is used to pay off government debt in the next period. A

non-Ricardian regime is slightly more difficult to identify. The response of the debt ratio in a non-Ricardian regime depends on the possible correlation between the current balance and future balances. First, consider the case of a non-Ricardian regime and no correlation between the current balance and future balances. In such a case, an innovation in s_t will lead to a zero change in w_{t+1} for the following reasons. In period t, the increase in s_t leads to a one-by-one increase in w_t through a decrease in the price level as a result of one of the mechanisms explained in Section 2. In the next period, the increase in s_t pays off debt by the same amount. Therefore, w_{t+1} is unaffected by an increase in s_t.

Next, consider the case of a non-Ricardian regime and positive correlation between the current balance and future balances. In this case, a positive response of w_{t+1} will follow after a positive shock in s_t. The innovation in s_t leads to a higher expected present value of future balances as a result of the positive correlation. Even though the shock in s_t pays off part of the debt in period w_{t+1}, the increased present value of future balances leads to a decrease in the price level. Consequently, w_t and w_{t+1} are expected to respond positively to an increase in s_t.

Last, consider the case of a non-Ricardian regime and negative correlation between the current balance and future balances. In such a case, a negative response of w_{t+1} will occur after a positive shock in s_t since the shock leads to a lower expected present value of future balances. The decrease in the expected present value of future balances will lower w_t through an immediate increase in the price level. In addition, the higher balance pays off part of the debt which leads to a lower w_{t+1} as well. Thus, an observed negative response of w_{t+1} may be evidence in favour of a Ricardian regime or a non-Ricardian regime depending on the correlation between the current balance and future balances.

In order to identify whether a Ricardian or a non-Ricardian regime is more plausible in case of a negative response of w_{t+1}, we will follow CCD and analyse autocorrelation coefficients between the current balance and future balances. In a non-Ricardian regime, a negative response of w_{t+1} can only occur if there is a negative correlation between the current balance and future balances. On the other hand, a negative response of w_{t+1} together with a positive correlation between the current balance and future balances is interpreted as evidence in favour of a Ricardian regime.

Thus, if a positive shock to the balance is followed by a negative response of debt, and the autocorrelation of balances is positive (negative), the regime is Ricardian (non-Ricardian). If a positive shock to the balance is followed by a positive response of debt, and autocorrelation of balances is positive, the regime is non-Ricardian. If a positive shock to the balance is followed by a zero response of debt, and the autocorrelation of balances is zero, the regime is also non-Ricardian.

4. Data

To analyse the plausibility of Ricardian versus non-Ricardian fiscal regimes at the euro area level, we use the Area Wide Model (AWM) fiscal database of the ECB, which is compiled by Paredes, Pedregal and Perez (2014). The dataset includes seasonally adjusted data on the levels of general government revenues, expenditures, and debt for the euro area-18 aggregate.[4] The time period that is available is 1980q2-2013q4.

In order to construct the primary balance variable, net interest payable should be added to the total government balance. However, the AWM fiscal database only includes data on interest payable and not on interest receivable. Data on interest receivable and interest payable can be obtained from the Eurostat Government Finance Statistics database, albeit for a shorter time span. The seasonally adjusted series (using Census X13) are exhibited in Figure 3. Net interest payable and interest payable follow roughly the same pattern for the euro area-18. In addition, the fraction of interest receivable in the net interest calculation is fairly small. Therefore, interest receivable is considered to be zero and the interest payable from the AWM database is interpreted as being net interest payable. Thus, primary balances are calculated as net borrowing or lending plus interest payable.

[Insert Figure 3]

Nominal GDP is also obtained from the AWM database, that is, from the non-fiscal counterpart compiled by the ECB. It is inferred from real GDP and the GDP deflator, since the AWM database does not give the nominal GDP as such.

[4] The euro area-18 consists of: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Luxembourg, Malta, The Netherlands, Portugal, Slovakia, Slovenia, and Spain.

From the data on the primary balance, government debt and nominal GDP, we calculate the balance and debt ratios. Figure 4 shows the time series for the euro area. Descriptive statistics for the two variables are given in Table 1. Two significant structural breaks seem to be present when examining Figure 4. The first one occurs around the implementation of the ECC fiscal requirements in the third quarter of 1997 and is depicted by the first vertical line. The ECC enforced rules on the fiscal policies of euro area countries which led to a sharp increase in primary balances. The second structural break occurs around 2008q3 and is depicted by the second vertical line. It corresponds to the start of the GFC, which caused primary deficits and government debts to increase sharply.

[Insert Figure 4]

[Insert Table 1]

A Chow (1960) structural break test points out that structural breaks indeed occur in 1997q3 and 2008q3. The F-statistics in Table 2 show that for both series the structural breaks are statistically significant at a 1% significance level.

