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Public Debt Dynamics: The Effects of Austerity, Inflation, and Growth Shocks

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Public Debt Dynamics: The Effects of Austerity, Inflation, and Growth Shocks

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Abstract

We study how macroeconomic shocks affect U.S. public debt dynamics using a VAR with debt feedback. Following a fiscal austerity shock, the debt ratio initially declines and then returns to its pre-shock path. Yet, the effect is not statistically significant. In a weak economic environment, the likelihood of a self-defeating austerity shock is much higher than in normal times. An inflation shock only slightly reduces the debt ratio for a few quarters. A positive growth shock unambiguously lowers debt. In our specification, the debt ratio is stationary, whereas a VAR excluding debt may imply an explosive debt path.

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I. INTRODUCTION

The 2008 global financial crisis caused widespread large deficits and swelling public debt as output collapsed in many countries. The IMF (2012) estimated that the level of public debt for advanced countries increased from about 75 percent of GDP before the crisis to above 100 percent of GDP in 2011, a level unseen since the Second World War. A possibility of another Great Depression triggered expansionary fiscal policies in many countries in 2009. However, fiscal stimulus accounted for only a small fraction of the increase in debt, whereas collapsing revenues and higher unemployment and social benefits contributed the largest share (IMF, 2011).

In the wake of the Great Recession in the U.S., the policy debate shifted from high unemployment to fiscal consolidation. Growth was not large enough to stimulate sufficient employment, and by mid-2012, the unemployment rate has only gradually declined to 8.3 percent from the end-2009 peak of 9.9 percent. Nevertheless, the focus of the policy debate switched to fiscal consolidation as public debt and deficit have soared since the crisis began. The Congressional Budget Office (CBO) estimates that federal public debt would rise to above 70 percent of GDP by end-2012 from 36 percent at end-2007. The federal deficit has skyrocketed from about 1 percent of GDP to 10 percent in 2009 and is estimated at about 7.5 percent in 2012.[2] Many would argue that big debt and deficit levels carry high vulnerabilities and reducing public debt and deficit is important.

Choosing the optimal timing, pace, and tools to reduce public debt are the main challenges confronting policymakers faced with high public debt. From the debt dynamics equation, fiscal consolidation, high growth, large inflation, or low interest rates constitute the elements of a debt-reduction strategy. In the current environment of weak domestic growth and the zero-interest rate bound, fiscal consolidation, or austerity, could prove to be self-defeating.[3] In contrast, stimulating growth could improve both debt dynamics and fiscal balance, bringing more revenues to government coffers.[4] Increasing growth in the short run without adding substantially to public debt would require “bang for the buck” strategies.

Higher inflation and “financial repression” measures—such as regulations on capital movements and interest rates (Reinhart and Sbrancia, 2011)—are other possibilities to reduce debt. A dose of inflation would reduce the real value of debt and financial

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[2] The CBO’s baseline projections are at current law as of June 2012 (http://www.cbo.gov/publication/43288). The IMF (2012), using general government data, estimates the debt ratio to increase to about 107 percent of GDP in 2012 from 67 percent at end-2007.

[3] See DeLong and Summers (2012). Furthermore, the IMF (2010) has shown that a one percentage point reduction in the fiscal balance leads to about ½ percent reduction in the growth rate. Cottarelli (2012) argues that lower growth may in fact increase the interest rates, further offsetting the impact of consolidation. In addition, Blanchard (2012) points to the “schizophrenic” behavior of markets with respect to growth and consolidation.

[4] Hall and Sargent (2010) show that about 80 percent of the 85 percent of GDP debt reduction in 1946-1974 in the US is attributed to growth and primary surpluses (about equally split). The rest is due to inflation.

repression can keep the interest rate low.[5] Financial repression was also found to be more successful in reducing debt when accompanied by inflation. However, allowing for a higher inflation target, even temporarily, would require a radical change in monetary policy.

In this paper, we provide an empirical framework to analyze debt dynamics and focus on the effects of austerity, inflation, and growth shocks on reducing public debt using the US data. To study the relationship between public debt and major macroeconomic variables, we use a modified VAR framework in the tradition of Sims (1980) that includes a separate debt equation as in Favero and Giavazzi (2007, 2009). The VAR model includes the debt-to-GDP ratio (and its lags) as an exogenous variable and the macro aggregates that are part of the debt equation as endogenous variables. Thus, we account for the reaction of agents to changes in the level of public debt as argued by Sims (2011).[6] A separate deterministic debt equation keeps track of the debt dynamics. Computed impulse responses incorporate the dynamic effect of the debt-to-GDP ratio, feeding from the debt equation, on macro aggregates that in turn affect the debt ratio going forward. We show that in our specification—a VAR with debt feedback—the debt ratio is stationary, whereas VARs excluding debt could imply an explosive debt path.

If the economy continues to behave as in the recent past (1980-2007 period), the debt ratio is expected to converge to its long-term average of about 40 percent of GDP, and deviations resulting from macroeconomic shocks are temporary.[7] Moreover, taking into account the effect of debt on macroeconomic aggregates introduces nonlinearity into VARs, implying that the economic environment could matter. We find that the median impulse responses are not substantially altered by changes in initial economic conditions. However, the uncertainty or risk around the median path could be dramatically affected.

We find that the public debt ratio falls in response to primary surplus shocks, then returns to its pre-shock path. Following an exogenous primary surplus shock of 1 percent of GDP, the debt ratio falls by about 4.5 percent of GDP in about 3 years. Fiscal consolidation would continue beyond the initial shock—primary surpluses of cumulative 5.5 percent of GDP are run within 3 years, thus lowering the debt ratio. The resulting lower growth counteracts the austerity efforts. Furthermore, the debt ratio goes back to its pre-shock baseline after a period of time, implying that in the long run, the debt ratio reverts to its stationary level. In our model, the debt ratio eventually declines over time when starting at a high level of debt. The austerity shock may be unnecessary as the future debt path already incorporates the debt-reducing dynamics of the past.

[5] With the short rate at the zero bound and a weak economy, high interest rates are not likely to be problematic in the short run.

[6] Fiscal reaction functions estimated in the literature include the debt ratio. The debt ratio can also affect growth (Kumar and Woo, 2010) and interest rates (Baldacci and Kumar, 2010) and thus should be included in all VAR equations.

[7] The projected debt ratio does not take into account future aging or health care related costs.

The effect of austerity is not statistically significant, and the uncertainty around the median path is substantial, especially in a weak economy. In the narrative identification of primary balance shocks the austerity shock does not have a statistically significant effect on the debt ratio. This is true even under average or "normal" conditions. Moreover, the confidence interval suggests that there is a 25 percent chance that the debt ratio could increase in the first few years as growth deteriorates. In recessionary times, when fiscal multipliers are larger than in normal times (as shown by Auerbach and Gorodnichenko, 2011), an austerity shock might result in an increasing debt ratio. In other words, austerity shocks could be self-defeating. Under the initial conditions prevailing in 2011—a weak economy, low interest rates and inflation, large deficit, and rising debt—confidence bands are wider for all identification methods than those under "normal" economic times. Consequently, risks to a self-defeating austerity shock are much higher in the weak economic environment than in normal times.

An inflation shock results in an increasing debt ratio after only a few quarters, whereas a positive growth shock lowers debt substantially. We contend that the positive or negative response of debt to inflation, or for that matter, interest rate shocks, depends largely on the monetary and fiscal policy regimes in place. A more conservative monetary authority, as in the post-Volcker era, would most likely respond aggressively to inflation shocks. The fiscal policy regime also matters in determining the relationship among inflation, interest rate, and ultimately debt (Sims, 2011). If monetary and fiscal policy reacted to higher inflation as observed in the recent past (post-1980), a 1 percent inflation shock could lead to a rise of the debt ratio within a few quarters despite falling by about 0.5 percent of GDP on impact. As a result of an inflation shock, the interest rate rises, and growth falls. These responses are consistent with a supply shock such as a hike in oil prices. The debt ratio starts increasing as higher interest rate, lower growth, and eventually higher primary deficit counteract the effect of higher inflation.[8] A positive shock to growth has a large impact on reducing public debt as both higher growth and primary surpluses contribute to lower debt—a 1 percentage point increase in growth rate reduces the debt ratio by around 1.5 percent of GDP in 3 years.

The paper is structured as follows. Section II discusses related literature, and section III presents an empirical methodology and data. Section IV is the main section of the paper, which analyzes the U.S. public debt dynamics. Section V concludes.

