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Gerhard Reitschuler* Rupert Sendlhofer†

Abstract

We empirically investigate whether the relationship between interest rates and public deficits/debt may be nonlinear for the U.S. Using threshold estimation, we find evidence of level-dependent effects on interest rates, implying a significant effect of projected deficits and debt in the U.S. only if the deficit surpasses approximately 5% of GDP.

JEL classification: E43, E62, H62

Keywords: Public debt, public deficit, long-term interest rates, nonlinearity, threshold models, Domar model.

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1 Introduction

The financial crisis and its subsequent recession resulted in huge increases of public deficits all over the world. This holds also true for the U.S.: In the pre-crisis years (2001-2007) the U.S. budget deficit (i.e., the net lending position of the general government) amounted to 3.2% of GDP on average but rose to 6.5%, 9.9% and 8.9% in the subsequent years. The forecasts for 2011 and 2012 are 9.8% and 7.0%, respectively (CBO, 2011). Recently, debates around the evolution of U.S. debt have emerged again, mainly in the context whether and by how much to extend the debt ceiling which was at approximately 14 trillion U.S. dollars as of July 2011. The point is that the failure to extend the debt limit would have rendered the U.S. government unable to pay its obligations, thus causing a default with obvious repercussions.¹ As a consequence of an insufficient fiscal consolidation plan and a relatively fast rising debt-to-GDP ratio the U.S. credit rating was downgraded by Standard & Poor's. Hence, in order to stabilize the debt-to-GDP ratio and prepare for long-run challenges (such as ageing of the population or growth in public health-care expenditures) the deficit needs to be reduced. This task is even more pressing if there are effects of fiscal variables on the interest rate.²

In general, the search for an (empirical) answer regarding the nature of the link between interest rates and fiscal variables is long and challenging. A priori, the effect of deficits on interest rates is unclear. According to textbook theory increasing deficits will raise interest rates (the conventional view) whereas Ricardian equivalence suggests that individuals view deficits as postponed tax liabilities, thus deficits should have no effects on interest rates. One possible explanation for this latter finding is that interest rates are related much more to the expectation of future budget deficits than to current and past budget deficits.

There is an extensive empirical literature on interest rate effects of public deficits and debt, most studies deal with estimating these effects for the U.S.³ Generally, the empirical evidence is mixed (see Gale and Orszag, 2003): papers using deficit projections, such as the ones by Gale and Orszag (2004) or Laubach (2009), tend to show significant positive effects of deficits on interest rates. Results from studies using a VAR-framework are more

¹Zivney and Marcus (1989) find that the only known instance of technical default in the U.S. in 1979 caused a 60 basis point increase in T-bill rates.

²The Council of Economic Advisers (2003) estimates that interest rates rise by about 3 basis points for every additional \$200 billion in government debt.

³For Europe see, e.g., Faini (2006), Afonso (2010) or Marattin and Salotti (2010).

ambiguous: Engen and Hubbard (2004) find significant effects of government debt on the long-term real rate of interest; Evans and Marshall (2007), who analyze which type of shock affects interest rate variability, find no evidence that fiscal policy shocks have an effect on the interest rate.

Several recent contributions have assessed interest effects of fiscal variables within a panel setting: Ardagna et al. (2007) find significant effects of deficits/debt on long-term interest rates using a nonlinear specification for a panel of 16 OECD countries. In accordance with these results, Baldacci and Kumar (2010) show that higher deficits/debt lead to a significant increase in long-term interest rates for a panel of 31 countries. The magnitude of this effect depends on country specific characteristics (e.g., fiscal and institutional conditions) and spillovers from global financial markets.

All in all, even though most studies in the recent literature finds an effect of deficits/debt on the interest rate in the U.S., the overall evidence is still ambiguous which may be due to the fact that nonlinearity has been discarded. Nonlinear effects have been considered in the literature by estimating the underlying model using square terms (e.g., Ardagna et al., 2007), country-specific characteristics (e.g., Baldacci and Kumar, 2010) or sub-samples of countries (e.g., Marattin and Salotti, 2010).⁴ We contribute to this literature by applying another methodology and showing that there are indeed such nonlinear effects. In addition, we demonstrate how such nonlinear impacts can change the standard results in the tradition of Domar (1944) and hence the leeway of fiscal policy.