[Insert Table 2]

Based on the results of the Chow break tests, two dummy variables are constructed, one for the introduction of the ECC (D_{ECC}) and one for the recent financial crisis (D_{GFC}). D_{ECC} is constructed to equal 0 for periods before 1997q3 and to equal 1 for periods after 1997q3. D_{GFC} is constructed to equal 0 for periods before 2008q3 and to equal 1 for periods after 2008q3.

5. Results

Estimation of the VAR model described in Section 3.1 for the euro area aggregate gives the estimated parameters presented in Table 3. Two lags are included in the VAR as suggested by several lag length criteria.[5] An eigenvalue stability test shows that all eigenvalues lie within the unit circle which indicates that the estimated VAR is stable.

[5] To determine the appropriate lag length, the following information criteria are analysed: the likelihood ratio (LR), the final prediction error (FPE), Akaike's information criterion (AIC), the Hannan-Quinn information criterion

[Insert Table 3]

The estimated coefficients are obtained by first estimating a VAR model including the dummy interaction terms as endogenous variables for the whole sample period. Estimation by OLS gives us estimates for the constant terms, for the parameters of the endogenous variables and for the parameters of the dummy interaction terms.

The inclusion of the two dummy interaction terms allows us to distinguish three periods. The period for which $D_{ECC}=D_{GFC}=0$ corresponds to the period before the implementation of the ECC and before the start of the GFC, and it will be referred to as the pre-ECC period. The period for which $D_{ECC}=1$ and $D_{GFC}=0$ corresponds to the period after the implementation of the ECC but before the start of the GFC. It will be referred to as the post-ECC period. The period for which $D_{ECC}=D_{GFC}=1$ corresponds to the period after the implementation of the ECC and after the start of the GFC, and it will be referred to as the post-GFC period. The three distinct VAR models are constructed by adding the coefficients of the endogenous variables to the estimated coefficients of the respective dummy interaction terms, as explained in Section 3.

Comparing the estimated VAR models for the three periods shows that the signs of the estimated coefficients are generally the same while their magnitudes may differ across the three periods. A difference exists between the estimated coefficients of the debt equations which may lead to differences in the IRFs. As the estimated response of debt deserves most interest in our analytical framework, these differences in the estimated coefficients suggest that contrasting conclusions may arise across the three periods.

The IRFs are calculated for the three distinct VAR models. Different conclusions are drawn for each period as is discussed below. In constructing the IRFs, the primary balance is ordered first. We examine the robustness of the results by using different specifications of the VAR models.[6] The results are robust to the exclusion of the constant term, the inclusion of a time trend and the inclusion of 1 lag instead of 2 lags. Furthermore, the VARs are also estimated by specifying both variables in first differences. Alternative IRFs are calculated by using the reverse ordering

(HQIC), and Schwarz's Bayesian information criterion (SBIC). All information criteria suggest that including two lags is optimal for our VAR estimation.

[6] For reasons of space, the results of the robustness are not reported, but are available from the authors.

of the variables. For the latter two specifications the results are qualitatively the same; however, the confidence intervals are wider.

5.1 Pre-ECC

The period of our first VAR model corresponds to the pre-ECC period. During this period government balances have generally increased in the euro area in order to comply with the fiscal requirements of the ECC. This is also shown in Figure 4 where balances increase sharply around 1997q3, the quarter in which the fiscal requirements were introduced. At the same time, the debt ratio decreases. As a result a Ricardian regime is expected to be more applicable for this period.

Figure 5 shows the IRFs of both variables after a positive shock to the balance in the pre-ECC period. As can be seen, the estimated response of debt does not significantly differ from zero. Referring to our analytical framework, presented in Figure 2, a zero response of debt after a positive shock to the balance can be seen as evidence in favour of a non-Ricardian regime. However, this is only the case if correlation between the current balance and future balances is also zero.

[Insert Figure 5]

Therefore, to determine whether a Ricardian or a non-Ricardian regime is more plausible given the negative response of debt, an analysis of the correlation structure of balances is needed. Autocorrelation coefficients of balances for the three distinct periods are given in Table 4. For the pre-ECC period, autocorrelation coefficients are positive and significant for at least 15 periods. Therefore, our results are not considered to be favourable for either of the two regimes.

[Insert Table 4]

5.2 Post-ECC until GFC

Figure 6 shows the IRFs of both variables after a positive shock to the balance in the post-ECC period until the GFC. The response of debt is negative and significant after 2 periods. As listed

in Figure 2, a negative response of debt can occur in both a Ricardian and a non-Ricardian regime. Therefore, in order to examine which fiscal regime is more plausible, correlation coefficients between the current balance and future balances need to be analysed.

[Insert Figure 6]

Autocorrelation coefficients of balances for the post-ECC period are given in Table 4. For this period, autocorrelation coefficients are positive for the first nine lags but after the tenth lag autocorrelation coefficients turn negative, meaning that a positive balance in the current period is negatively correlated to the balance ten quarters later. As explained above, a non-Ricardian regime is plausible when the response of debt is negative and correlation between the current balance and future balances is negative.