II. Related Literature

If one uses the VAR methodology in debt and fiscal policy empirical analysis, we contend that the VAR with debt feedback is the recommended approach to take. Favero and Giavazzi (2007, 2009) emphasized the importance of using the debt feedback

[8] Our result is consistent with the study of Hamilton and Herrera (2004) analyzing the response of U.S. real GDP to changes in oil prices. They find that the effect of an oil price hike on the economy takes 3 to 4 quarters to peak.

equation since excluding debt in the VAR could result in an omitted variable bias.[9] The linear approximation of debt-to-GDP implicit in standard VARs may be misleading. The post-1980 U.S. sample suggests that excluding debt feedback in the VAR results in explosive debt dynamics and persistent impulse responses of debt to shocks. If the underlying debt dynamics are not on a stable path, the estimated effects of fiscal policy on macroeconomic aggregates may no longer be meaningful, and the question of the magnitude of a deviation from the explosive path would take the back seat.

Our specification is robust to changing sample periods, whereas other specifications are not. As a result, it is not possible to identify whether these models imply that current policies are unsustainable or that the models are misspecified. We thus add another angle to the misspecification problem discussed in Favero and Giavazzi (2007, 2009). Lastly, another approach used in the literature is to include debt as part of the VAR's endogenous variables. However, this specification ignores the nonlinearity part of the debt equation, which may be sizeable. Moreover, the impulse responses do not depend on initial conditions. In contrast, we show that initial conditions affect the width of confidence bands and thus risk.[10]

Several papers incorporate public debt in VAR estimations, but they do not extensively analyze impulse responses of debt to macroeconomic shocks. For the most part, these papers test for the sustainability of debt, examine fiscal policy effects on growth, or study other countries than the U.S.[11] In addition, Bohn (1998) in a single regression, incorporating the tax smoothing model of Barro (1979), shows that the U.S. public debt is stationary as the primary surplus reacts to higher levels of debt. Celasun, Debrun, and Ostry (2007) simulated debt paths for emerging countries based on combining an estimated fiscal reaction function from a panel regression and country-specific VARs of other macroeconomic variables without debt feedback.[12] Focusing on debt forecasts, Kawakami and Romeu (2011) apply the VAR with debt feedback to the Brazilian data. Many others use cross-country data to study the link between the level of debt and macroeconomic variables such as growth (e.g. Reinhart and Rogoff, 2010, and Kumar and Woo, 2010).

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[9] Favero and Giavazzi (2007, 2009) analyzed the effects of expenditure and revenue shocks on growth using the narrative approach of Romer and Romer (2010) and the structural approach of Blanchard and Perotti (2002). Our paper's emphasis is, however, on public debt dynamics. In general, impulse responses of the main macroeconomic aggregates are not substantially altered in the post-1980 sample by excluding debt feedback as shown by Favero and Giavazzi (2007, 2009).

[10] In the post-1980 US sample, the nonlinearity part of the debt equation does not matter substantially. In the VAR model with endogenous debt, the out-of-sample debt forecast deviates by about 5 percent of GDP.

[11] Some of these papers use one lag of debt in the VAR (Afonso and Sousa, 2009) or incorporate public debt as one of the endogenous variables (Hasko, 2007, and Corsetti, Meier, and Muller, 2009), which may result in misspecification. Others employ long-term cointegration approach (Boisinnot, L'Angevin, and Monfort, 2004, and Polito and Wickens, 2007) or do not include debt in the VAR (Tanner and Samake, 2008). Chung and Leeper (2007) use a VAR with cross-equation restrictions arising from the present-value condition of debt sustainability. Barro (1980) studied the effect of US public debt shocks on output and unemployment using regressions without the VAR dynamics.

[12] See Celasun and Keim (2010) for an application to the U.S.

Two recent papers by Hall and Sargent (2010) and Aizenman and Marion (2009) explore the role of inflation in reducing debt. Hall and Sargent (2010) show that about 23 percent of the debt reduction from 1946 to 1974 was due to inflation. They indicate that the average maturity of public debt shortened to about three years in the late 2000s from seven in the aftermath of the Second World War, hence reducing the benefit of inflation in lowering the debt ratio. Aizenman and Marion (2009) point out that although the maturity of debt is shorter now, a higher proportion of debt held by foreigners creates an incentive to inflate. They find that an inflation of 6 percent could reduce the debt-to-GDP ratio by about 20 percent over 4 years. Yet the authors caution that the result depends on model parameters, especially the parameter determining the cost of inflation, and that modest inflation may result in unintended consequences in terms of inflation acceleration. Our findings show that the response of debt to a positive inflation shock, using the dynamics observed post-1980, would generate higher debt after about a year, driven mostly by higher interest rate and lower growth.

III. Empirical Model, Estimation, and Data

A. Empirical Model

To keep the model parsimonious, the VAR is based on the following four variables in the endogenous vector Y specified in equation (1): primary deficit-to-GDP ratio (primary expenditures minus revenues, pb), real GDP growth rate (g), inflation rate based on the GDP deflator (π), and nominal average interest rate based on interest payments on debt (i). The variables used are exactly those that enter equation (2) describing the debt dynamics.[13] The VAR specification also includes the debt-to-GDP ratio (d) as an exogenous variable:

$$Y_t = \sum_{i=1}^{k} A_i Y_{t-i} + \sum_{i=1}^{l} \gamma_i d_{t-i} + \varepsilon_t , \qquad (1)$$

where k and l are the number of lags used ($k = 4; l = 2$). Equation (2) describes the debt dynamics:[14]

$$d_t = \frac{(1 + i_t)}{(1 + \pi_t)(1 + g_t)} d_{t-1} + pb_t \qquad (2)$$

[13] The model does not include the marginal interest rate such as the Treasury bill rate or the fed funds rate controlled by the Federal Reserve. The difference between the average interest rate on debt and the Treasury bill rate would narrow with a short debt maturity, which has been decreasing over time. Moreover, the correlation between the average interest rate on debt and the Treasury bill rate is above 80 percent, suggesting that our model captures the interest rate dynamics relatively well. In interpreting impulse responses, a shock to the average interest rate would imply a larger underlying shock to the marginal rate.

[14] We ignore the debt residual, including non-deficit financing, in our specification. For the US, the debt residual was historically marginal as shown in Favero and Giavazzi (2007) for the period between 1947 and the end of the century.

Equations (1)-(2) define our system of equations. Only equation (1) is needed to estimate the parameters of the model. The debt equation (2) keeps track of the debt dynamics, which is needed to compute impulse responses and dynamic forecasts.

B. Estimation and Impulse Responses

The model estimation is straightforward, but the computation of impulse responses (IRs) requires keeping track of the debt feedback in equation (1). The VAR is estimated using OLS. Similarly to Favero and Giavazzi (2007), we find that it is the change in debt that affects VAR dynamics as the coefficients on lagged debt are similar in absolute values but are of the opposite signs in each row of equation (1). Since equation (2) includes all the estimated variables in (1) and has no parameters, it does not need any estimation. In computing forecasts or impulse responses, debt at each time period in equation (2) is calculated based on the macro variables obtained from equation (1) and is then inserted back into equation (1). The impulse response is defined as the difference between projections based on equations (1) and (2) with and without an initial shock (a "shock" path and a "no-shock" path, or a baseline, respectively). We use a bootstrap methodology to compute confidence intervals.[15]

The inclusion of the debt-to-GDP ratio in the VAR implies a nonlinear relationship among variables, which may make the interpretation of traditional IRs difficult. We compute IRs similar to generalized impulse responses (GIRs) of Koop, Pesaran, and Potter (1996) to deal with the history and shock dependence inherent to nonlinear models. These IRs provide a natural way to examine out-of-sample forecasts and impulse responses. They are conditional expectations based on history and initial shocks. The computed IRs are defined as the difference between the expectations conditional on history (w) and an initial shock (v) for the response and on history (w) for the baseline:

$$IR(Y; v_t, w_{t-1}, n) = E(Y_{t+n} \mid v_t, w_{t-1}) - E(Y_{t+n} \mid w_{t-1}) \; for \; n = 0,1,2,.... \qquad (3)$$

We use a simple bootstrapping procedure and an estimated variance-covariance matrix of reduced form residuals in equation (1) to generate shocks, compute expectations, and derive IRs based on (3).[16] Using the bootstrapped residuals and the estimated VAR, "shock" and "no shock" forecast paths of variables are computed. Expectations are calculated with 1000 iterations. The IR is the difference between "shock" and "no shock" expected forecast paths.[17] In terms of history (w), we condition the calculation of IRs on the most recent observations in our data. Alternatively, we average initial conditions, w_{t-1}, based on the re-sampled data from the estimation sample. That is, we eliminate history from the conditional expectation.