The paper is organized as follows: Section 2.1 introduces the empirical model and the regression results for the linear case, section 2.2 sketches the idea of nonlinearity and the corresponding empirical results. Section 3 shows some simulations of rising deficits/debt under the hypothesis of nonlinearity and section 4 concludes.

⁴Laubach (2009) discusses structural breaks in the fiscal coefficients, but he does not consider nonlinear effects. In a more recent paper (Laubach, 2011) he actually mentions the possibility of nonlinearity with regard to the interest rate-deficit nexus.

2 Empirical results

2.1 The baseline model

For our empirical investigation we use annual as well as semiannual data for the U.S. from 1976 to 2011.⁵ In testing the relationship between deficits/debt and interest rates we use the baseline specification in Laubach (2009).⁶ Thus, the baseline regression is:

$$E_t i_{t+k} = \beta_0 + \beta_1 E_t \pi_{t+k} + \beta_2 E_t f_{t+k} + \beta_3 E_t u_{t+k} + \epsilon_t \quad (1)$$

where the dependent variable is the long-term nominal interest rate expected to exist k periods ahead (in most regressions we use the five-year-ahead ten-year forward rate calculated from the zero-coupon yield curve), f_{t+k} is the given measure of fiscal policy, i.e. (projections of) government deficits/debt (we use the five-year-ahead projections from the U.S. Congressional Budget Office (CBO henceforward)), $E_t \pi_{t+k}$ is an indicator for expected inflation,⁷ and u_{t+k} stands for additional regressors. As additional regressors we use the dividend yield and the trend growth rate.

Insert Table 1 around here

The results of the linear model with annual as well as semiannual data show that public deficits and debt seem to have a significant positive effect on the long-term interest rate.⁸ Two of the control variables, namely the dividend yield and the trend growth rate, turn out insignificant, inflation expectations turn out positive and significant as expected.⁹

One issue to be mentioned is endogeneity. The main problem with regard to the underlying specification is potential reverse causality since the effects of fiscal policy can hardly be

⁵A detailed documentation of the data can be found in the appendix.

⁶Other specifications have been tried as well, using other variables does not change the results significantly. The results are available upon request.

⁷Lindé (2001) states that the use of expected inflation in the empirical specification plays a role, i.e., conventional view is supported when a proxy for expected inflation is used.

⁸Note that all regressions using semiannual data suffer from autocorrelation. This is due to the fact that deficits/debt projections of the CBO in January and in mid-year are relatively similar (the correlation coefficient is 0.90). Thus the regressions using semiannual data have to be treated with caution. Adding an AR-term changes the results slightly, the main conclusions, however, stay the same.

⁹Engen and Hubbard (2004) note that instead of using levels of interest rate and debt changes should be used. Using changes renders some of the control variables insignificant, however, the main effect of deficits and debt stays the same.

isolated from other factors affecting interest rates such as, for instance, the business cycle. Since automatic fiscal stabilizers increase deficits during recessions, whereas at the same time long-term interest rates decrease due to an expansive monetary policy stance, deficits and interest rates may be negatively correlated even though the partial effect of deficits on interest rates is positive. As mentioned by Laubach (2009) one solution is to use fiscal variables and interest rate projections several years into the future which are likely to be little affected by the current state of the business cycle, which is also the strategy followed in this paper. Hence the estimation results above and below should not suffer too much by reverse causality. However, in order to test statistically whether the underlying specification should take endogeneity into account (i.e., whether it should be estimated using instrumental variables), the Durbin-Wu-Hausman test was performed. The test statistic for annual (semiannual) data takes the value of 0.426 (0.852), hence we cannot reject the null that OLS estimation yields consistent estimates (i.e., any endogeneity among the regressors would not have deleterious effects on OLS estimates).