However, we still consider a Ricardian regime more plausible. For later periods, the autocorrelation coefficients become smaller in absolute value. As a result, the change in present value of balances due to the positive shock to the balance is still expected to be positive. If the present value change in balance is positive, in a non-Ricardian regime, a positive response of debt is expected, which we do not find. Therefore, we conclude that a Ricardian regime is more plausible for the post-ECC period.

In addition, the IRFs show that according to our estimated model, a positive response of the balance is expected after a positive shock to the balance. This can be seen as additional evidence for the positive autocorrelation of balances and as additional evidence in favour of a Ricardian regime.

5.3 Post-GFC

At the start of the GFC around the third quarter of 2008, deficits increased sharply in the euro area. This structural break is clearly present in Figure 4 for both variables. During this period government balances (or rather deficits) were not necessarily determined by the debt ratio but rather by large shocks caused by the financial crisis. As a result, a non-Ricardian regime is considered more likely for this period.

Figure 7 shows the IRFs of both variables for the post-GFC period. Again, after a positive shock to the balance, the immediate response of debt is negative. However, the response quickly turns insignificant. As listed in Figure 2, a negative response of debt can occur in both a Ricardian and a non-Ricardian regime. The correlation structure of balances needs to be analysed, in order to determine which regime is more plausible.

[Insert Figure 7]

Autocorrelation coefficients of balances for the post-GFC period are given in Table 4 and are positive until 5 lags. Thereafter, the autocorrelation coefficients turn negative. Since most coefficients are negative, a decrease in the expected present value of balances after a positive shock to the balance is more likely for this period. Consequently, given our analytical framework in Figure 2, the evidence points in the direction of a non-Ricardian regime in the post-GFC period.

However, the fact that only a short period is available to calculate the autocorrelations for the last period makes it hard to derive firm conclusions. Autocorrelation coefficients are given for 15 lags and for the last lags available, autocorrelation coefficients tend to become lower in absolute value. Consequently, whether a decrease in the present value of balances is expected depends on subjective judgement.

Moreover, the estimated response of the balance after a positive shock to the balance in Figure 7 is positive and significant up to 6 periods. Therefore, the estimated response of the balance presents contrasting evidence for the negative correlation structure of balances found in Table 4. As a result, we are not able to conclude with certainty whether a Ricardian or a non-Ricardian regime is more plausible for the post-GFC period. Nevertheless, the initial negative and significant response of debt in Figure 7 combined with the negative autocorrelation coefficients in Table 4 present some evidence in favour of a non-Ricardian regime.

6. Discussion

Evidence in favor of non-Ricardian regimes indirectly indicates the existence of fiscal price determination. If government balances are set independently of the initial debt level, and the

government is to remain solvent, prices need to adjust. Therefore, the presence of non-Ricardian regimes has important implications for monetary policy as the central bank has less power in determining the price level in this case. Fiscal price determination becomes more likely and fiscal authorities need to play a bigger role in price stabilization. Due to the effective lower bound problem that the ECB is currently facing, the FTPL gained a renewed interest as it provides an alternative theory of price determination. If fiscal policy is the nominal anchor in determining the price level, the intended effects of monetary policy may not be realized as they are countered by the effects of fiscal policies on the price level.

The plausibility of Ricardian versus non-Ricardian regimes differs for the three periods that we analyze. For the pre-ECC period the response of debt is insignificant. Therefore, we cannot consider one regime more plausible over the other. For the post-ECC period until the GFC, we find a Ricardian regime to be more plausible. After a shock to the balance, the debt ratio decreases. Given the positive autocorrelation coefficients it is unlikely that an increase in nominal GDP causes the debt ratio to decrease. It is more likely that after the positive shock to the balance, part of the nominal government debt is paid off. Therefore, we consider this negative response as evidence in favor of a Ricardian regime and price determination seems to be a monetary phenomenon during this period. In other words, monetary policy is the nominal anchor in stabilizing the euro area price level and fiscal authorities respond in a Ricardian manner in order to remain solvent.

For the period after the start of the GFC we find some evidence indicating a non-Ricardian regime. This evidence mainly results from the negative autocorrelation coefficients of the balance. That is, if the government unexpectedly has a higher balance in the current period, future balances will tend to decrease. In a Ricardian regime, nominal GDP is not affected by this. An unexpectedly higher balance pays off part of nominal government debt which causes the decrease in the debt ratio. In a non-Ricardian regime however nominal GDP *is* affected by an unexpected increase in the balance since the negative autocorrelation lowers the present value of future balances. Therefore, in a non-Ricardian regime, the decrease in the debt ratio mainly results from an increase in nominal GDP. Given our IRFs and the negative autocorrelation coefficients, a non-Ricardian regime is plausible. Nevertheless, our results do not unambiguously indicate a non-Ricardian regime. It still depends on subjective judgement whether the present value of future balances is expected to decrease. Given our estimated

negative response of the debt ratio, a non-Ricardian regime can only be plausible if this decrease in the present value occurs.

