IMF Working Paper

What Really Drives Public Debt: A Holistic Approach

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INTERNATIONAL MONETARY FUND

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Abstract

This paper presents a novel approach to detail the propagation of shocks to public debt. The modeling technique involves a structural vector auto-regression (SVAR) estimator with an endogenous debt accumulation equation. It explores how the main drivers of sovereign debt dynamics—the primary balance, the interest rate, growth and inflation—interact with each other. Such analysis is particularly useful for debt sustainability analysis. We find that some interactions exacerbate the impact of shocks to the accumulation of debt, while others act to stabilize debt dynamics. Furthermore, the choice of monetary policy regime plays an important role in these debt dynamics – countries with constrained monetary policy are more at risk from changes in market sentiment and must rely much more on fiscal policy to constrain debt.

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I. INTRODUCTION

Recent years have witnessed a rapid increase in public debt—in 2007, gross general government debt in advanced economies stood at around 70 percent of GDP; by 2013, this had risen to over 105 percent (IMF, 2014). Concerns over sovereign debt sustainability have led to significant financial and economic disruption; and the optimal policy response to these elevated debt levels is a topic of controversy amongst policymakers and academics. The proximate causes of this rapid increase in debt are well know. Deep recessions reduced nominal GDP and caused primary balances to deteriorate; banking sector recapitalisation forced step changes in the debt level; and in some cases, sovereign bond yields spiked, increasing the cost of debt. But what is less clear is how these various drivers of debt interacted with each other, to propogate or mitigate the eventual impact on the debt level. For instance, a shock to the marginal interest rate on sovereign debt, perhaps as a result of increased risk aversion will, ceteris paribus, lead to an increase in the debt-to-GDP ratio. But this spike in yields may also have a detrimental effect on real growth, which would worsen debt dynamics further. On the other-hand, the government may react to this increase in yields by undertaking fiscal conslidation, which would improve debt dynamics. The overall path of debt, especially over the medium term, is unclear. But gaining a deeper understanding of these dynamics is critical for assessing risks to sovereign debt sustainability.

This paper explores how the various drivers of sovereign debt – the primary balance, the interest rate, growth and inflation—interact with each other. At the core of this analysis is the standard debt dynamics equation:

Equation 1:

$$d_t = d_{t-1} \frac{(1 + i_t^e)}{(1 + g_t)(1 + \pi_t)} - pb_t$$

where d_t is the sovereign debt-to-GDP ratio; i_t^e is the effective interest rate on sovereign debt; g_t is real growth; π_t is the GDP deflator; and pb_t is the primary balance to GDP ratio. Using a structural vector auto-regression (SVAR) framework, this paper considers how these components interact with each other in a holistic manner. The paper will also explore the role of monetary policy regime. This choice is often cited as an important determinant of sovereign debt dynamics. It has been argued that an independent central bank may have better control over nominal GDP; greater access to seignorage revenues; and is better able to prevent creditor runs—all of which should contribute to more stable debt. This paper considers the extent to which this matters for debt dynaimcs.

The remainder of the paper is organised into four additional sections—Section 2 summarizes the relevant literature on this topic; Section 3 sets out the methodology used and describes the data; Section 4 presents the results; and, Section 5 concludes and discusses potential extensions.

II. SURVEY OF THE LITERATURE

As far as we are aware, this is the first paper to explore how the various components that drive debt interact with each other in a single unified framework. There are, however, several important strands of literature that look at specific interactions in this regard. These can be summarized into three main categories—i) the response of discretionary fiscal policy to the debt level and other variables; ii) factors that influence the interest rate on sovereign debt, with particular focus on the credit spread; and, iii) the significant literature on fiscal multipliers. The methodology used in this paper draws heavily from the literature to estimate the fiscal multiplier. Finally, the literature on monetary policy and debt is briefly explored. Each of these strands are summarized in turn.

Several papers find that governments tighten fiscal policy in response to higher debt. Using data on the U.S., Bohn (1998, 2005) demonstrates that when the business cycle and temporary expenditure shocks (e.g. wars) are controlled for, the primary balance reacts positively to debt. This, he argues, provides evidence that U.S. sovereign debt does not follow a random walk but reverts to some steady-state level and therefore is sustainable. Abiad and Ostry (2005) use a similar methodology, but with a panel of emerging markets. When controlling for additional factors, such as commodity prices and the quality of institutions, they also find that the primary balance reacts to stabilize debt. Also focusing on emerging markets, Mendoza and Ostry (2007) find a non-linear relationship between the primary balance and debt. At low debt levels, the primary balance responds positively to debt, but at higher debt levels, this response diminishes. One explanation for this is that sovereigns suffer from 'fiscal fatigue' whereby they cannot increase the primary balance beyond certain levels.

A number of models assume that the market interest rate on sovereign debt increases with the debt level, but identifying this channel is difficult. Ceteris paribus, one would expect the interest rate on sovereign debt to increase as debt rises, as both the willingness and ability of governments to honor their debt obligations should decline. But finding an empirical relationship between the two has been difficult. This is because the sovereign's 'ability to repay' is an important omitted variable. Corsetti, Kuester, Meier and Mueller (2014) model sovereign default as a function of the distance to a 'debt limit'—a point where debt is so high that a sovereign is no longer able or willing to service it. As agents are forward looking, this affects market interest rates in a non-linear fashion. Ghosh, Kim, Mendoza, Ostry, and Qureshi (2011) combine a non-linear fiscal reaction function with a similar debt limit concept. Here interest rates are a function of both the 'debt level' and 'ability to repay'. The paper uses this methodology to calculate the 'fiscal space' of individual countries.

Controlling for sovereign debt is important when estimating the size of the fiscal multiplier. In their seminal paper, Blanchard and Perotti (1998) use a structural vector auto-regression (SVAR) model to estimate the size of the U.S. fiscal multiplier. They use out-of-model estimates of automatic stabilizer elasticities in order to identify the impact of changes in taxes

and spending on growth. This technique has been used by many subsequent models, including in this paper. Favero and Giavazzi (2007) introduced the debt level as a fully endogenous component of this system. They argue that this is important for two reasons. First, fiscal policy can react to debt, and so excluding this from the system introduces an important omitted variable bias. Second, it is important to track the evolution of debt to ensure that the results of the model do not imply unrealistic (i.e. explosive) debt paths. Cherif and Hasanov (2012) use a similar technique, but focus more on debt sustainability in the U.S.. They find that positive shocks to growth have a significant impact on reducing debt, but shocks to inflation or fiscal consolidation are less effective at containing debt. This suggests that in some cases, austerity can be self-defeating. A SVAR with endogenous debt dynamics is the foundation of the model, which will be explained more fully in the subsequent section.

The role of monetary policy in influencing debt sustainability has been a matter of debate in recent years. De Grauwe and Ji (2013) show empirical evidence that euro zone countries (without 'stand-alone' central banks) are more susceptible to self-fulfilling liquidity crises. Krugman (2014) illustrates this point using a more generalized theoretical framework. However, Hilscher, Raviv and Reis (2014) argue that there is little scope to reduce the US's debt burden through central bank generated inflation. The trade-off between default risk and inflation risk is illustrated in Reis (2013), although this paper also demonstrates how central banks can reduce the risk of multiple equilibriums. Corsetti and Dedola (2013) develop a model that illustrates how central banks can tackle liquidity crises, but not solve solvency crises. The results of this paper suggest that monetary policy regime plays a crucial role in sovereign debt dynamics.

III. Methodology and Data

The model is best divided into two components – the SVAR estimation process and the construction of the impulse response functions. The SVAR estimator is standard in the literature:

Equation 2:

$$Y_t = \sum_{i=1}^{P_1} A Y_{t-i} + \sum_{i=1}^{P_2} \gamma d_{t-i} + u_t \qquad Y_t = \begin{pmatrix} pb_t \\ g_t \\ \pi_t \\ i_t^m \end{pmatrix}$$

All of the variables defined in Y_t are components found in the simple debt accumulation equation (1). This will be important when the impulse response functions (IRFs) are constructed. In regard to the interest rate (i_t^m), the *marginal* rather than the *effective* rate is used. The reason for this is that the effective rate tends to be slow moving, as it is the weighted average of past borrowing costs. The marginal interest rate on new government borrowing is more responsive to changes in debt sustainability risks; and as such, is a more important signal for markets and governments, which will influence how they react. It is

important to note that the marginal interest rate is not the monetary policy rate, but the rate on new sovereign borrowing (defined by average maturity).