2.2 The nonlinear extension

In a recent paper, Laubach (2011) emphasizes the potential relevance of nonlinear effects with regard to the relationship between fiscal variables and interest rates: While usually the effects of government debt or deficits on interest rates seem to be significant but modest, there are situations (particularly in times when default risk becomes an issue) in which interest rates react very sensitively to fiscal policy changes and interest rate effects can thus become very large.

Thus the intuition with regard to the nonlinear relationship between interest rates and government deficits/debt is straightforward:

It is known from the literature of (Non-Keynesian) effects that the relationship between deficits/debt and consumption may be nonlinear (see, e.g., Giavazzi et al., 2000, Giavazzi and Pagano, 1990): Up to a certain level, expansive fiscal policy (i.e., rising deficits and debt levels) stimulates consumption. This effect, however, may revert at some point (of debt level) when consumers feel that an adjustment is about to come which implies that expectations play a central role when a certain trigger point is reached.¹⁰ Indeed, the re-

¹⁰Bertola and Drazen (1993) hypothesize that significant government spending cuts take place only when the ratio of government spending to output hits a trigger point.

spective literature has found evidence that such expectations do exist. There are certainly reasons to hypothesize that such nonlinear effects may also hold true with respect to the relationship between interest rates and deficits/debt.

In fact, some papers have found such nonlinear effects such as the papers by Ardagna et al. (2007) and Baldacci and Kumar (2010) mentioned above. In addition, Favero and Giavazzi (2007) find that fiscal policy effects on interest rates depend on the path of the debt-to-GDP ratio: these effects are weaker when the debt ratio is on stable path. Reinhard and Rogoff (2010) and Reinhard et al. (2003) in their “debt intolerance” analysis find that thresholds obviously matter with regard to public debt, i.e. as debt levels rise towards historical limits or as countries hit debt intolerance ceilings, risk premia begin to rise sharply. Caporale and Williams (2002) find that when the stock of debt is low, financial markets consider it as high quality and an increase in its level is associated with a fall in interest rates. However, when government debt reaches a threshold, further increases are associated with higher interest rates. These findings also suggest that the relation between long-term interest rates and debt might be nonlinear and depend on the level of the debt. Thus, in a nutshell, thresholds obviously matter when it comes to estimating the effects of deficits and debt on interest rates.

The assumption of nonlinearity raises the question of the appropriate empirical specification to be tested. An initial indication of the presence of nonlinearities can be drawn from Figure 1 that shows the five-year-ahead ten-year forward rate against the CBO’s five-year-forecast of deficits and a locally weighted scatterplot smoothing line (see Cleveland, 1993 and 1994). This non-parametric approach fits a local linear regression line for each data point in the sample, weighting the other observations: Data points that are relatively far from the point being evaluated get small weights in the sum of squared residuals, while closer data points get higher weights. The resulting nonlinear curve is presented in Figure 1. The shape of the curve suggests that deficit projections do not affect interest rates up to a certain threshold which then subsequently takes place. Figure 1 in line with the literature mentioned above thus suggests the use of a specification which takes this specific nonlinear form into account.

Insert Figure 1 around here

The empirical investigation of nonlinearity in the relationship between interest rate and debt was formalized in papers by Ardagna et al. (2007), Gruber and Kamin (2010) and Faini (2006). They estimate the nonlinear model adding a square term for the fiscal variable.

Thus the baseline model given by (1) is extended as follows:

$$E_t i_{t+k} = \beta_0 + \beta_1 E_t \pi_{t+k} + \beta_2 E_t f_{t+k} + \beta_3 E_t f_{t+k}^2 + \beta_4 E_t u_{t+k} + \epsilon_t \quad (2)$$

The estimation results can be seen in Table 2. The results using annual and semiannual data show contradicting evidence: as for deficits, the fiscal variable is nonsignificant in levels but positive and significant for the square thus confirming the hypothesis of nonlinearities. As for debt, however, both the simple as well as the quadratic term are nonsignificant.

Insert Table 2 around here

However, assessing nonlinearity by using a square term may actually show a misleading picture as the contradicting results using the square specification already indicate. The main problem is that such a specification approximates a hump- or U-shaped relationship, i.e. the function has to be symmetric. Thus, when the real function is discontinuous, a quadratic model would be misspecified. In order to approximate an asymmetric function, a piecewise-linear methodology may hence be more appropriate. Such a specification can approximate an asymmetric function, at the same time, however, a hump-shaped function is also nested in this approach.