In summary, our modeling results only give conclusive and unambiguous evidence of a Ricardian fiscal policy for the sub-period starting with the introduction of the euro convergence criteria (ECC) and ending with the global financial crisis (GFC). This outcome is plausible, as during the early years of EMU, countries did make strong efforts to fulfill the ECC needed for membership of the currency union. The ECC prompted participating countries to aim at fiscal solvency by reducing deficits and reaching sustainable debt levels. Thus, the EMU during this episode worked as it should to promote fiscal solvency. Unfortunately, the GFC strongly shocked the banking sector in most euro area countries which forced governments to bail out large and systemically important banks, and led to a severe recession. The GFC led to higher deficits and debt. Consequently, for the period since the GFC, we find no conclusive evidence of Ricardian fiscal policy.

7. Conclusion

In this paper, the plausibility of Ricardian versus non-Ricardian regimes is investigated for the euro area. According to the FTPL it is fiscal policy that acts as a nominal anchor in determining the aggregate price level. If a government sets its balances in an arbitrary way, the price level adjusts in order to guarantee government solvency. Such a fiscal regime is called a non-Ricardian regime as in Woodford (1995). On the other hand, a fiscal regime where the government sets its balances in such a way as to guarantee government solvency, is called a Ricardian regime.

To investigate whether a Ricardian or a non-Ricardian regime is more plausible for the euro area, we estimate a VAR model, following Canzoneri, Cumby and Diba (2001). The model includes the variables primary government balance and government debt. We extend the methodology used by CCD by including two dummy interaction terms in our VAR model that account for the two structural breaks that are present in the period to be analysed. The first dummy interaction term accounts for the introduction of the ECC and the second dummy interaction term accounts for start of the GFC.

The impulse response functions for the pre-ECC period do not point towards either of the two regimes. For this period, the response of debt after a positive shock to the balance is not significantly different from zero. This can be evidence in favour of a non-Ricardian regime if the current balance and future balances are not correlated. Since we do not find this zero correlation, our results are not considered to be favourable for either of the two regimes.

For the period between the introduction of the ECC and the start of the GFC we find a negative response of debt after a positive shock to the balance. This negative response can be evidence in favour of both a Ricardian and a non-Ricardian regime. However, in a non-Ricardian regime, the negative response can only be explained if there exists a negative correlation between the current balance and future balances. Since evidence for this cannot be found, a Ricardian regime is more plausible for the post-ECC period. Thus, during this episode the EMU worked as it should to promote fiscal solvency and monetary policy is the nominal anchor in determining the price level.

For the post-GFC period, the debt ratio again responds negatively to an increase in the balance. However, in this case we do find some evidence for a negative correlation between the current balance and future balances. Whether this negative correlation leads to a decrease in the expected present value of balances and, thus, presents evidence in favour of a non-Ricardian regime, depends on subjective judgement. Moreover, the IRFs of our estimated model show a positive response of the balance after a positive shock to the balance. Therefore, even though some evidence exists in favour of a non-Ricardian regime in the period after the start of the GFC, it is not conclusive. Yet, the existence of a non-Ricardian regime has important implications for the effectiveness of monetary policy as fiscal policy becomes the nominal anchor in stabilizing the euro area price level.

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APPENDIX A. Theoretical model

The determination of the price level according to the FTPL evolves around the way in which the present value budget constraint is satisfied. Founders of the FTPL derive theoretical models including representative households and general equilibrium conditions (see Woodford (1994, 1995), Leeper (1991), and Sims (1994)). However, since the defining features of Ricardian and non-Ricardian regimes lie in the way the government's budget constraint is satisfied, attention is focused on this part of the theoretical models here.

Consider the following government budget constraint in nominal terms at any period j:

$$W_j = (T_j - G_j) + W_{j+1}/(1 + r_j), \tag{A.1}$$

where W_j is the stock of government debt at the beginning of period j, $T_j - G_j$ is the primary government balance during period j, and r_j is the nominal interest rate for period j. Conventionally, a government's budget constraint also includes the change in the monetary base on the right hand side, meaning that the existing level of government debt can be monetized. However, for reasons given in Section 4, the monetary base is neglected in the analysis of this paper.