The estimates derived in the A matrix are used to illustrate how each of these components interact with each other, both contemporaneously and through time. In order to identify these coefficients, the following restrictions are imposed:

Equation 3:

$$Au = Be$$

$$A = \begin{pmatrix} 1 & \mu_{pb,g} & \mu_{pb,\pi} & \mu_{pb,i} \\ \alpha_{21} & 1 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & 1 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & 1 \end{pmatrix} \qquad B = \begin{pmatrix} b_{11} & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 \\ 0 & 0 & b_{33} & 0 \\ 0 & 0 & 0 & b_{44} \end{pmatrix}$$

In order to transform the reduced form errors, u, into structural error terms, e, the A matrix imposes certain identification conditions. Following Blanchard and Perotti (1998), the μ terms are elasticities, which are estimated separately from this model—they represent the elasticity of the primary balance with respect to growth ($\mu_{pb,g}$); the elasticity of the primary balance with respect to inflation; and the elasticity of the primary balance with respect to the marginal interest rate. The first two components are forms of 'automatic stabilizers', while the third is assumed to equal zero (the government is assumed to be too slow to react to changes in the interest rate contemporaneously). These country specific elasticities are taken from Girouard and Andre (2005), although as discussed in Section IV.F., the results are not particularly sensitive to these values. The α coefficients are estimated, and are ordered in a way which is standard to the literature.[1]

The IRFs are constructed using an endogenous debt accumulation equation. Equation 2 includes debt as a lagged variable. But as mentioned earlier, the evolution of debt can be fully derived from the endogenous variables included in Y_t. This relationship is used when constructing the impulse response functions, which are used to summarize the results. In the initial period, debt is taken at its existing level, and all of the variables in Y_t respond to this level by the coefficients estimated in the γ vector (equation 2). The variables Y_{t+1} are then used to construct debt in the following period, using equation 1. This process continues for all subsequent periods. Equation 1 (the estimated SVAR system) and equation 2 (an 'auxiliary equation) are combined when deriving the impulse response functions. This

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[1] Aside from the primary balance, it is assumed that shocks to growth will contemporaneously impact inflation and interest rates; shocks to inflation will impact interest rates, but not growth; and shocks to interest rates will have no contemporaneous effect on growth or inflation.

introduces a non-linear relationship between debt and its components, which is summarized here again for illustrative purposes:

$$Y_t = \sum_{i=1}^{P_1} AY_{t-i} + \sum_{i=1}^{P_2} \gamma d_{t-i} + u_t$$

$$d_t = d_{t-1} \frac{(1 + i_t^e)}{(1 + g_t)(1 + \pi_t)} - pb_t$$

The debt accumulation equation (1) will only approximate the actual evolution of debt. Other factors, such as bank recapitalization (not included in the primary balance) or methodological changes to debt or nominal GDP calculations, will also affect debt-to-GDP. But these factors will not be accounted for in equation 1. However, Figure 1 shows that the approximation is very close, and should not bias the results in this analysis.

The computation of the IRFs requires taking into account the debt feedback equation, otherwise the result suffers from an omitted variable bias (i.e. the impact of the debt level on other variables in the system). The inclusion of the debt feedback equation also implies nonlinear relationships among the variables. In order to take this into account, the impulse responses are computed as in Cherif and Hasanov (2012), similar to the generalized impulse responses by Koop and others (2006). The IRFs are constructed as the difference between the forecast of the model (equations 1 and 2) for n periods ahead with and without a given shock, subject to some initial values. The confidence intervals are computed using a bootstrapping method[2]. These non-linear relationships also mean that the IRFs illustrated in Section IV often do not resemble the smooth IRF curves normally derived

The relationship between the marginal and effective interest rate is defined with a second auxiliary equation. Given that equation 1 uses the *effective* interest rate and equation 2 uses the *marginal* interest rate, then a second auxiliary equation is needed to link the two. Following Caprioli and Momigliano (2011), the relationship between these two variables is approximated as follows:

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[2] The bootstrapping technique is used to calculate the median response, as well as the confidence bands in the following way. First, after the initial estimation of the original reduced form VAR, the residuals are resampled and used to compute new data. In a second step the VAR is re-estimated, the structural identification is performed and the different IRFs are computed. This last step is repeated 2000 times to obtain the bootstrapped distribution of the IRFs. From the distribution, we obtain the median IRF for each shock, and the 16% and the 68% quantiles which represent the confidence bands.
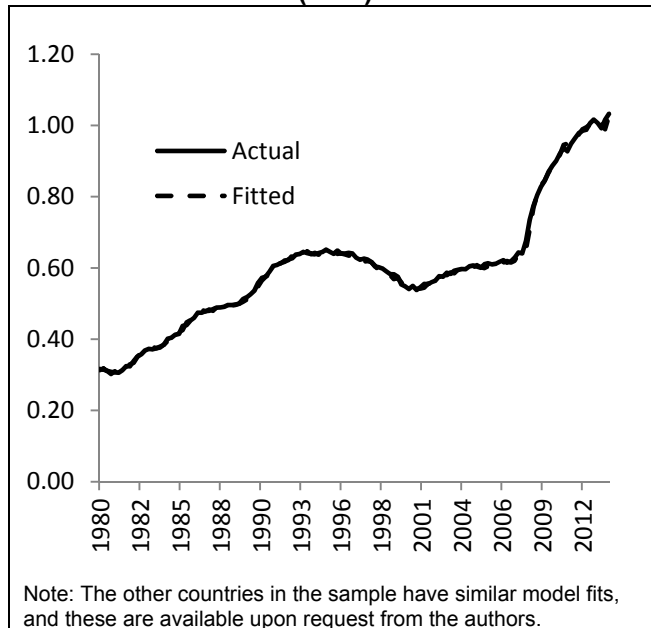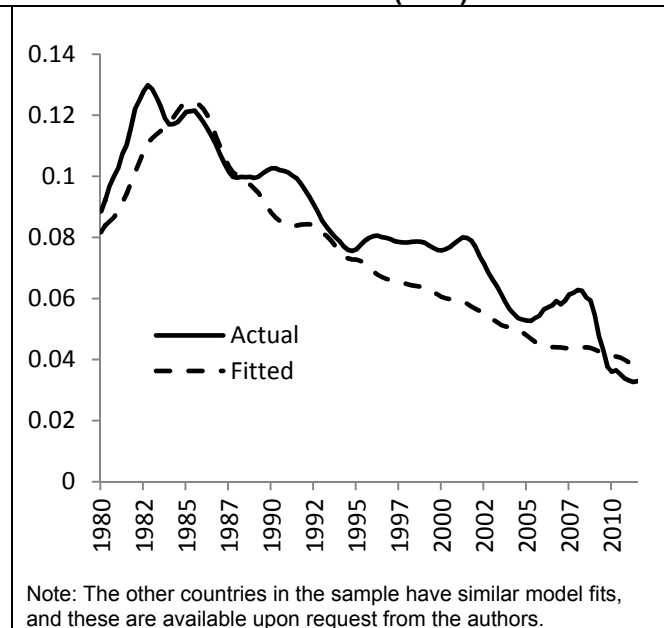
Equation 4:

$$i_t^e = \frac{1}{2n_t} \sum_{j=1}^{2n_t} i_{t-j}^m$$

where n_t is the average maturity of the sovereign at time t. This, as with the debt accumulation equation, is also an approximation to the actual evolution of the effective interest rate. But as Figure 2 illustrates, the relationship is also close.

Figure 1. Actual and Derived Debt-to-GDP (U.S.)

Figure 2. Actual and Derived Effective Interest Rate (U.S.)

Note: The other countries in the sample have similar model fits, and these are available upon request from the authors.

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The data covers fifteen OECD countries (Australia, Canada, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy, Norway, Spain, Sweden, the United Kingdom and the United States), and was retrieved from several sources—this data is available upon request.[3] Most of the data covers the period 1999-2014 on a quarterly basis, however, depending on availability, longer time series are used for some countries.

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[3]Sources: Eurostat, U.K. National Statistics Office, Federal Reserve Bank of St. Louis, Datastream, Haver, IMF debt database, OECD, Direccão Geral do Orcamento Portugal, International Financial Statistics, IMF Fiscal Monitor, U.K. debt management office, Bank of Italy.