A specification that allows for such an asymmetry is given by

$$E_t i_{t+k} = \beta_0 + \beta_1 E_t \pi_{t+k} + \beta_2^i E_t f_{t+k} + \beta_3 E_t u_{t+k} + \epsilon_t \quad (3)$$

where

$$i = \begin{cases} 1 & \text{if } E_t f_{t+k} \leq \gamma \\ 2 & \text{if } E_t f_{t+k} > \gamma \end{cases} \quad (4)$$

The specification is, thus, piecewise-linear, and the expected level of government deficits/debt, $E_t f_{t+k}$, is responsible for the regime being active. The threshold parameter, γ , needs to be estimated as well. If γ were known, the estimation of β_2^i , $i = 1, 2$ would be relatively simple by dividing the sample into two subsamples, assigning label 1 and 2 according to (4) and estimating the β_2 -parameter for each subsample. However, for the underlying model, following Hansen (2000), the estimation of γ is performed by conducting a grid search on $E_t f_{t+k}$

and estimating (3) for every realized value of $E_t f_{t+k}$.¹¹ Finding a least squares estimator of γ is achieved by evaluating the sum of squared errors of model (3) for all possible values of γ and choose the estimator $\hat{\gamma}$ fulfilling

$$\hat{\gamma} = \underset{E_t f_{t+k}}{\operatorname{argmin}} \sum_t \hat{\epsilon}_t(E_t f_{t+k})^2 \quad (5)$$

that is the value of $E_t f_{t+k}$ which minimizes the sum of squared residuals in (3)-(4).¹²

Another issue is the test for linearity. Testing $\beta_2^1 = \beta_2^2$ under H_0 presents an extra difficulty since the threshold parameter, γ , is only identified under the alternative hypothesis of nonlinearity, thus classical tests (such as the F-test) have nonstandard distributions. The problem is solved by applying a bootstrap procedure where – using the linear relationship – artificial data on the dependent variable is simulated and both a linear and a piecewise linear model with the estimated threshold is calculated.¹³ The corresponding test statistic is computed and the procedure is repeated a large number of times, leading to an approximate distribution of the test statistic under the null of linearity. The percentage of replicated test statistics that exceed the original value of the test statistic computed with real data is then the p-value of the linearity test.¹⁴

Insert Table 3 around here

Insert Table 4 around here

Tables 3 and 4 present the estimated parameters from equation (3)–(4) with annual and semiannual data, together with the test statistic for linearity and the p-value resulting from the bootstrap method described above. While the linear model shows a significant effect of government debt and deficits on interest rates and the addition of a quadratic term leads to contradicting results, these conclusions change if we allow for a nonlinear, level-dependent effect of government debt and deficits on interest rates. The results indicate evidence of nonlinearity at the 0% significance level, and the estimated threshold is at $\gamma = 4.72$ (annual

¹¹The grid search is proceeded after trimming a certain percentage (in our case 25%) on the tails of the empirical distribution of $E_t f_{t+k}$ for obvious identification reasons.

¹²See Hansen (1996, 2000) for the properties of this estimator.

¹³See Andrews and Ploberger (1994), Hansen (1996, 2000).

¹⁴The asymptotic distribution of the likelihood ratio test is nonstandard and strictly dominates the χ^2 distribution. Due to its distribution the critical values cannot be tabulated.

data) and $\gamma = 3.37$ (semiannual data). The significant partial correlation between interest rates and government debt and deficits in the linear model now changes: there is no effect of government debt and deficits on interest rates below the estimated threshold, above the threshold the relationship appears positive and significant and much larger in magnitude than in the linear case. The adjusted R^2 rises by several percentage points as compared to the simple and the squared specification. As a robustness exercise we also estimated the nonlinear model given by (3) using the three-year-ahead five-year forward rate and the three year forecast of deficits/debt (see tables 5 and 6). In both cases the estimates are very much the same as in the baseline nonlinear regressions.