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[15] The procedure is as follows: (i) Resample residuals from the original VAR and compute new Y and corresponding d; (ii) Reestimate the VAR, identify shocks, and compute IRs; (iii) Repeat steps (i) and (ii) 1000 times to obtain bootstrapped distributions of IRs and compute confidence intervals.

[16] We also used Monte Carlo normal sampling, and we obtained similar results, which indicate that shocks are likely to be Gaussian.

[17] Koop, Pesaran, and Potter (1996) describe in detail how to compute IRs.

We use the outlined approach to calculate the IRs with three different identification methods to identify a causal shock in the initial period. To tackle the causality issue, we use both narrative and structural methods. We include exogenous tax shocks from the narrative approach of Romer and Romer (2011) as primary balance shocks. We also add the defense news variable of Ramey (2011) as an expenditure shock to tax shocks to get another measure of primary balance shocks. These primary balance shocks are added as a separate exogenous variable in our VAR system.[18] The structural approach of Blanchard and Perotti (2002) is used to identify the contemporaneous relationship among VAR, or reduced-form, residuals. Favero and Giavazzi (2007) use Perotti's (2008) updated elasticities of taxes and spending to growth and inflation. We broadly follow Favero and Giavazzi (2007) in our structural identification scheme.[19]

The third identification method used is GIR methodology. The shocks in the GIR framework are generated from the observed correlations among shocks. In essence, a shock to a variable in this framework is an innovation to the variable that comes together with innovations to other variables that one would expect given sample correlations among innovations. It amounts to ordering the variable "shocked" first each time. For instance, a shock to primary deficit will be accompanied with shocks to growth, inflation, and interest rate as observed empirically. In this particular order, the GIR's formulation of a primary deficit shock would also be identical to a shock derived from Cholesky identification.

C. Data and Descriptive Statistics

The data used are quarterly series and are available from several sources. Total revenues, expenditures, and interest payments (seasonally adjusted) are taken from the Bureau of Economic Analysis's National Income and Product Accounts (NIPA, Table 3.2). Nominal and real GDP and GDP deflator series come from the same source (Tables 1.1.5, 1.1.6, and 1.1.9, respectively). The quarterly data are available from 1947. Federal debt held by public is taken from St. Louis Federal Reserve's FRED database. The quarterly debt series are available from 1970 while the annual data start earlier. To impute quarterly nominal values between the adjacent annual figures, we add up quarterly overall fiscal balance figures and linearly interpolate the residual. Our whole

[18] The shocks are scaled by nominal GDP in the previous period.

[19] The reduced form residuals, u, are related to structural residuals, e, in the following way: $Au = Be$. The residual vector lists variables in the following order: primary balance, growth, inflation, and interest rate. B matrix is diagonal, and A matrix (with ones on the diagonal) has the following structure. The first row of A matrix includes the elasticities of primary balance to growth, inflation, and interest rate: (i) 0.1, elasticity of primary balance/GDP to growth, is obtained using tax elasticity of about 2 and spending elasticity of zero with respect to growth and the quarterly spending to GDP ratio of about 5 percent (post-1980 sample); (ii) 0.07, elasticity of the primary balance ratio to inflation, is computed using tax elasticity of 1.4 and spending elasticity of zero to inflation and 5 percent spending/GDP ratio; and (iii) zero is assumed for elasticity of the primary balance ratio to interest rate. Other parameters in A matrix are identified recursively (implying zeros above the diagonal in other rows). The free parameters in A and B matrices (10 remaining elements) are then estimated using the variance-covariance matrix of the reduced-form residuals (10 distinct elements in a 4-equation VAR).

sample covers the period from the second quarter of 1947 to the third quarter of 2011. Given a structural break[20] occurring at about 1980 as shown, for instance, in Perotti (2004), we focus our results on the post-1980 sample. The estimation sample ends in the fourth quarter of 2007 due to the availability of exogenous tax shocks data and the advent of the global financial crisis in 2008.

The debt-to-GDP ratio drifted both downward and upward in the latter part of the 20th century (Figure 1). It stood at about 90 percent of GDP after the Second World War but steadily declined afterward to the mid-20s range by the late 1970s. The debt ratio doubled in the 1980s to about 50 percent of GDP and decreased to its mean level of about 40 percent of GDP in the 1990s (Table 1). Another debt buildup has been occurring since late 2008, primarily because of the financial crisis and a subsequent collapse in output. The estimation sample, 1980-2007, shows some interesting correlation patterns in the data. Higher deficit is associated with lower interest rate and debt ratio, whereas the debt ratio is positively correlated with growth. We examine the dynamics of these variables in the next section.

IV. Public Debt Dynamics and Impulse Responses

A. Debt Impulse Responses to an Austerity Shock

The debt ratio falls as a result of an austerity shock (a negative shock to the deficit) but then returns to its pre-shock path. Figure 2 shows responses of the debt ratio to a one standard deviation increase in the primary surplus (0.11 percent of GDP).[21] All identification schemes suggest that the debt ratio would fall by about 0.5-0.75 percent of GDP in about 2.5-3 years before rising and converging to the pre-shock baseline sometime after 10 years. The debt ratio declines and then rises as the primary balance improves in the first years after the shock and then deteriorates in later years. Furthermore, the convergence of the baseline debt ratio is ensured by including the debt feedback in the model, whereas a model without debt in the VAR (an implicit linear approximation) does not capture the feedback effect. As a result, the debt ratio can even evolve along an explosive path, and debt impulse responses can be persistent (Appendix A, Figures A1-A3).[22]

The decline in the debt ratio is primarily driven by the primary surplus and, to less extent, by inflation, whereas growth and the interest rate counteract the fall in the debt ratio (see

[20] Due to possible changes in the economic structure and monetary and fiscal policy regimes.

[21] Based on Blanchard-Perotti approach. We scale the shock in the narrative approach to correspond to the same change in the primary surplus.

[22] Without the debt feedback, the projected debt ratio is on a path that is either unsustainable or nondecreasing. The debt ratio does not decrease using the initial conditions of 2011 and can actually spiral beyond 130 percent of GDP in ten years when using the initial conditions at the height of the crisis in early 2009. The results are similar irrespective of whether the debt feedback component is shut down in the forecast or whether the debt path is computed based on the VAR that excludes debt completely. The VAR with the debt feedback produces a robust result that the debt dynamics are not explosive unlike the VAR without the debt feedback.

Figure 3 and Appendix B for the derivation). Despite the initial shock of about 0.1 percent of GDP, over the following 3 years, the primary balance continues to increase by another 0.5 percent of GDP (using the narrative identification). The debt ratio declines by 0.5 percent of GDP in the same period. Lower growth, as a result of austerity, dampens the debt decline. Growth falls on impact by about 0.1 percent and decreases further over the 3-year period (a cumulative decline of about 0.3 percent). A slightly higher inflation rate, probably due to positive tax shocks, lowers the debt ratio. Yet the decreasing effect is countered by higher interest rate that most likely goes up due to higher inflation.

The effect of an austerity shock on the debt ratio is not statistically significant in the narrative identification, and the uncertainty around the median debt ratio path is higher in a weak economy than normal times. Although the austerity shock reduces the debt ratio, the 90 percent confidence interval under the narrative identification strategy suggests that the self-defeating effect of the shock cannot be ruled out (Figure 4). In fact, the upper confidence band actually increases in the first few years after the shock with about 25 percent chance that the debt ratio would actually increase. The confidence bands for Blanchard-Perotti and GIR (Cholesky) identification are much tighter and suggest that the effect of an austerity shock on debt is statistically significant for about 8 years. However, given that the model with the debt feedback is nonlinear, the initial conditions may matter. Constructing impulse responses using the latest available observations (the third quarter of 2011), the confidence intervals become much wider (Figure 5) and shows that the debt ratio decline is statistically insignificant within 2 years even for Blanchard-Perotti specification.