IV. RESULTS

A. General patterns

The results consist of 375 different IRFs—5 responses to each of the 5 different shocks over the 15 countries in the sample. In order, therefore, to make these results tractable to the reader, they are presented in two formats. The first is a simple summary table, which draws out the median results derived from the estimates. The second is the standard IRFs, which will be presented to highlight specific differences within the sample. In regard to the former, Table 1 presents the results that one might expect to find based on *a-priori* economic intuition. In this table, the rows summarize four potential shocks imposed on the system—the primary balance, real growth, marginal interest rates and debt. The columns summarize how one would expect the other variables to respond.[4] Each cell in the table has the expected direction of the reaction in brackets.

Table 1. A-prior Expectation of Economic Relationships

		Response		
		Primary Balance	*Marginal Interest Rate*	*Debt to GDP ratio*
Shock	*Primary Balance (positive shock)*	Shock	Market reaction (fiscal) (-)	Debt equation (-)
	Real Growth (negative shock)	Government reaction (growth) (?)	Market reaction (growth) (+)	Debt equation (?)
	Marginal Interest Rate (positive shock)	Government reaction (interest rates) (+)	Shock	Debt equation (?)
	Debt to GDP ratio (positive shock)	Government reaction (debt) (+)	Market reaction (debt) (+)	Shock

Take the example of a positive shock to the primary balance i.e. a shock that causes fiscal consolidation (first row). In this case, the marginal interest rates might be expected to fall as markets may view this as increasing the ability of the government to repay its debts. Debt would then be expected to decline as repayments increase and interest payments gradually fall. Next, assume a negative shock to growth. It is unclear, *ex-ante*, how a government might react—it may choose to pursue expansionary fiscal policies, in order to stimulate growth. Or it may choose to consolidate, in order to ensure that debt does not increase too significantly. The reaction of markets is, however, likely to be push up interest rates. This means the overall impact on debt is ambiguous. **Table 1 can, therefore, be viewed as a set of hypotheses that this paper tests.** As well as the direction of the response, this analysis will also investigate both the magnitude and persistence of these effects. By first considering the

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[4]To simplify the illustration of the results, the inflation shock and the potential response of inflation and growth are not included in this table. This is because inflation was not well identified in the VARs, with most IRFs being not statistically different from zero. Growth is excluded as there is already a significant literature on the impact of growth from changes in the government balance and interest rates, and so this is not the focus of the paper.

average response of all countries in the sample, this sheds light on the hypotheses described above (Table 2). The IRFs used to construct this table are shown in Figures A1-9 in the Annex.

Table 2. Summary of All Countries

		Response (median)		
		Primary Balance[1]	*Marginal Interest Rate*[1]	*Debt to GDP ratio*[1]
Shock	*Primary Balance (positive shock)*	*1.00*	0.04	-1.25
	Real Growth (negative shock)	-0.60	0.01	1.60
	Marginal Interest Rate (positive shock)	0.7	*1.00*	0.45
	Debt to GDP ratio[2] (positive shock)	0.21	-0.04	*1.00*

[1]Reflects the peak response to the shock

[2]Debt is an auxiliary variable in this system, so exogenous shocks cannot be generated using traditional IRFs. Nevertheless, variables do response to the debt level, and this is exploited to generate "pseudo-IRFs". These "pseudo IRFs" are constructed as the difference of the solution of the model for n periods ahead from a ten-percentage points increase in debt, and the solution of the model without the increase in debt.

The primary balance reacts actively to growth shocks and is highly sensitive to changes in the marginal interest rate. The response of the primary balance to growth shocks appears to be counter-cyclical, despite controlling for automatic stabilizers in the SVAR. This suggests that governments in the sample use active discretionary fiscal policy to help stimulate/suppress demand in the face of growth shocks—the peak response of a 1 percent fall in growth is a 0.6 percent loosening in the (structural) primary balance. The government reaction function also seems to be sensitive to the marginal interest on its debt. A 1 percent increase in the marginal rate leads to an average tightening of the primary balance of around 0.7 percent. This reaction may be explained by the governments' desire to stabilize debt in order to prevent interest rates increasing to unsustainable levels. This is followed by a loosening as the interest rate shock dissipates. Finally, the primary balance reacts to debt positively—a 1pt increase in debt, on average generates a 0.2pt tightening in the primary balance. In summary, governments in this sample seem to actively react to shocks that impact debt dynamics—these responses are designed to stabilize debt, and thus mitigate the second round effects of these shocks.

The estimated market reaction to these shocks does not match the economic priors summarized in Table 1. The market reaction to the primary balance, growth and debt shocks are close to zero. Part of this counter-intuitive result can be explained by factors other than credit risk driving long-term interests—most notably a decline in the long-term real rate associated with the crisis. However, as explored in greater detail below, this sample average hides more interesting (and more intuitive) cross-country differences.

The final column of Table 2 illustrates the peak impact on debt from each of the shocks and subsequent responses. Debt reacts through the feedback equation (1), and so is not exogenous response to these shocks. However, it is interesting and important to note that debt eventually stabilizes following each of these shocks. This means that while some of the responses act to exacerbate the impact on debt, the overall system does bring debt back to its pre-shock level. This will be explored in more detail, below, when specific country are discussed.

B.   Splitting the sample

Within this sample average, there lies a number of interesting differences between countries. In this regard, the countries are split into two categories that seem to be important in determining differences in debt dynamics. The first category includes sovereigns that do not have full control over monetary policy, such as those in a currency union or have a fixed exchange rate regime. The second category includes sovereigns which have an unconstrained monetary policy regime, typically 'inflation targeters'. There are a number of reasons why the presence of an independent monetary policy regime may be important for sovereign debt dynamics. First, country authorities can better control nominal GDP, therefore providing a mechanism to stabilize debt-to-GDP without resorting to fiscal consolidation. Second, a central bank can use seigniorage revenues to help repay debt (potentially at the expense of higher inflation). Third, large purchases of government debt (sterilized or unsterilized) can help 'coordinate' creditors in order to avoid a 'run' on sovereign debt i.e. the central banks can reduce the likelihood of multiple equilibria. The following section will explore how these two country groups ('constrained' and 'unconstrained' monetary policy) react differently to various shocks to the components of debt. In each example, the median country IRF in each group is used to illustrate this relationship.[5]
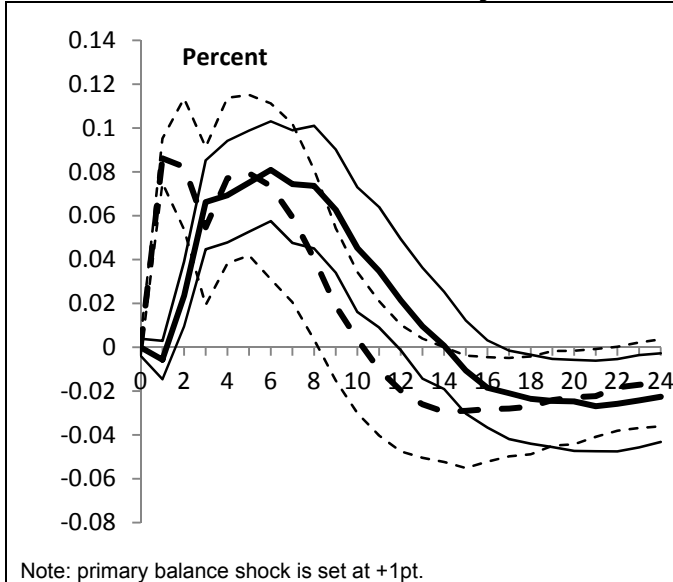
C.   The response of interest rates

The response of the marginal interest rate to shocks to the primary balance and growth is small, and similar for both monetary policy regime groups. Figure 3 shows that a 1pt shock to the primary balance generates a small increase in the marginal interest rate, for both groups, peaking at around 0.08pts. This somewhat counter-intuitive result may be associated with correlation, or an unspecified common shock may be driving both fiscal consolidation and higher borrowing costs. The response of marginal interest rates to growth shocks is essentially insignificant for both monetary policy regime groupings (Figure 4). In summary, therefore, this evidence suggests that markets do not significantly react to changes in two key determinants of debt dynamics. This may be because shocks to these variables are often not viewed as being a threat to debt sustainability—they may only matter in times of crisis. In

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[5]Countries defined as having constrained monetary policy in the sample include – Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy and Spain. Countries defined as having *un*constrained monetary policy in the sample include – the Australia, Canada, Norway, Sweden, the United Kingdom and the United States.

this regard, therefore, the debt level itself may be a more important determinant of the marginal interest rate.