Insert Table 5 around here

Insert Table 6 around here

The results (using annual data) imply that there is a significant effect of projected deficits and debt in the U.S. only if the deficit surpasses approximately 5% of GDP. For deficits above the threshold, a percentage point increase in the deficit-to-GDP ratio (debt-to-GDP ratio) raises the interest rate by approximately 40 basis points (5 basis points). This result sheds new light on the interest rate-deficit/debt nexus: the fiscal impulse has to be of a rather large magnitude in order to have an effect on interest rates.

Empirically, the years where (projected) deficits surpass the estimated threshold are from 1982 to 1985, i.e. the period where the military buildup under Reagan took place. It was also the time when actual deficits were substantial (i.e., between 4 and 6 percent of GDP) and when the debt ceiling surpassed one trillion for the first time. In the period from 1981 to 1985 the debt ceiling more than doubled (the cumulative extension amounted to 111%), which was never the case again before and after that time. The massive investment in military in the Cold War years in combination with the substantial extension of the debt ceiling thus may have shaped the expectation among market participants of permanently high future budget deficits with obvious effects on the path of public debt.

3 Simulations

This section shows how our empirical results could change the leeway of fiscal policy. We simulate the implications within the framework of a standard model in the tradition of

Domar (1944).¹⁵ The model shows the limits of the debt-to-GDP ratio (b) and the interest-to-GDP ratio (z) with a constant deficit-to-GDP ratio (d), a constant nominal interest rate (i) and a constant growth rate of nominal GDP (n).¹⁶ The debt-to-GDP ratio converges to $b^* = d/n$ and the interest-to-GDP ratio to $z^* = i(d/n)$ with continuous time.¹⁷

The limits of b and z are calculated for different values of d and i (in the case of i only if d surpasses the threshold). Thus the long-run effects of a gradual increase in the deficit-to-GDP ratio can be simulated.¹⁸ We use the estimation results based on annual data, therefore the nonlinear effects set in when d surpasses the threshold value of 4.72%.¹⁹ We simulate the effects of increasing deficits on b^* , z^* and on the limit of the primary deficit-to-GDP ratio (dp^*). For a given limit of z we can calculate the limit of dp using $dp = d - z$. If $dp < 0$, there is a primary surplus.

Three scenarios are simulated (see Table 7): In scenario A (the baseline) there are no effects of deficits or debt on the interest rate, in scenario B (C) there is a nonlinear effect of deficits (debt). The following values are used in our calculations: The initial value of i amounts to 7.9% (equivalent to the mean of the long-term nominal interest rate used in our estimations), n is 6.5% (equivalent to the mean of the growth rate of nominal GDP from 1976-2010). d starts with 0% and increases stepwise with 0.1 percentage points thus rising gradually to 12%.

¹⁵Further developments and extensions of the standard model can be found in Blanchard et al. (1990) and in Frisch (1997).

¹⁶As we have estimated the effects on the nominal interest rate we use the model in nominal terms. The growth rate n remains at a constant level in the simulations. In a Non-Ricardian world there could be long-run effects of public debt on the growth rate (Zagler and Dürnecker, 2003). Freedman et al. (2009) show within a DSGE model that a permanently higher deficit-to-GDP ratio leads to lower levels of real GDP in the long-run; another recent study (Bassetto and Butters, 2010) demonstrates that there is no positive relationship between high deficits and high inflation in industrialized countries. Hence, the negative effect of deficits/debt on the real growth rate is not counterbalanced. Therefore our simulation results with a constant growth rate of nominal GDP could be quite favorable cases. With a lower growth rate the limits of b and z would be higher.

¹⁷We concentrate on b^* and z^* as the data and the estimation results can only be meaningfully used for these calculations.

¹⁸Mind that we are not interested in the short-run effects and in the concrete paths to the limit.

¹⁹Using semiannual data, the results are very similar. However, in the case of debt effects (scenario C) semiannual data lead to considerably lower limits of z for high deficit-to-GDP ratios. Thus, there is almost no difference between the limits of z and dp in the case of scenario B and C.