In summary, using austerity shocks to reduce the debt ratio may prove counterproductive if the economy is weak and may not be needed since regardless of the shock, debt converges to its long-run value. Driven by improving economic conditions and decreasing deficits as seen in the past, the debt ratio is projected to fall (Figure 6). Yet the uncertainty around the median forecast suggests that the debt ratio decline could be very slow. There are in fact theoretical arguments against a rapid fiscal adjustment.[23] Barro's tax smoothing hypothesis implies that the short run cost of adjusting fiscal policy could exceed its long run benefits if the interest rate is relatively low. Moreover, Kirsanova and Wren-Lewis (2012) show that in a model where monetary policy is determined endogenously, the optimal fiscal feedback is small and the pace of adjustment is slow.

Our results indicate that a one percent of GDP austerity shock leads to a cumulative increase in the primary surplus of 5.5 percent of GDP in 3 years and a decline in the debt ratio by about 4.5 percent of GDP at the expense of about 3 percent fall in growth. A short-run pain of lower growth and thus higher unemployment may not be worth a small adjustment in the debt ratio as a result of the austerity shock. Further, the short-run debt reduction may not materialize due to the uncertainty in the estimated macroeconomic relationships. The risks, especially in the weak economic environment, are relatively

[23] See the discussion "The optimal speed of debt correction" on Simon Wren-Lewis' blog (mainly macro) on March 20th, 2012 (available: http://mainlymacro.blogspot.co.uk/2012/03/optimal-speed-of-debt-correction.html).

high. As the goal of policymakers is to decrease the debt ratio in a reasonable time, the debt reduction would require the usual response to the debt buildup as in the past. Historically, economic growth brought in primary surpluses and facilitated the debt reduction. The time to start gradually reducing debt comes when robust economic recovery is underway.

B. Debt Impulse Responses to Inflation and Growth Shocks

An inflation shock reduces the debt ratio slightly for only a few quarters, after which the debt ratio rises above its pre-shock path. It falls by about 0.1 percent of GDP on impact after a one standard deviation inflation shock of 0.16 percent (Figure 7).[24] The debt ratio starts increasing almost immediately, reaching the peak increase of about 0.3 percent of GDP in 5 years. The change in debt is driven by a combination of opposing forces—higher interest rate, lower growth, and higher deficit on one hand, and higher inflation on the other hand. These effects are consistent with higher inflation emanating from a supply shock. Growth falls, deficit increases, inflation rises, and interest rates increase. Initially, higher inflation reduces the debt ratio despite lower growth and higher interest rates. Primary deficits rise, and eventually, inflation alone is not enough to compensate for higher deficit and interest rate and lower growth. The debt ratio starts declining after growth turns positive, and primary deficit becomes a surplus.

Reducing debt through an inflation shock may not work unless we expect monetary policy to react differently. With an inflation shock, interest rate is higher than in the baseline, suggesting that the monetary policy is being tightened. Looser monetary policy with less aggressive interest rate hikes may be needed for the inflation shock to play a strong role in reducing debt. For instance, Krugman (1998, 2011), Mankiw (2009) and Rogoff (2009, 2011) have argued for a higher inflation target that the Fed would announce in the times of the zero-interest bound to improve economic recovery and speed up the deleveraging process.

Following a positive shock to growth, the debt ratio would unsurprisingly decline first, and then converge back to its pre-shock path. With a growth shock of one standard deviation (about 0.5 percent), the debt ratio falls on impact by about 0.2 percent of GDP (Figure 7). Primary surplus starts contributing with a larger share to the debt decline as growth continues to increase by another 0.3 percent in the first year. In about 3 years, the debt ratio falls by 0.8 percent of GDP as primary surplus increases by 0.7 percent of GDP. Inflation and interest rates increase slightly but their contributions to the debt dynamics are relatively small in the first few years. The debt ratio converges back to the baseline as primary deficit returns. If policymakers wanted to achieve the same medium-term reduction in the debt ratio through austerity, they would need to run surpluses by about 30 percent larger than those under the growth shock. More importantly, with a positive shock to growth, employment would benefit, too, as opposed to declining growth and employment after an austerity shock.

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[24] Blanchard-Perotti identification is used, and the results with the GIR identification are similar.

V. CONCLUDING REMARKS

Using a VAR with debt feedback, we study the dynamics of the U.S. public debt in response to shocks from major macroeconomic aggregates. Our results suggest that taking into account relationships among macroeconomic variables and the dynamic effect of debt in assessing the response of debt to shocks is important. In the medium term, an austerity shock reduces the debt ratio on average. However, there is large uncertainty about the projected debt impulse response, especially in a weak economic environment. Reducing debt via austerity in the 2011 environment may lead to the opposite outcome with the debt ratio barely changing or even increasing. The policy regime in place will affect the response of debt to higher inflation. Our findings suggest that given the economic dynamics of the recent past, an inflation shock, for example due to a hike in crude oil price, would in fact increase the debt ratio after only a few quarters. Finally, we find that a positive growth shock can substantially reduce debt with none of the pain associated with austerity.

Since the debt ratio converges to its long run value of about 40 percent of GDP, a short run fix to debt may not be needed, and a long run view in reducing debt should be taken. Stimulating growth in the short run and reducing deficits when growth has taken a strong hold would be a better policy response, in line with past dynamics. If policymakers and economic agents respond to the debt buildup and their economic environment as in the past, we should expect lower deficits amid higher growth and eventually a decreasing debt ratio. The post-crisis environment may be saddled with lower potential growth and long term fiscal pressures stemming from rising health care costs and aging population. Nevertheless, reducing debt and deficits in expansionary times may still be easier to implement and less risky in terms of growth and employment effects.

Finally, we argue that it is important to incorporate the debt feedback in VAR models as the forecast debt path may not be stable and the impulse responses of debt could be persistent. Using the linear approximation of debt in standard VARs or using debt as an endogenous variable in the VAR could result in misspecification and does not take account of initial conditions. The simulation of standard VARs could produce stationary paths for the variables explicitly included. Yet, an important but implied variable such as a stock of debt could be building up in an unreasonable fashion in the background. If it is the case, the original model without debt may not be a valid way to study the relationships among variables, especially if it concerns debt. In addition, linear models do not distinguish between different initial conditions in terms of impulse responses and in terms of uncertainty and risk in general. In contrast, we showed that risks to the debt impulse responses are substantially larger in a weak economic environment than in normal times. This paper suggests that when the economy is weak, the safest policy to deal with high debt is to stimulate growth.

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Table 1. Descriptive Statistics

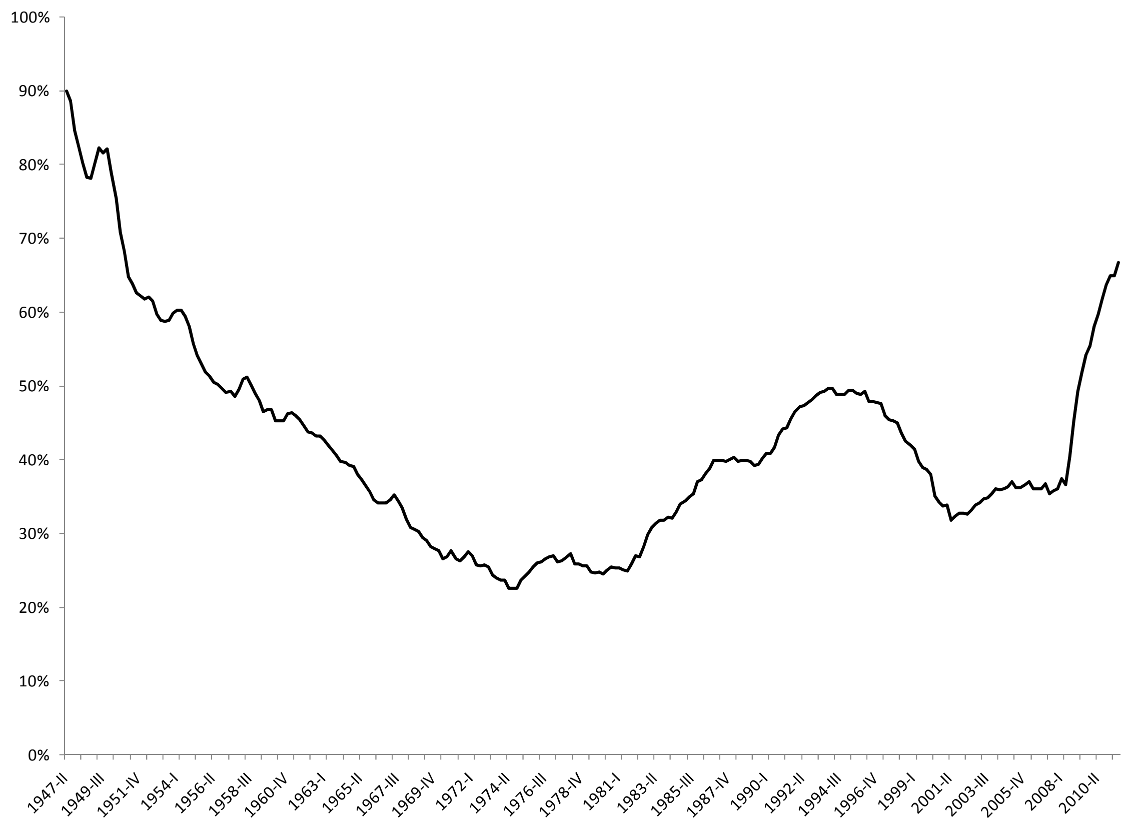
	Mean	*St. Dev.*	*Min*	*Max*
Primary deficit	-0.0010	0.0047	-0.0126	0.0066
Growth	0.0073	0.0071	-0.0207	0.0222
Inflation	0.0077	0.0047	0.0017	0.0273
Interest rate	0.0219	0.0055	0.0129	0.0331
Debt	0.3842	0.0694	0.2449	0.4965