Scaling the government's budget constraint with nominal GDP, we obtain:

$$\frac{W_j}{P_j y_j} = \frac{T_j - G_j}{P_j y_j} + \frac{W_{j+1}}{(1+r_j)(P_j y_j)} = \frac{T_j - G_j}{P_j y_j} + \frac{y_{j+1}/y_j}{(1+r_j)(P_j/P_{j+1})} \frac{W_{j+1}}{P_{j+1} y_{j+1}}, \tag{A.2}$$

where P_j and y_j are the price level and the level of real GDP in period j, respectively. Thus, the ratio of debt to nominal GDP in period j needs to be equal to the ratio of the balance to nominal GDP in period j plus a discount factor times the ratio of debt to nominal GDP in the next period. The discount factor equals the ratio of growth in real GDP to the real interest rate. By defining w_j as the debt-to-GDP ratio, s_j as the balance-to-GDP ratio, and α_j as the discount factor, Eq. (A.2) can be rewritten as:

$$w_j = s_j + \alpha_j w_{j+1}. \tag{A.3}$$

Following Woodford (1995) and CCD, solving forward yields the present value budget constraint in the current period *t*:

$$w_t = s_t + E_t \sum_{j=t+1}^{+\infty} \left(\prod_{k=t}^{j-1} \alpha_k \right) s_j. \tag{A.4}$$

Thus, the equilibrium condition in Eq. (A.4) states that the debt-to-GDP ratio equals the expected present value of all future balance-to-GDP ratios. The derivation of Eq. (A.4) assumes that government solvency is ensured and the following holds in the limit:

$$\lim_{T \to +\infty} E_t \left(\prod_{k=1}^{T+t-1} \alpha_k \right) w_{T+t} = 0. \tag{A.5}$$

FIGURES

Figure 1: Debt-to-GDP ratios euro area-18 countries in 2013q4

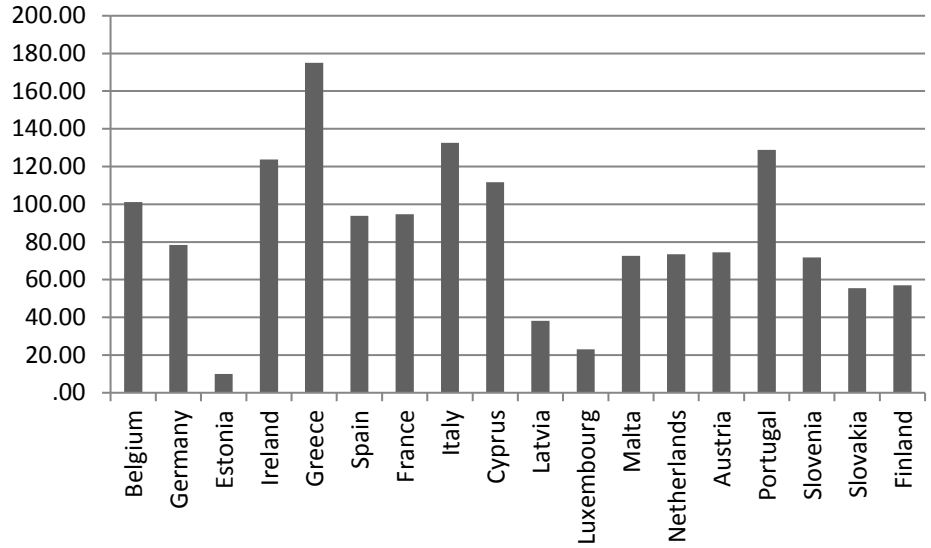
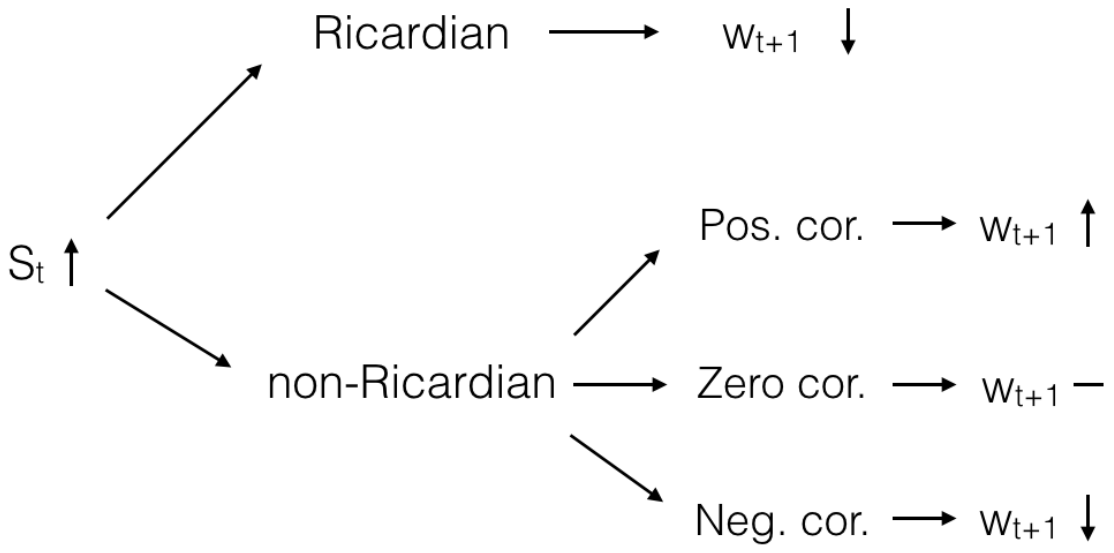


Figure 2: Analytical framework Ricardian versus non-Ricardian regime



Note: After an (unexpected) positive shock to s_t, a decrease in w_t is expected in a Ricardian regime. In a non-Ricardian regime, the response of w_t depends on the autocorrelation structure of government balances. In case of zero autocorrelation between current and future balances, no response of w_t is expected in the period after the shock. In case of positive (negative) autocorrelation, a positive (negative) response of w_t is expected.