Figure 3. Response of the Marginal Interest Rate from a Shock to the Primary Balance
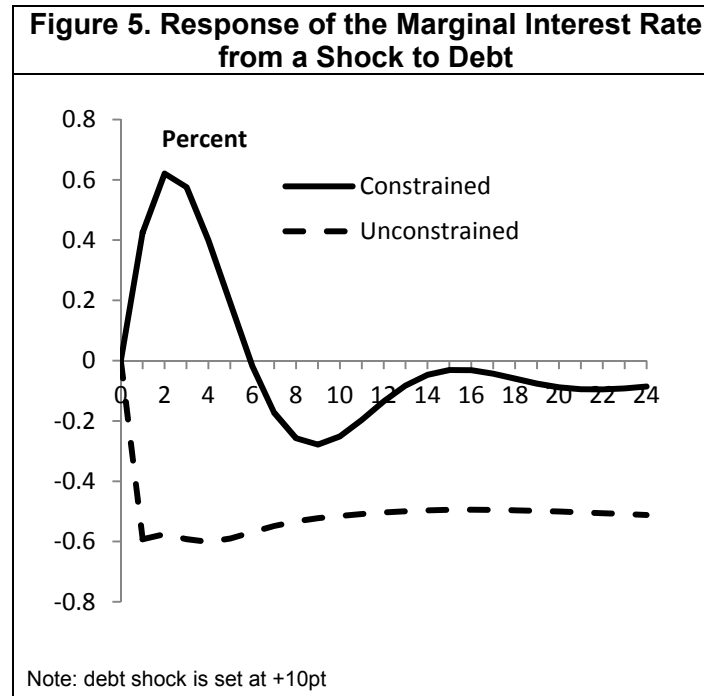
Figure 4. Response of the Marginal Interest Rate from a Shock to Growth

Note: primary balance shock is set at +1pt.

Note: growth shock is set at -1pt.
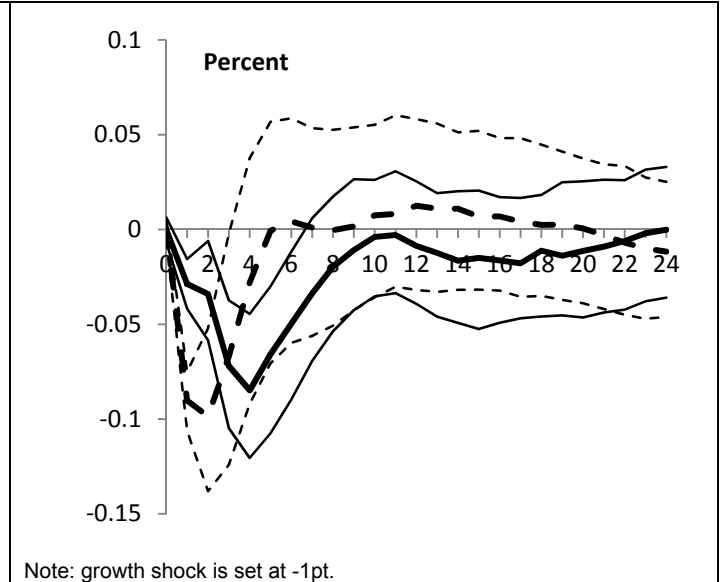
The reaction of marginal interest rates to a shock to debt is more striking (Figure 5).[6] Following a positive shock to the debt level (perhaps as a result of bank recapitalization costs), the marginal interest rate on the constrained monetary policy group increases sharply, and is persistent for around 1.5 years. This presumably reflects the market's perception that the credit risk for these sovereigns has materially increased. The gradual reduction in interest rates only occurs once debt has been stabilized, primarily through fiscal consolidation (see below). In contrast, the marginal interest rate seems to persistently *fall* for the unconstrained monetary policy group. This somewhat puzzling result *may* be attributed to how these country authorities use monetary policy in such circumstances. These countries may be able to manipulate long-term sovereign rates (perhaps through asset purchase facilities or forward guidance) in order to stabilize debt dynamics. Hence this could point to evidence that country authorities use monetary policy as a tool to stabilize debt dynamics. However, the modeling approach used here is not able to determine this hypothesis precisely given the reduce form nature of the estimation technique. And furthermore, it cannot determine whether such monetary policy action is an *explicit* policy to help stabilize debt, or whether it is the *unintended consequence* of other monetary policy objectives.
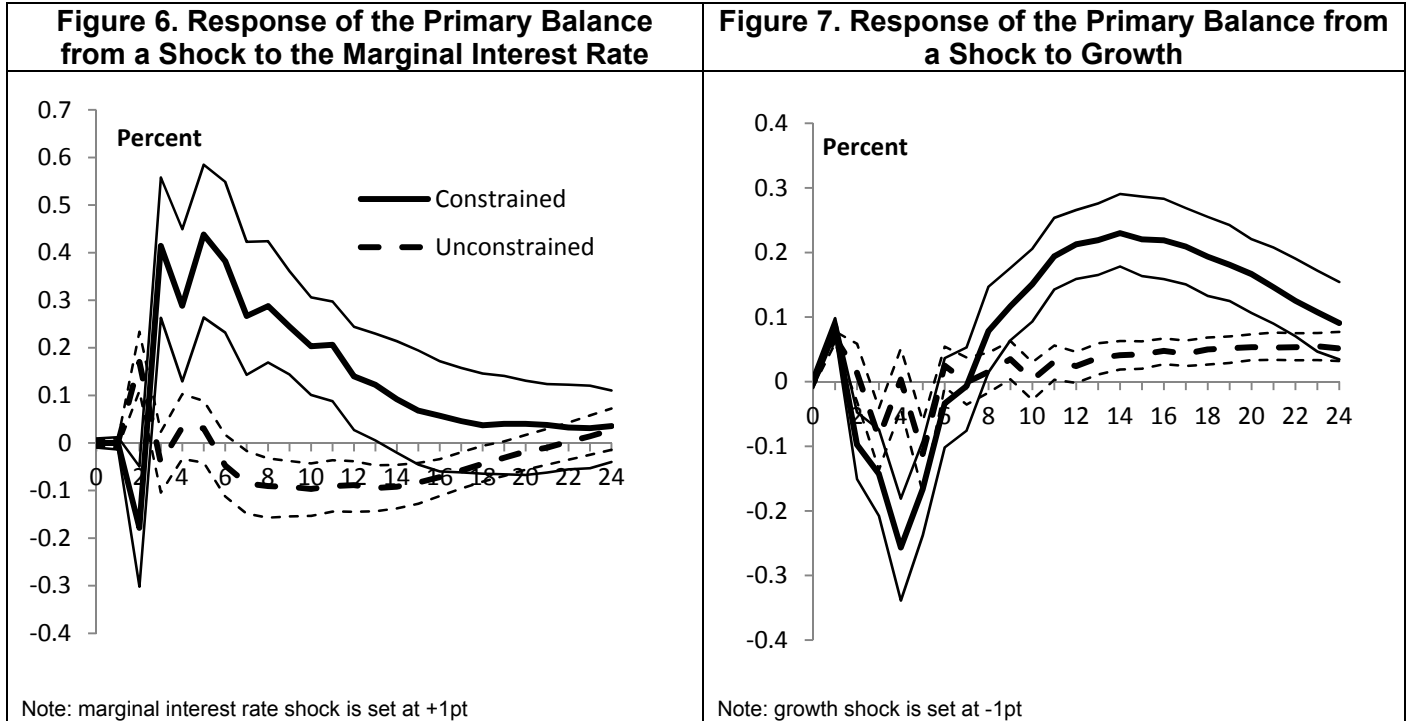
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[6]Since debt is not part of the endogenous system, but is included as a predetermined (lagged) variable into the VAR model, it is not possible to calculate standard IRFs. Therefore, Figure 5 presents the "pseudo IRFs" (see the details above), for which no confidence bands have been calculated.