Correlation coefficients

	Primary deficit	*Growth*	*Inflation*	*Interest rate*	*Debt*
Primary deficit	1				
Growth	-0.015	1			
Inflation	0.202	-0.258	1		
Interest rate	0.182	-0.057	0.467	1	
Debt	-0.201	0.183	-0.612	-0.326	1

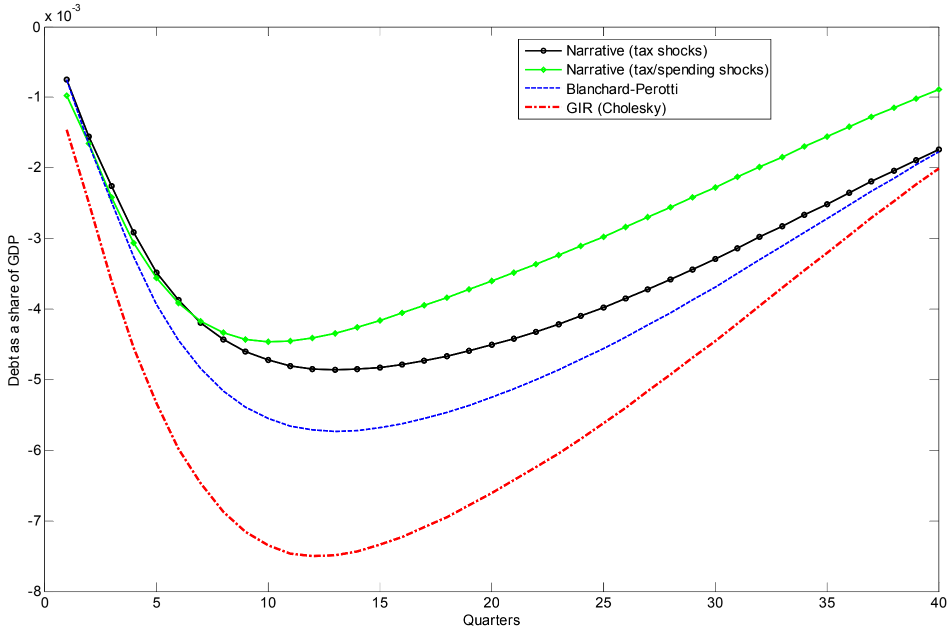
The table shows descriptive statistics and correlation coefficients among the following quarterly variables: primary deficit (share of GDP), growth rate, inflation rate, average interest rate on debt, and debt ratio (share of GDP).

Figure 1. Evolution of Public Debt (Percent of GDP, 1947:II-2011:III)



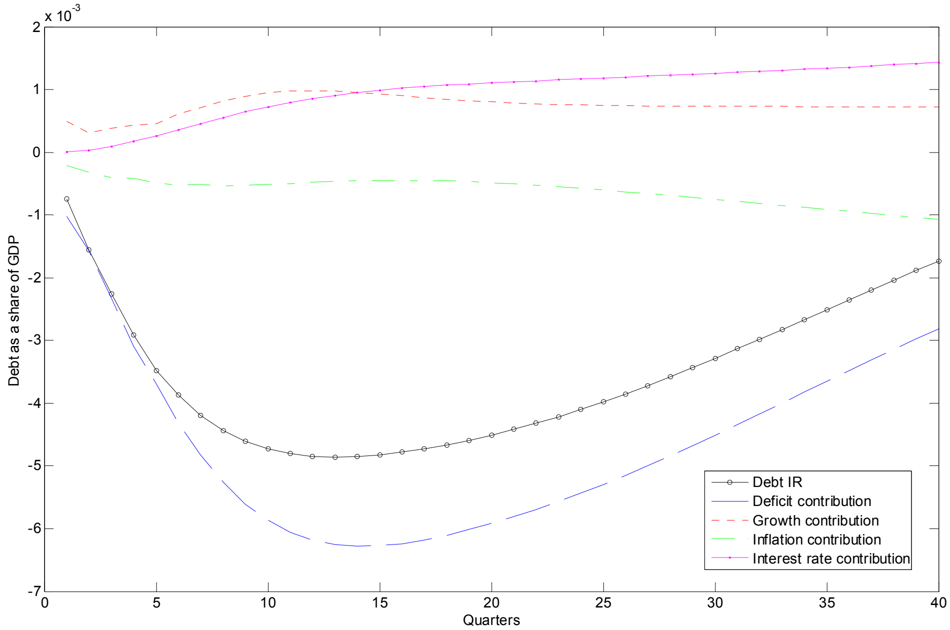
The figure shows the dynamics of the federal debt held by public (percent of GDP) in the US over the past 60 years.

Figure 2. Debt Impulse Response: The Effect of a One Standard Deviation Primary Surplus Shock on the Debt Ratio



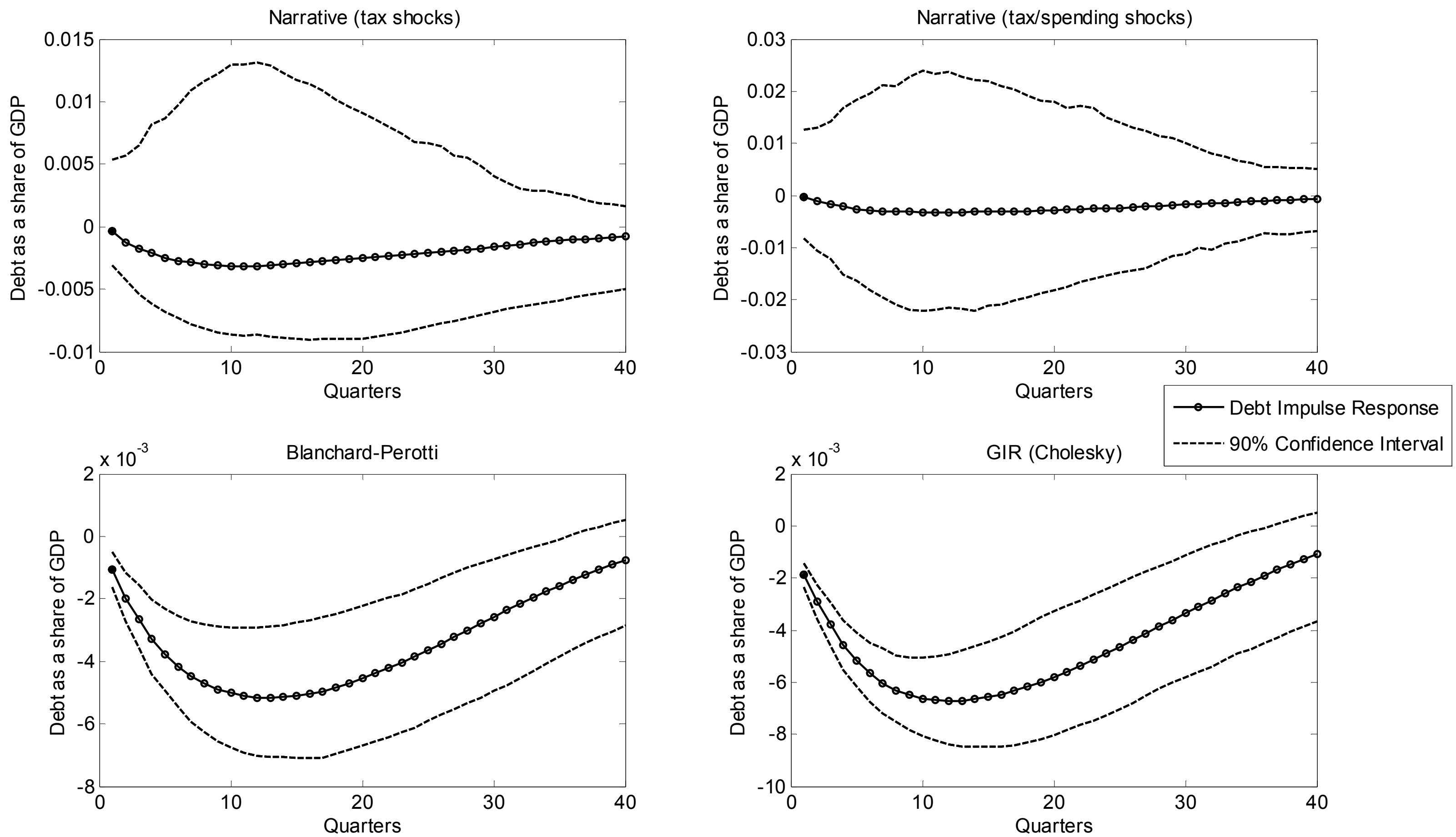
The figure traces the response of the debt ratio (share of GDP) to a one standard deviation austerity shock (0.11 percent of GDP) for four identification strategies.