Figure 3: Interest payable versus net interest payable, i.e. interest payable minus interest receivable, for the euro area aggregate

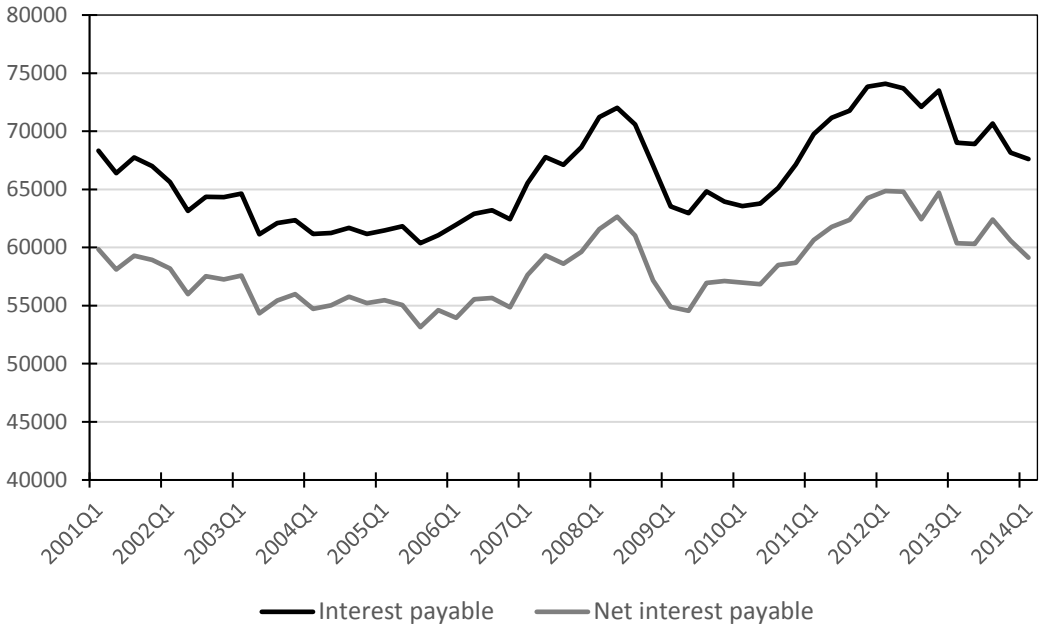
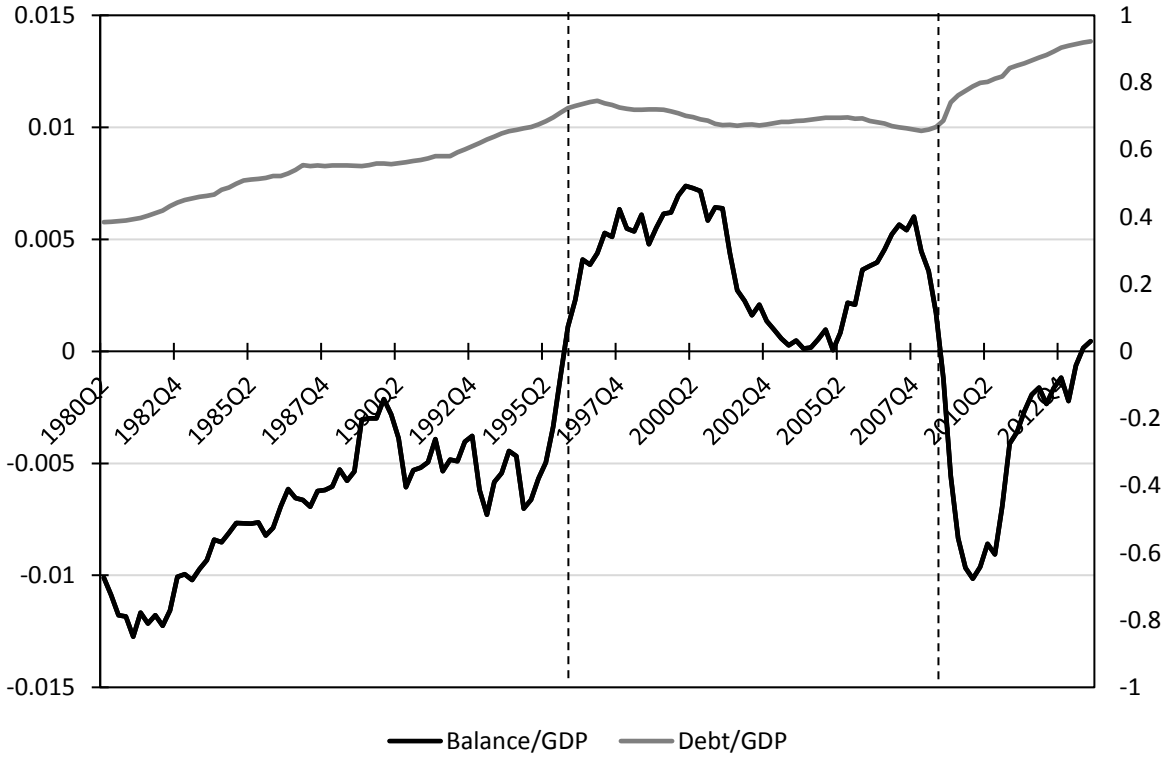