**Figure 5. Response of the Marginal Interest Rate
from a Shock to Debt**

Note: debt shock is set at +10pt

## D. The response of the primary balance

The response of the primary balance to a shock to the marginal interest rate is very different for the two groups. A shock to interest rates typically generates a large and persistent increase in the primary balance from countries without full control of monetary policy (Figure 6). This finding may be explained by the country authorities' perception that they are more vulnerable to a loss of confidence in their ability to control debt, and so react strongly to any increase in marginal borrowing costs. In contrast, there is virtually no reaction from countries with an unconstrained monetary policy regime. This may be because these countries are less concerned by a loss of confidence by markets; or because they perceive changes in interest rates as being attributed to other factors than an increase in the probability of default. For whatever reason, there is no systemic response of the primary balance for this group.

A similar pattern is also found for the response of the primary balance to a shock to growth. Similar to the interest rate shock, the (structural) primary balance does not react to shocks to growth for countries with unconstrained monetary policy (Figure 7). These countries can use monetary policy to counter demand shocks, and thus help to stabilize debt dynamics without needing to resort to fiscal consolidation. This is not the case for countries with constrained monetary policy. When these countries are hit by a growth shock, they need to pursue persistently tighter primary balance in order to stabilize debt dynamics. Put differently, these countries seem more vulnerable to growth shocks than countries with unconstrained monetary policy.

Figure 6. Response of the Primary Balance from a Shock to the Marginal Interest Rate	Figure 7. Response of the Primary Balance from a Shock to Growth

Note: marginal interest rate shock is set at +1pt

Note: growth shock is set at -1pt

Both country groupings tighten fiscal policy in response to debt shocks, but the response from the constrained monetary policy group is much larger. Although the primary balance in countries with independent monetary policy may not react to growth and interest rates shocks, they typically will tighten fiscal policy in response to a shock to the debt level (Figure 8). This confirms the result of Bohn (1998, 2005) and others that the primary balance reacts proportionally to the debt level. This result is also found for constrained monetary policy group, but the response is significantly larger. This is perhaps not surprising given the results described above. These countries do not have full control over monetary policy to stimulate aggregate demand, and so must rely on more on fiscal tightening in order to stabilize debt – hence the larger response shown in Figure 8.

An important caveat to note is that most of the countries in the constrained group were also subject to fiscal rules imposed by the euro area Stability and Growth Pact (SGP). This may have systematically influenced fiscal policy over this period. Although this is not something that can be directly tested in this framework, there are two factors that suggest that these rules are not driving these results. First, the SGP rules were broken on a number of occasions, so were not deemed binding on policy. Second, many countries in the unconstrained group - for example, the UK, USA and Australia - also had fiscal rules (see Schaechter, Kinda, Budina and Weber (2012)), but experienced fiscal policy that was very different to the constrained group.

Figure 8. Response of the Primary Balance from a Shock to Debt
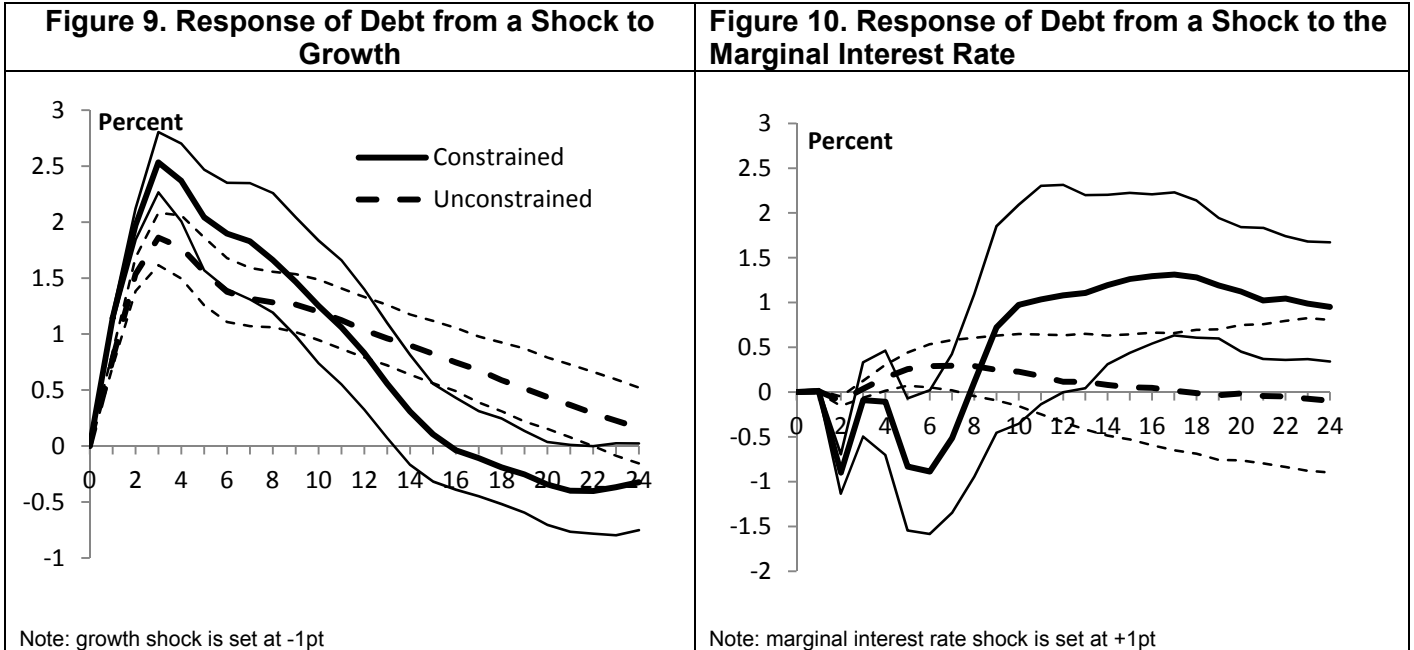