Figure 3. Decomposition of the Debt Impulse Response under the Narrative Identification Using Exogenous Tax Shocks



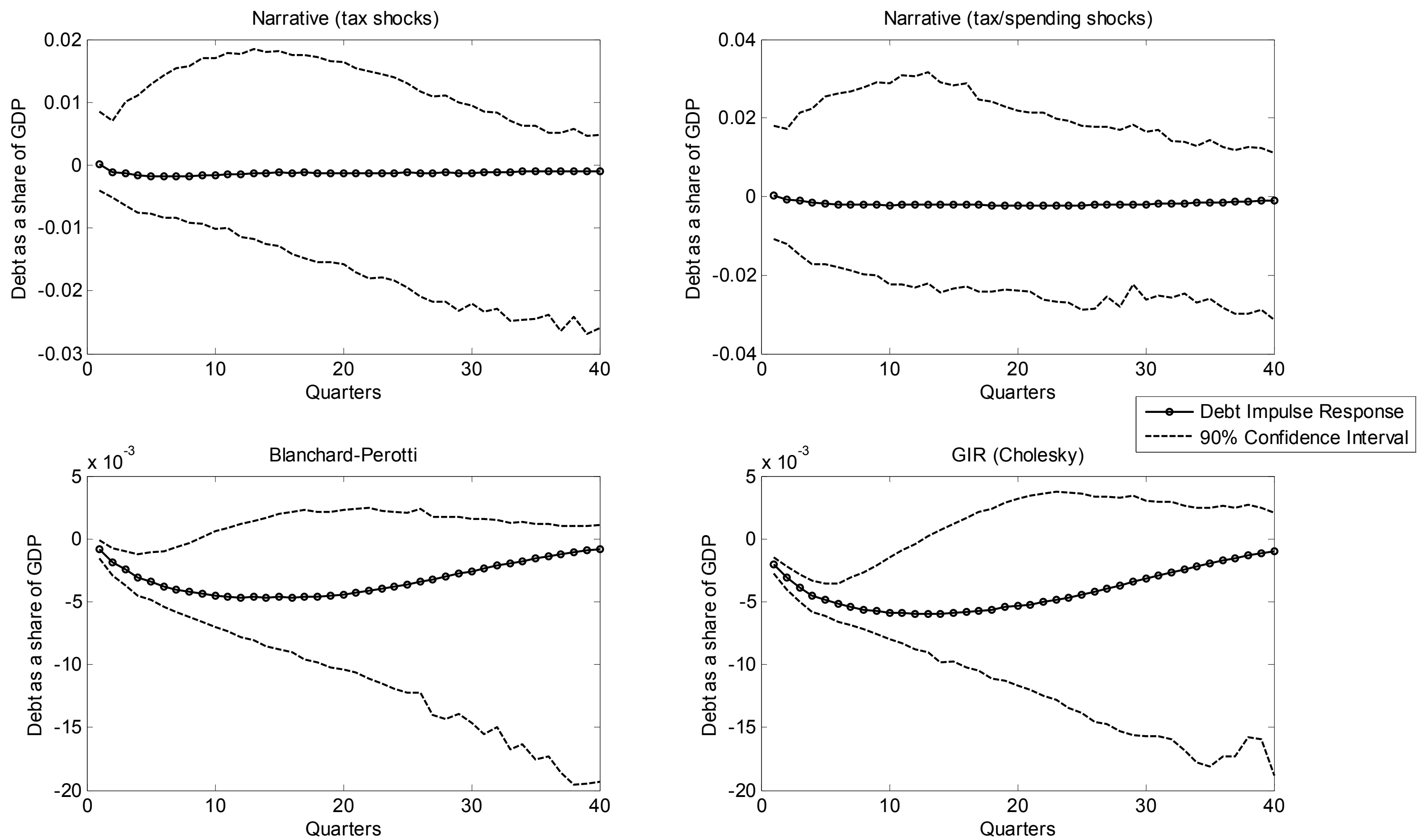
The figure decomposes the response of the debt ratio to a one standard deviation austerity shock (under the narrative identification with exogenous tax shocks) into the contributions from primary deficit, growth, inflation, and interest rate (see Appendix B).

Figure 4. Debt Impulse Responses to a One Standard Deviation Primary Surplus Shock: Average Initial Conditions (Normal Times)



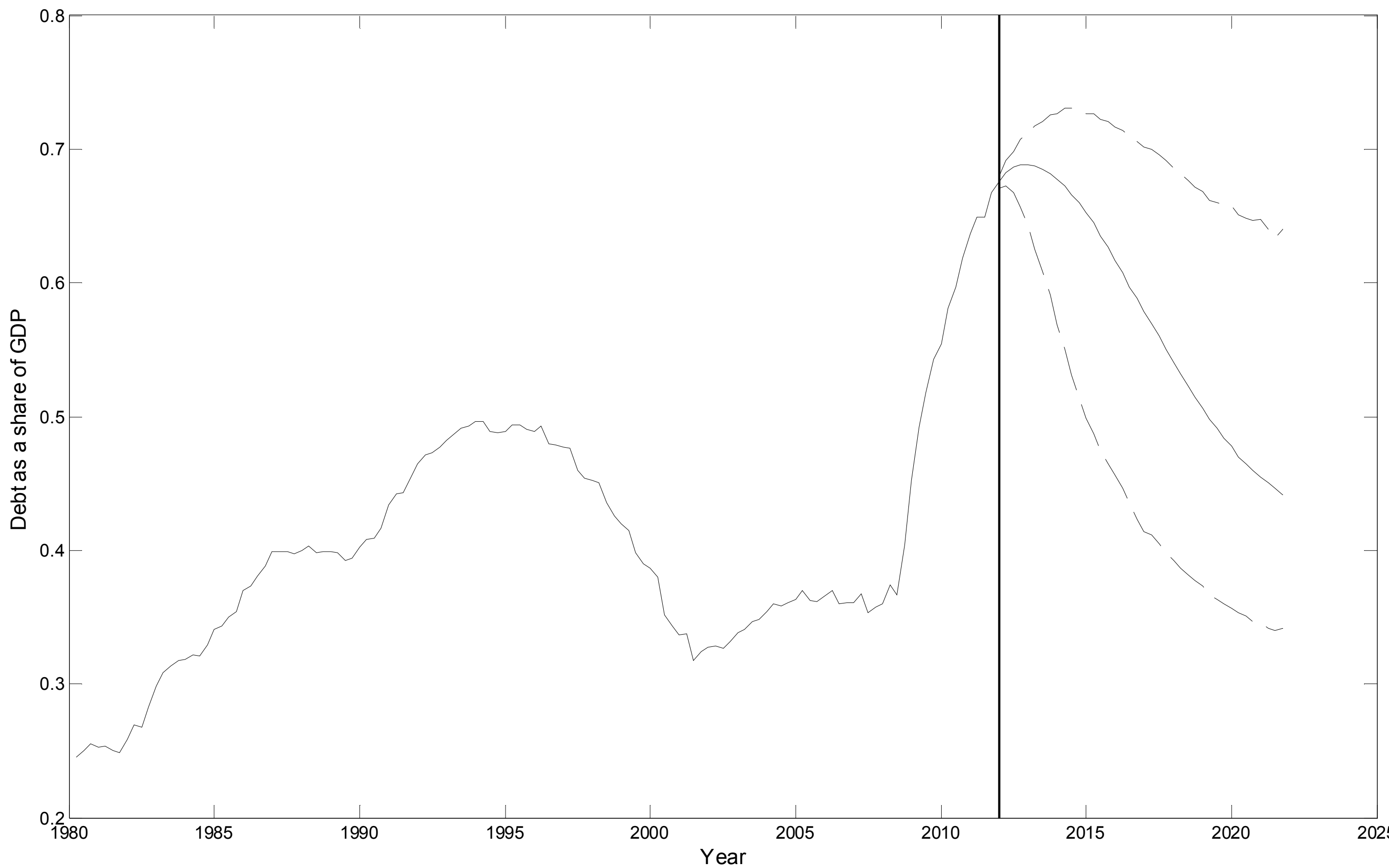
The figure shows median responses and 90 percent confidence bands of the debt ratio due to a one standard deviation austerity shock under the initial conditions of normal times (based on the 1980-2007 sample). The charts for four identification strategies are presented.