Figure 4: Primary government balance (left y-axis) and debt (right y-axis), both proportional to nominal GDP, for the euro area aggregate



Note: the first vertical line indicates the break occurring at the introduction of the ECC. The second vertical line indicates the break occurring at the start of the GFC.

Figure 5: Impulse response functions after a positive structural shock to the balance (pre-ECC period)

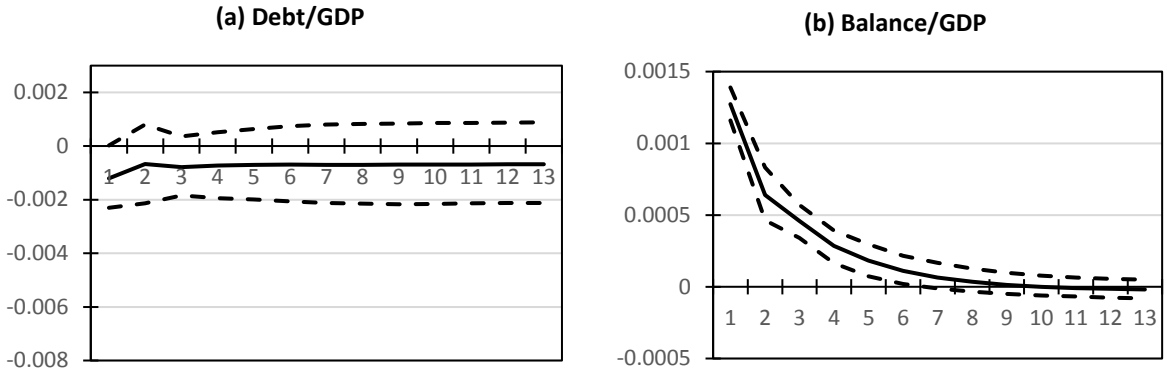


Figure 6: Impulse response functions after a positive structural shock to the balance (post-ECC period)

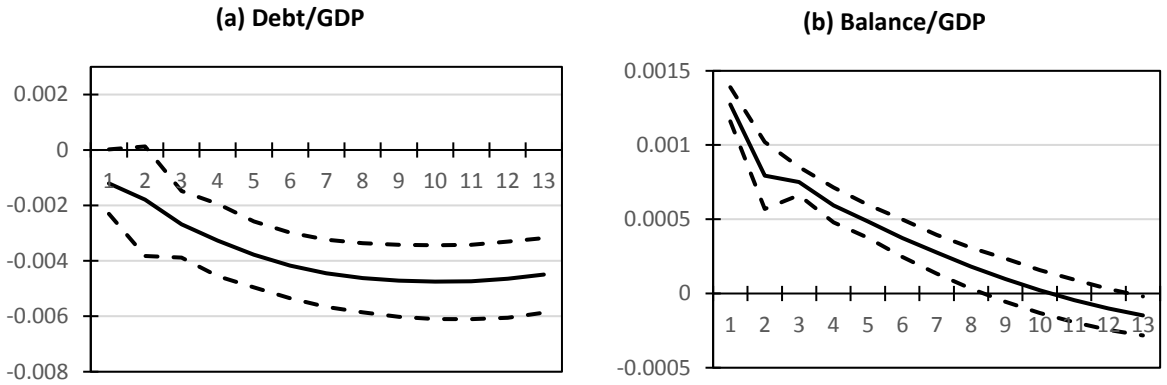
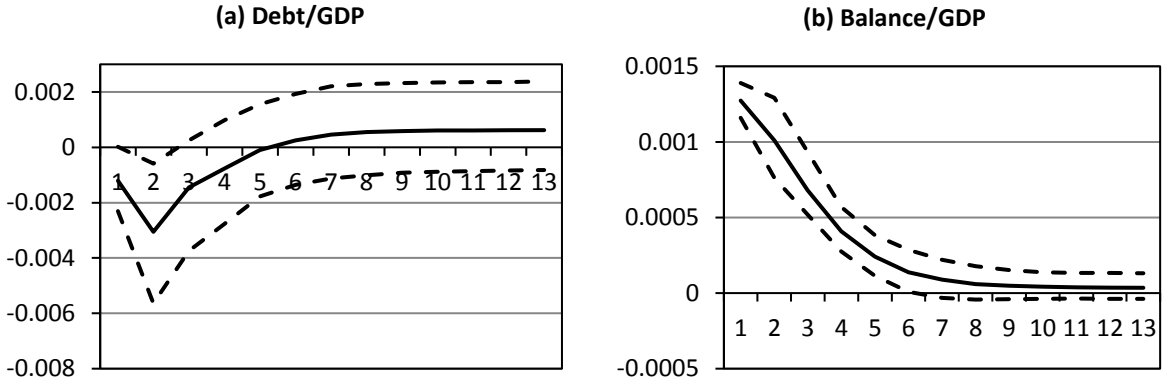