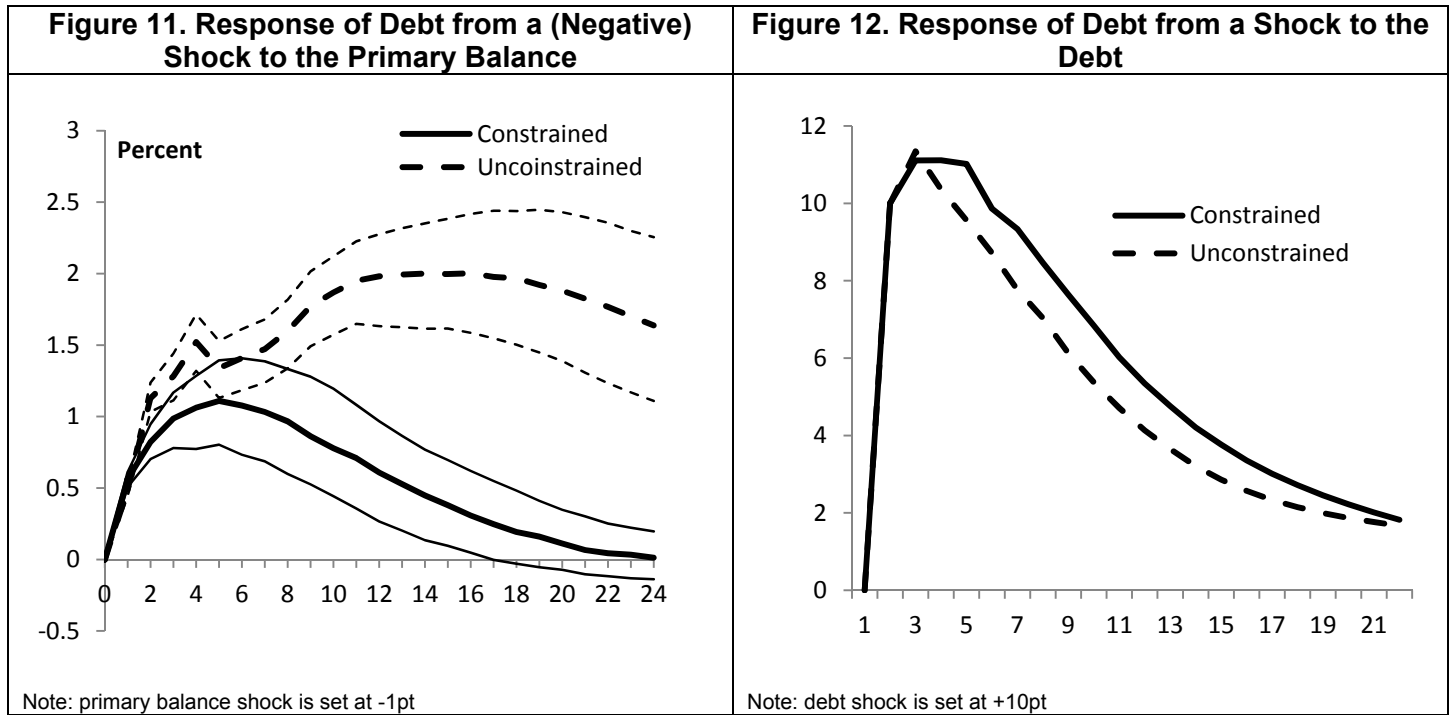Note: debt shock is set at +10pt
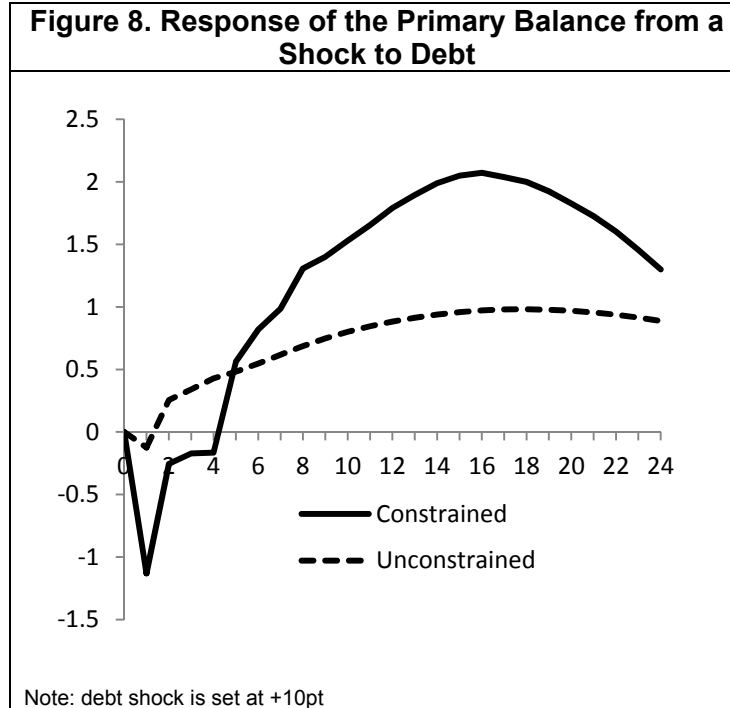
E. The evolution of debt

The final part of the results section explores how the various components of debt interact together to influence the overall trajectory of debt. While some relationships act to exacerbate the impact of shocks to debt, in all cases the debt level converges back to the pre-shock level. However, the deviation from the original debt level and the persistence of this impact differs significantly depending on the nature of the shocks and the monetary policy regime in place.

Growth shocks generate a significant increase in the debt level for both country groups (Figure 9). The median debt levels increase by around 2–2.5 percent of GDP at the peak following a minus 1 percent shock to growth. The constrained group experiences a slightly larger peak impact on its debt level partly because the rising debt level causes a larger increase in marginal interest rates than the unconstrained monetary policy group. However, a stronger primary balance response causes the debt level to return to its precrisis level at a faster rate. The unconstrained group, in contrast, can afford to reduce its debt level at a more measured pace, perhaps because the risk of an adverse market reaction is less acute. Interest rates shocks matter very little for the debt of countries with unconstrained monetary policy (Figure 10). For these countries, the impact on debt quickly dies out. In contrast, the impact on the debt of an interest rate is highly persistent.

Figure 9. Response of Debt from a Shock to Growth	Figure 10. Response of Debt from a Shock to the Marginal Interest Rate

Note: growth shock is set at -1pt

Note: marginal interest rate shock is set at +1pt

Debt takes significantly longer to return to pre-shock levels when countries with unconstrained monetary policy are hit with primary balance shocks (Figure 11). Considering a *negative* 1pts shock to the primary balance, the peak impact on the debt level is 2 pts for countries with unconstrained monetary policy, and this impact is highly persistent. This suggests that these countries are able to maintain this higher debt level for a long period of time, only gradually reducing debt back to pre-crisis levels. Countries with constrained monetary policy react by reducing debt at a much quicker rate—perhaps because country authorities feel more vulnerable to debt at a more elevated level. Figure 12 shows how a 10pt increase in debt—perhaps as a result of the realization of some contingent liability - will persist through time. Both country groups show a similar response with debt returning to its pre-shock level after around 5 years. These responses, which appear similar, likely hide differences in the underlying dynamics. Countries with unconstrained policy have more scope to reduce debt by stimulating growth. In contrast, as seen above, those with constrained policy are more likely to resort to fiscal consolidation.

Figure 11. Response of Debt from a (Negative) Shock to the Primary Balance	Figure 12. Response of Debt from a Shock to the Debt

Note: primary balance shock is set at -1pt

Note: debt shock is set at +10pt

F. Diagnostics and robustness tests

All data series used in the estimation process are stationary. Two unit root tests—the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test—were deployed. The ADF test rejected the hypothesis of a unit root for most of the time series, especially for real GDP growth and inflation. In the cases in which the hypothesis of a unit root could not be rejected, the KPSS test was implemented. On this basis, four countries—Japan, Portugal, Austria and the Netherlands—were found to have at least one non-stationary data series, so these were dropped from the sample. Therefore, the VAR analysis proceeded without major concerns about stationarity. The Jarque-Bera test was performed to assess whether the residuals are normally distributed. A test for residual normality was applied for each equation, as well as for *joint* normality. The results were mixed, likely driven by the limited observations in the specification. The process, therefore, relies on the assumption that the residuals are *asymptotically* normally distributed.

The model results are also robust to changes in the specification. Given the relatively small number of observations for each country, the lag length was varied to test whether this significantly altered the results. The results remained consistent - for instance, using a lag length of 2 (rather than 4) quarters did change the results a little, but the IRFs maintained the same sign, and similar magnitude and statistical significance. The sample period (1999-2014) was a time of structural change in the euro area, which can be characterized into two episodes – i) the adoption of the euro which led to 'financial convergence' with falling inflation and market interest rates; ii) the euro area crisis, where market interest rates diverged significantly. In order to test how this influences the results, the sample was

restricted to exclude the crisis years (2008-2014). For the countries where a longer time series is available (U.S., U.K.), there is no significant change in results. However, there are some differences for the other countries with shorter data series. In these cases, some have confidence bands that are wider and some shocks become insignificant. Given that the crisis period witnessed a significant amount of debt dynamics activity, this is perhaps not surprising. The median debt level for the unconstrained group is slightly below that of the constrained group, over the sample period (Figure A1). However, the large variance in debt levels within these groups suggests that this should not introduce a systematic bias into the estimates. The SVAR identification technique is also varied. Using a Cholesky decomposition, rather than imposing the automatic stabilizer elasticities, also maintains the results as largely unchanged. Removing 'outlier' countries (for instance, Norway with its large sovereign wealth fund) does also not materially change the results. On balance, therefore, the model is robust to altering the specification.

V. CONCLUSION

This paper explores how the various drivers of sovereign debt – the primary balance, the interest rate, growth and inflation—interact with each other. The SVAR estimator used in this study includes an endogenous debt accumulation equation, which allows debt feedback effects to be incorporated into these interdependencies. This technique allows a deeper understanding of how these relationships might act to exacerbate or mitigate the impact on debt following a shock to one of the *components* of debt. The sample of countries is made up of 15 advanced economies, with differing monetary policy regimes. This choice of policy regime plays an important determinant in explaining cross-country differences in debt dynamics.

Sovereign credit markets do not seem to systematically respond to shocks to growth or the primary balance, but are sensitive to the debt level. For countries with constrained monetary policy, such as those in a currency union or have fixed exchange rates, market interest rates react positively with the debt level—this increase presumably reflects an rise in credit risk. This is not the case for countries with unconstrained policy, where there is some evidence that higher debt may be associated with downward pressure on the long-term rate. This does not imply that advanced economies with unconstrained monetary policy do not need to be concerned with sovereign debt dynamics—only that these economies may have more tools at their disposal to tackle debt problems. This hypothesis is strengthened by the evidence that countries with constrained monetary policy are more reliant on fiscal adjustment to stabilize debt. These countries use fiscal policy to stabilize debt when faced with shocks to growth, the primary balance and the debt level itself. This is less pronounced for the unconstrained group, although some fiscal consolidation does seem to follow a shock to debt. These differences mean that the unconstrained group tends to bring debt back to its pre-shock level at a more measured pace.