Figure 5. Debt Impulse Responses to a One Standard Deviation Primary Surplus Shock: Initial Conditions of 2011



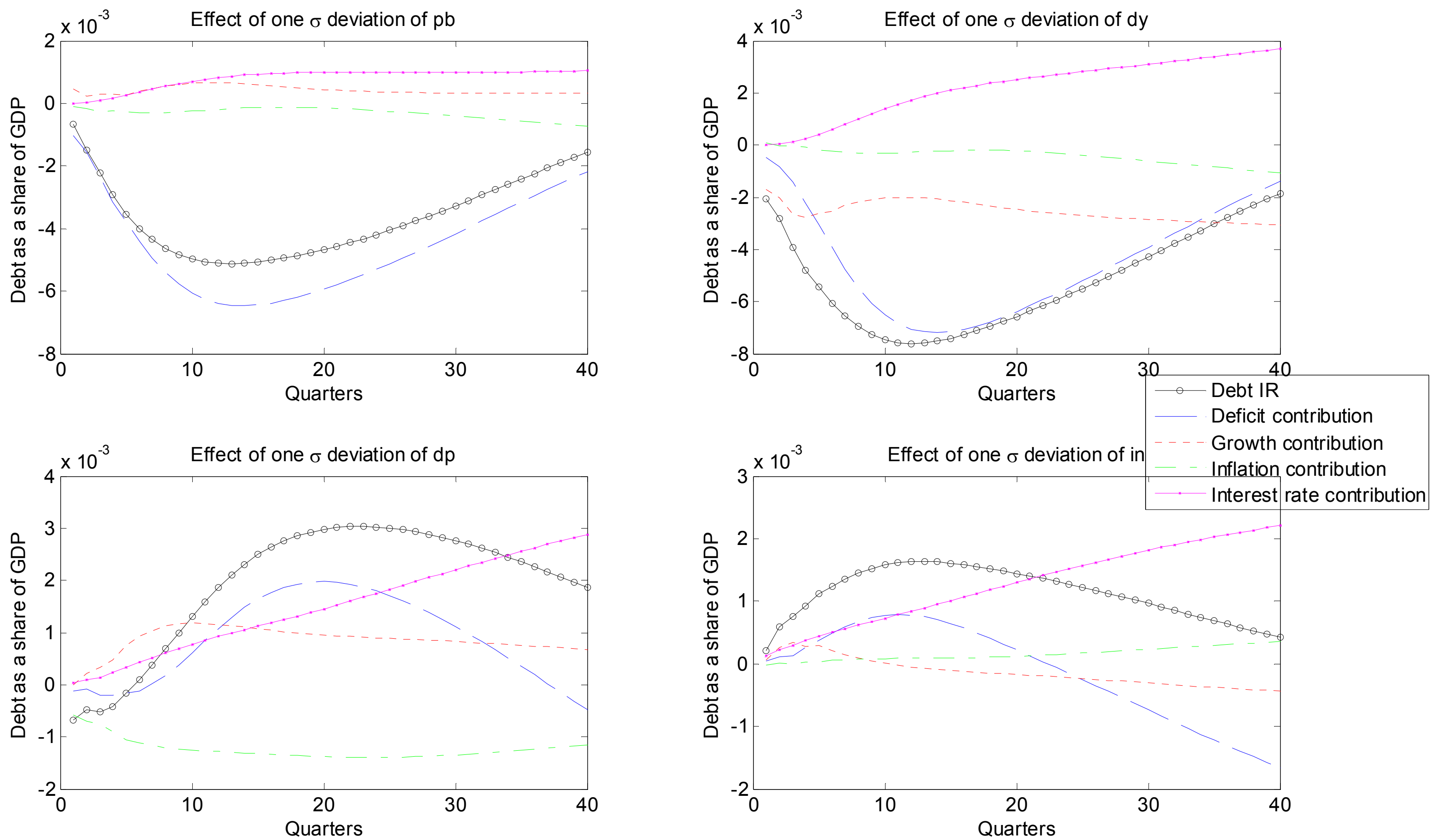
The figure shows median responses and 90 percent confidence bands of the debt ratio due to a one standard deviation austerity shock under the initial conditions prevailing in the beginning of 2011. The charts for four identification strategies are presented.

Figure 6. A Recent History and Forecast of the Debt Ratio Based on the Past Dynamics (2011:IV-)



The figure shows the debt ratio time series from 1980 onward and a 10-year forecast from the fourth quarter of 2011 based on an estimated VAR model with debt feedback (as described in the text). The 90 percent confidence interval is also presented.

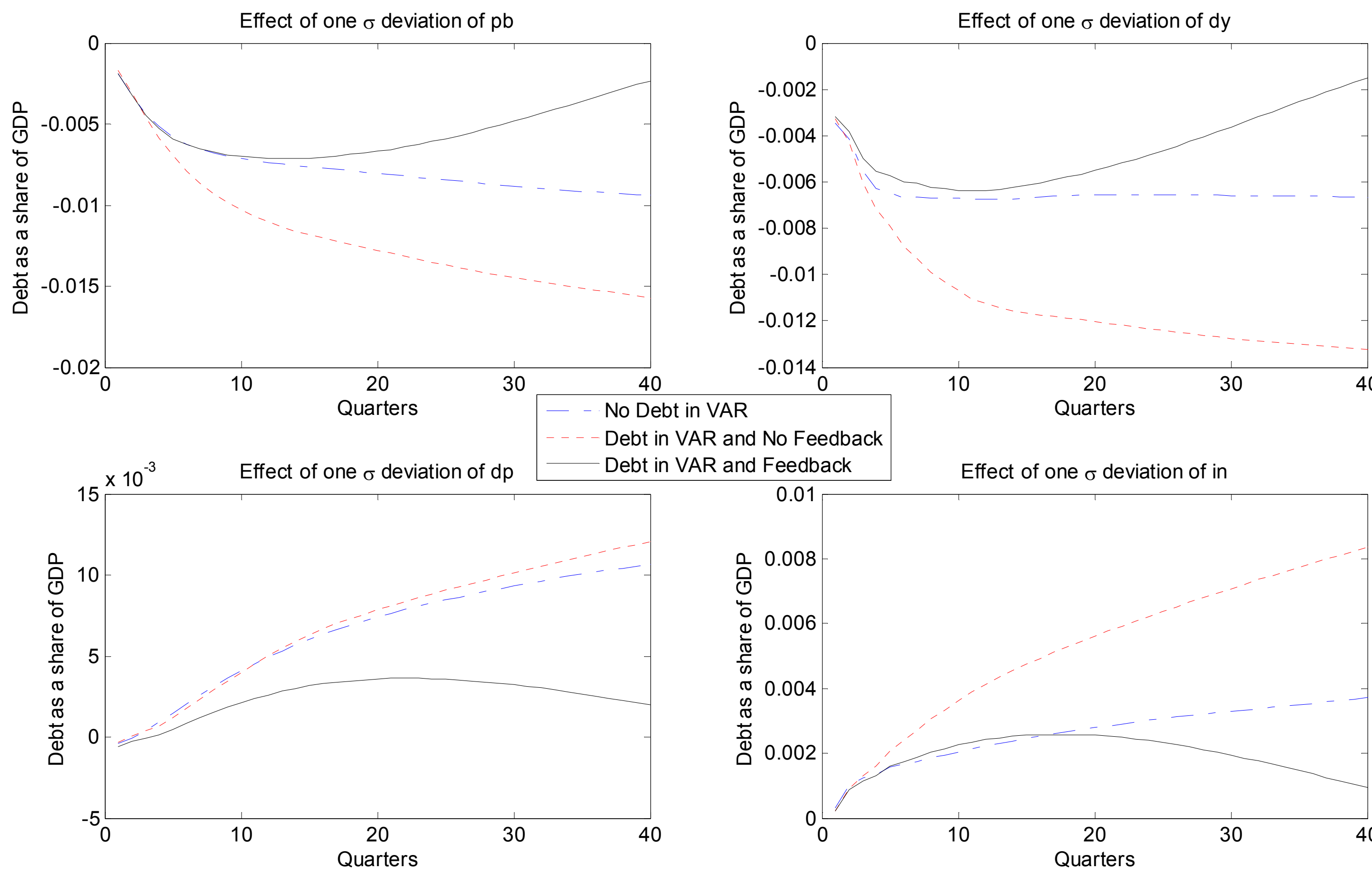
Figure 7. Debt Impulse Responses to Macro Shocks and Decomposition: Blanchard-Perotti Identification