Figure 7: Impulse response functions after a positive structural shock to the balance (post-GFC period)



TABLES

Table 1: Descriptive statistics of balance-to-GDP ratio and debt-to-GDP ratio for the euro area aggregate (sample period: 1980q2-2013q4)

	Balance/GDP	Debt/GDP
Sample mean	-0.002	0.644
Standard deviation	0.006	0.129
Minimum	-0.013	0.384
Maximum	0.008	0.922
Observations	135	135

Table 2: F-statistics of a Chow test including both an intercept dummy and a slope dummy

	D_{ECC}	D_{GFC}
Balance/GDP	90.27	177.00
Debt/GDP	229.49	233.54
Note: D_{ECC} equals 0 for periods before 1997q3 and 1 for periods after 1997q3. D_{GFC} equals 0 for periods before 2008q3 and 1 for periods after 2008q3. The critical F-value for a 1% significance level in our sample is F(2,131)=4.77.		

Table 3: Three distinct VAR models depending on the subsample

	Pre-ECC		Post-ECC		Post-GFC	
	s_t	w_t	s_t	w_t	s_t	w_t
Constant	-0.012*** (0.001)	0.015* (0.010)	-0.022*** (0.002)	0.026* (0.019)	-0.035*** (0.004)	0.068*** (0.028)
s_{t-1}	0.507*** (0.091)	0.210 (0.681)	1.135*** (0.145)	-0.503 (1.144)	1.933*** (0.219)	-2.201 (1.949)
s_{t-2}	0.109 (0.093)	-0.120 (0.685)	0.313** (0.144)	-0.470 (1.093)	0.223 (0.188)	1.700 (1.657)
w_{t-1}	-0.001 (0.012)	0.793*** (0.075)	0.001 (0.023)	1.567*** (0.150)	-0.001 (0.035)	2.323*** (0.221)
w_{t-2}	0.017* (0.012)	0.194*** (0.081)	0.033* (0.024)	0.405*** (0.161)	0.048* (0.036)	0.618*** (0.237)
Number of obs.	133					
Loglikelihood	1276.517					
AIC	-18.745					
Note: Bootstrapped standard errors within parentheses. ***, **, * p-value < 0.01, 0.05, 0.1.						

Table 4: Autocorrelations of balances for the three consecutive periods

	Pre-ECC			Post-ECC			Post-GFC		
LAG	AC	Q	Prob>Q	AC	Q	Prob>Q	AC	Q	Prob>Q
1	0.9174	61.48	0.0000	0.9402	41.61	0.0000	0.8126	16.602	0.0000
2	0.8172	110.98	0.0000	0.8641	77.596	0.0000	0.5665	25.073	0.0000
3	0.7177	149.72	0.0000	0.7847	107.99	0.0000	0.3557	28.59	0.0000
4	0.6172	178.81	0.0000	0.6708	130.76	0.0000	0.1774	29.513	0.0000
5	0.5132	199.24	0.0000	0.5589	146.97	0.0000	0.0099	29.516	0.0000
6	0.4199	213.12	0.0000	0.4379	157.19	0.0000	-0.1104	29.918	0.0000
7	0.3313	221.9	0.0000	0.3026	162.2	0.0000	-0.2000	31.327	0.0001
8	0.2645	227.59	0.0000	0.1696	163.81	0.0000	-0.2825	34.337	0.0000
9	0.2201	231.59	0.0000	0.0436	163.92	0.0000	-0.2758	37.426	0.0000
10	0.1949	234.78	0.0000	-0.0743	164.25	0.0000	-0.2622	40.451	0.0000
11	0.1746	237.38	0.0000	-0.1781	166.2	0.0000	-0.2860	44.378	0.0000
12	0.1615	239.65	0.0000	-0.2733	170.92	0.0000	-0.2945	48.956	0.0000
13	0.1554	241.78	0.0000	-0.3530	179.06	0.0000	-0.2747	53.382	0.0000
14	0.1341	243.4	0.0000	-0.4206	190.99	0.0000	-0.2424	57.261	0.0000
15	0.1133	244.58	0.0000	-0.4955	208.13	0.0000	-0.2200	60.913	0.0000

Note: AC refers to the autocorrelation coefficient. . Q refers to a Portmanteau (Q) test statistic that tests against the null hypothesis of white noise.

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