This paper, therefore, provides some empirical evidence to support the often cited opinion that monetary policy matters for sovereign debt sustainability. This analysis also provides the basis to assess how a shock—say to growth—will impact debt dynamics directly and through second round effects (such as through the primary balance and interest rates). This is particular useful for debt sustainability analysis—both in terms of looking at the impact of adverse shock to the system and in terms of assessing the realism of baseline projections. This analysis could be extended in a number of useful directions. First, a panel VAR could be used derive a more systematic and robust estimate of the median IRFs. Second, the analysis could be extended to emerging markets economies (where data is available)—this would likely require the addition of an exchange rate term into both the SVAR and auxiliary debt accumulation equation to control for foreign currency denominated debt. Papers by Adler and Sosa (2013) and Estevao and Samake (2013) provide useful analytical frameworks to support this type of extension. Third, Bayesian techniques to estimate the SVAR and/or the use of 'local projection models' (Jorda, 2005) may be useful alternative specifications to estimate the relationships discussed above.
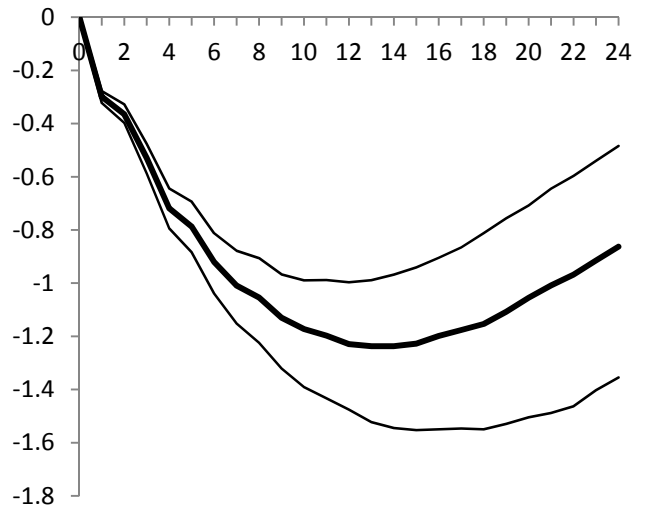
VI. APPENDIX

Figure A1. Response of the Marginal Interest Rate from a Shock to the Primary Balance
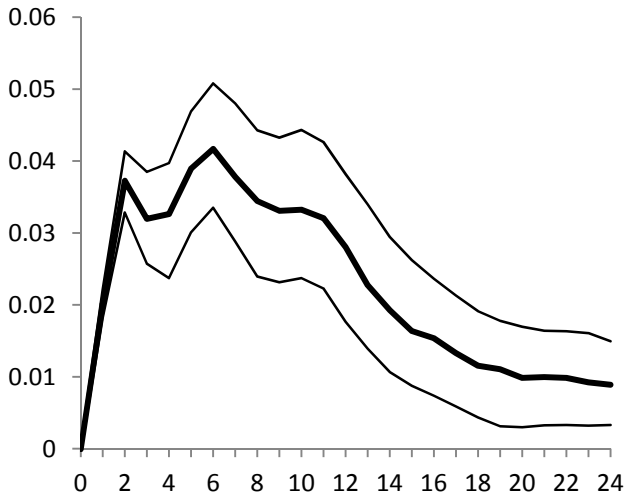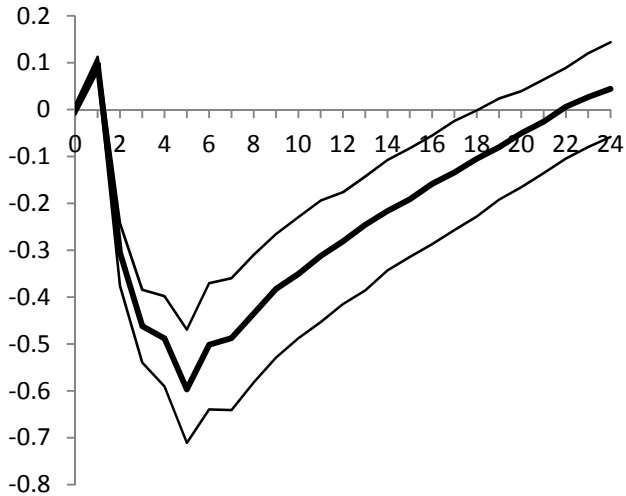
Note: primary balance shock is set at +1pt.

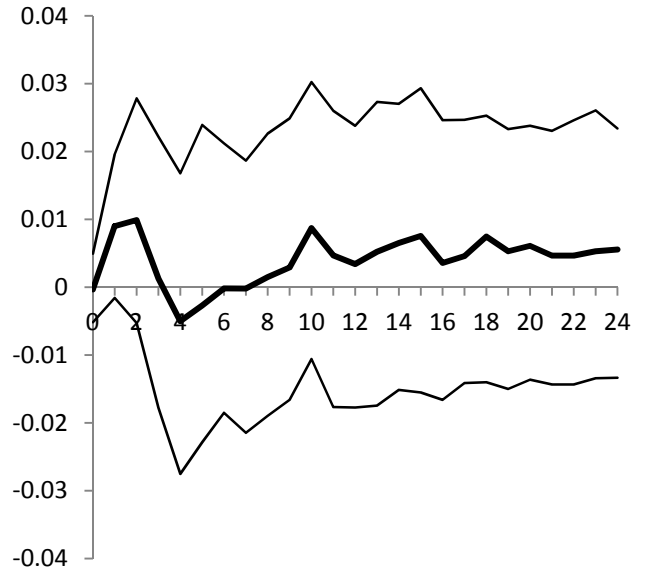**Figure A2. Response of Debt from a Shock to the Primary Balance**

Note: primary balance shock is set at +1pt.

Figure A3. Response of the Primary Balance from a Shock to Growth
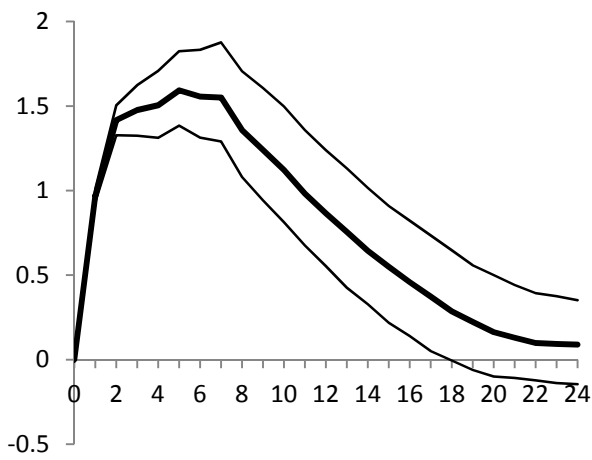
Note: growth shock is set at -1pt

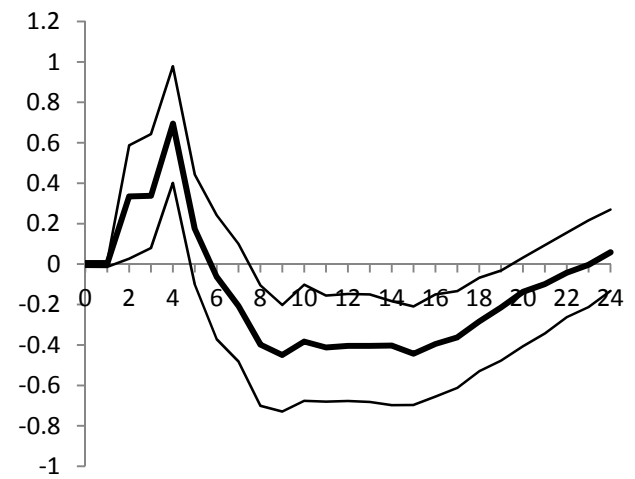**Figure A4. Response of the Marginal Interest Rate from a Shock to Growth**