The figure shows responses of the debt ratio to one standard deviation positive shocks in primary deficit (pb), growth (dy), inflation (dp), and interest rate (in) under Blanchard-Perotti identification. The decomposition of the responses to contributions from primary deficit, growth, inflation, and interest rate is also presented.

Appendix A

Figure A1. A Comparison of VAR Models: Debt Impulse Responses (GIR Identification)



The figure shows responses of the debt ratio to one standard deviation positive shocks in primary deficit (pb), growth (dy), inflation (dp), and interest rate (in) under GIR/Cholesky identification. Each chart in the panel presents debt ratio responses from three models: (i) standard VAR without debt; (ii) VAR with debt but without debt feedback in computing impulse responses; and (iii) VAR with debt feedback.

Figure A2. A Comparison of VAR Models: Debt Forecast, Starting 2011:IV

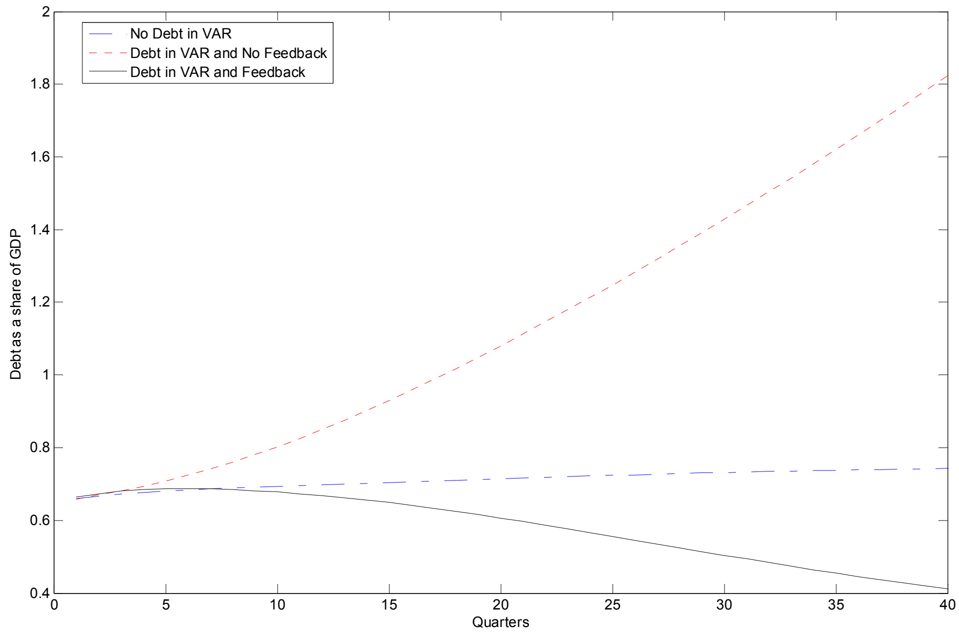
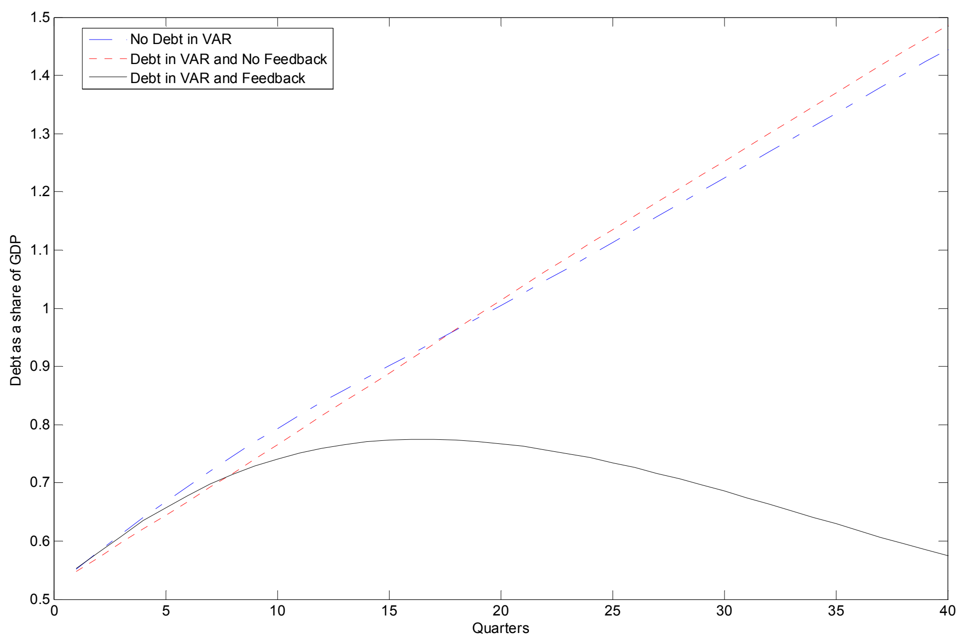


Figure A3. A Comparison of VAR Models: Debt Forecast, Starting 2009:III



The figures show a 10-year forecast of the debt ratio for three different VAR models with two sets of initial conditions: 2011:IV and 2009:III. The estimation sample is 1980-2007 in both figures.

Appendix B

We define the decomposition of the debt impulse response, d^{IR}, in terms of the contribution of each macroeconomic aggregate as follows:

$$d_t^{IR} = d_t^s - d_t^n = pb_t^* + i_t^* - \pi_t^* - g_t^*,$$

where s and n stand for "shock" and "no shock" debt paths. Using debt dynamics equation (2) in the text and approximating the nonlinear component, the components of the decomposition at time t are:

$$\begin{aligned}
pb_t^* &= \left(pb_t^s - pb_t^n\right) + \left(1 + i_t^s - \pi_t^s - g_t^s\right)pb_{t-1}^* \\
i_t^* &= \left(i_t^s - i_t^n\right)d_{t-1}^n + \left(1 + i_t^s - \pi_t^s - g_t^s\right)i_{t-1}^* \\
\pi_t^* &= \left(\pi_t^s - \pi_t^n\right)d_{t-1}^n + \left(1 + i_t^s - \pi_t^s - g_t^s\right)\pi_{t-1}^* \\
g_t^* &= \left(g_t^s - g_t^n\right)d_{t-1}^n + \left(1 + i_t^s - \pi_t^s - g_t^s\right)g_{t-1}^*
\end{aligned}$$

The first term in each equation indicates the difference between "shock" and "no shock" paths of the components scaled by the previous "no shock" debt ratio. The second term is the adjusted previous value of the component. Thus, the debt impulse response decomposition is:

$$d_t^{IR} = \Delta^{s/n} pb_t + \left(\Delta^{s/n} i_t - \Delta^{s/n} \pi_t - \Delta^{s/n} g_t\right)d_{t-1}^n + \left(1 + i_t^s - \pi_t^s - g_t^s\right)d_{t-1}^{IR},$$

where $\Delta^{s/n}$ stands for the difference between "shock" and "no shock" paths. Note also that the last term disappears in the initial period, $t = 1$, as the previous (before shock, $t = 0$), debt ratio is same.