Note: growth shock is set at -1pt

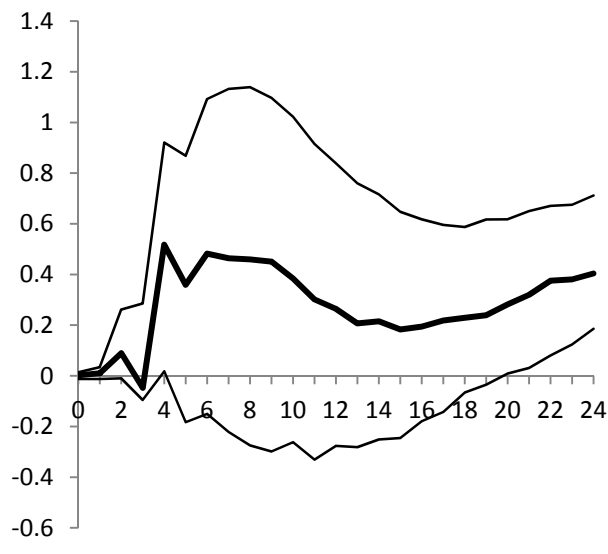**Figure A5. Response of Debt from a Shock to Growth**

Note: growth shock is set at -1pt

Figure A6. Response of the Primary Balance to a Shock to the Marginal Interest Rate
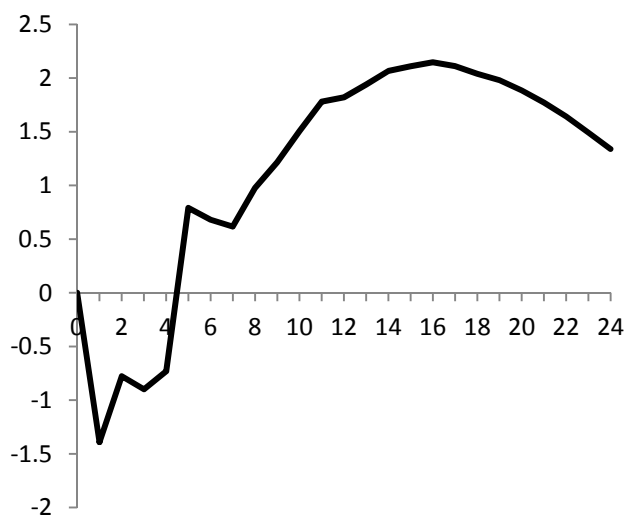
Note: marginal interest rate shock is set at +1pt

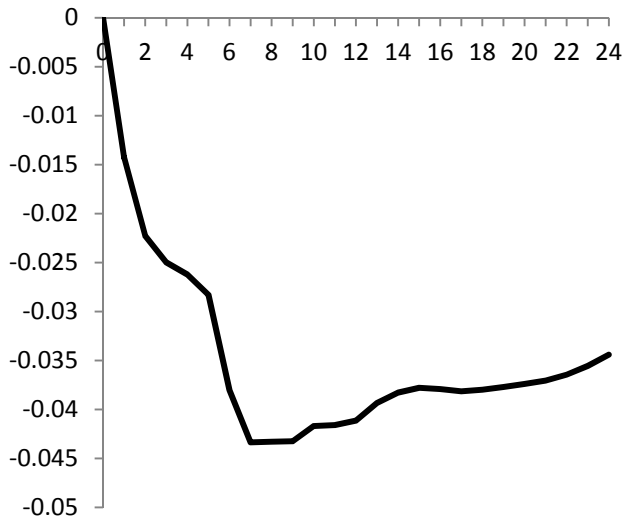**Figure A7. Response of Debt from a Shock to the Marginal Interest Rate**

Note: marginal interest rate shock is set at +1pt

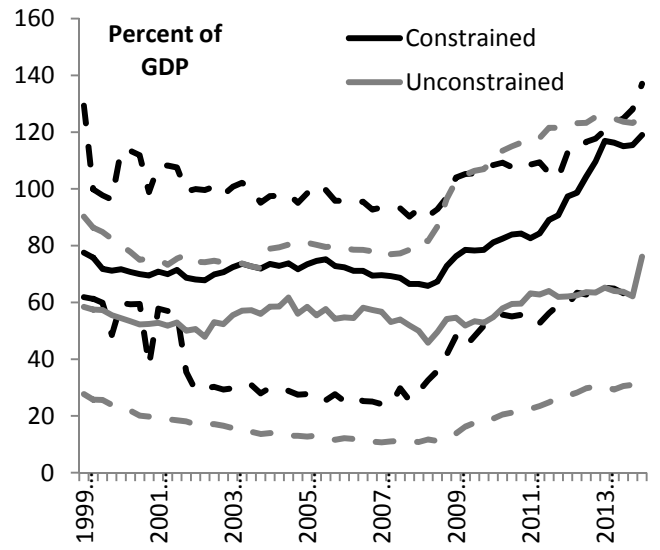**Figure A8. Response of the Primary Balance to a Shock to Debt**

Note: debt shock is set at +10pt

Figure A9. Response of the Marginal Interest Rate to a Shock to Debt	Figure A10. Median debt levels (with max and min values)

Note: debt shock is set at +10pt

VII. REFERENCES

Abiad, A., and Ostry, J., 2005, "Primary Surpluses and Sustainable Debt Levels in Emerging Market Countries," IMF Policy Discussion Paper PDP/05/6 (Washington: International Monetary Fund).

Blanchard, O., and Perotti, R., 1998, "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output," NBER Working Paper 7269.

Bohn, H., 1998, "The Behavior of U.S. Public Debt and Deficit," *The Quarterly Journal of Economics.*

———, 2005, "The Sustainability of Fiscal Policy in the United States," CESifo Working Paper No. 1446.

Cherif, R., and Hasanov, F., 2012, "The Effects of Austerity, Inflation, and Growth Shocks," IMF Working Paper 12/230 (Washington: International Monetary Fund).

Corsetti, G and Dedola, L., 2013 The Mystery of the Printing Press: Self-fulfilling debt crises and monetary sovereignty CEPR Discussion Paper 9358

Corsetti, G., Kuester, K., Meier, A., and Müller, G., 2014, "Sovereign Risk and Belief-driven Fluctuations in the Euro area," *Journal of Monetary Economics*, Vol. 61(C).

Caprioli, F., and Momigliano, S., 2011, "The Effects of Fiscal Shocks with Debt-Stabilizing Budgetary Policies in Italy," Bank of Italy Temi di Discussione, Working Paper No 839.

De Grauwe, P. and Ji, Y., 2013 " Self-Fulfilling Crises in the Eurozone: an Empirical Test" Journal of International Money and Finance

Estevao, M. and Samake, I., 2013, "The Economic Effects of Fiscal Consolidation with Debt Feedback", IMF Working Paper WP/13/136

Favero, C., and Giavazzi, F., 2007, "Debt and the Effects of Fiscal Policy," NBER Working Paper 12822.

Ghosh, A., Kim, J., Mendoza, E., Ostry, J., and Qureshi, M., 2011, "Fiscal Fatigue, Fiscal Space and Debt Sustainability in Advanced Economies," NBER Working Paper No. 16782.

Girouard, N. and Andre, C., 2005, "Measuring Cyclically-Adjusted Budget Balances for OECD Countries" OECD Working Paper No 434

Hilscher, J., Raviv, A., and Reis, R., 2014 "Inflating away the Public Debt? An Empirical Approach" NBER Working Paper 20339

International Monetary Fund, 2014, "Fiscal Monitor: Public Expenditure Reform—Making Difficult Choices," April (Washington).

Jordà, Ò., 2005, "Estimation and Inference of Impulse Responses by Local Projections," American Economic Review, Vol. 95(1), pp. 161–82.

Krugman, P., 2014, "Currency Regimes, Capital Flows, and Crises" IMF Economic Review Vol. 62

Mendoza, E., and Ostry, J., 2007, "International Evidence on Fiscal Solvency: Is Fiscal Policy Responsible?" NBER Working Paper No. 12947.

Reis, R., 2013, "The Mystique Surrounding the Central Bank's Balance Sheet,Applied to the European Crisis" American Economic Review: Papers & Proceedings

Schaechter, A., Kinda, T., Budina, N. and Weber, A., 2012, "Fiscal Rules in Response to the Crisis - Towards the "Next-Generation" Rules. A New Dataset" IMF Working Paper WP/12/187