The simulations illustrate what would have happened with regard to the limits if the expected deficit-to-GDP ratio had permanently increased to very high levels (e.g., 10% or higher) and how nonlinear effects influence these limits. Table 7 shows selected results for the limits of b , z and dp . The effects on b^* do not depend on the scenario as $b^* = d/n$. The limit of b is increasing from 0.308 ($d = 2\%$) to 1.846 ($d = 12\%$). Figure 2 illustrates the effects on z^* and on dp^* .

Insert Table 6 and Figure 2 around here.

In the baseline scenario of Figure 2 the increase in d leads to an ongoing rise in z^* which is the result of a growing debt-to-GDP ratio (baseline effect). In Scenario B (C) the overall effect consists of the baseline effect and the nonlinear interest rate effect of deficits (debt). The additional effects are not present until passing the threshold level. Scenario C with the nonlinear effect of debt shows the highest limits of z .

The limits of the primary deficit-to-GDP ratio (see Figure 2) represent the effect of different deficit levels on the leeway of fiscal policy. As a result of $i > n$ (which is usually the case) a primary surplus is needed in all scenarios and at all deficit levels to sustain a constant b . The need for a primary surplus increases with the deficit level. The highest primary surpluses are necessary in case of nonlinear debt effects. The nonlinear effects are in some way like pitfalls. Until passing the threshold level only the baseline effect is relevant for the limits of z and dp . After passing the threshold level fiscal policy is suddenly confronted with additional nonlinear effects on the interest rate.

4 Conclusions

This piece of research presents evidence concerning nonlinear effects of fiscal variables on interest rates for the U.S. Using threshold estimation, we find evidence of level-dependent effects of deficits/debt on interest rates, implying that the correlation between interest rates and government debt and deficits appears nonsignificant for levels of deficits below the estimated threshold which is at approximately 5% of GDP. For values of government deficits above the threshold, the relationship appears positive and significant. In other words, the fiscal impulse has to be of a rather large magnitude in order to have an effect on interest rates. In addition, we calculate how these nonlinear effects influence the limits of the interest-to-

GDP ratio and the primary deficit-to-GDP ratio. The negative effects on the leeway of fiscal policy are significantly increasing with the deficit-to-GDP ratio. Future research should attempt to cover the same aspects for other countries especially those that are strongly affected by the financial crises. Assessing the (potentially nonlinear) effect of debt and deficits on interest rates for a sample of countries, e.g, countries of the European Union, could help to shed new light on the interest rate-debt nexus in broader perspective.²⁰

A Data

We use data from 1976 to 2011. The variables used in this study are the long-term nominal interest rate expected to exist k periods ahead, forecasts of budget deficits and debt, inflation expectations, the dividend yield and the trend growth rate. Some of the time series we use have been recalculated and differ slightly from those in Laubach (2009). Using these time series, however, does not change the baseline results in Laubach (2009) significantly. Here follows a description of the main variables used:

Long-term nominal interest rate: Average of one-year forward rates 5-14 years ahead and 3-5 years ahead, calculated from the zero-coupon yield curve based on the data provided by Gürkaynak et al. (2007), sampled on the last trading day of the month of the CBO release.

Deficit and debt: The Congressional Budget Office's (CBO) projected 5-year-ahead deficit (+) or surplus (-) and debt held by the public as percent of GDP. The series was obtained by the biannual CBO budget report available from the website of the CBO.

Expected inflation: The series is composed of three parts, partly available from Laubach (2009). Until 1981:Q1, the series is an estimated step function based on Kozicki and Tinsley (2001). From 1981:Q2 until 1991:Q2 the series is based on the Hoey survey of bond market participants and since 1991:Q3 on the Survey of Professional Forecasters carried out by the Federal Reserve Bank of Philadelphia. The series is interpolated to monthly frequency and sampled corresponding to the interest rate data.

Dividend yield: Calculated as net dividends as percent of equity shares at market value

²⁰One major difficulty in international comparisons lies in interest rate projections which are not available to the extent as for the data used in this study (see Faini, 2006).

(directly or indirectly) held by households and nonprofit organizations excluding defined benefit plans. All series can be found in the Flow of Funds Accounts available from the website of the Fed.

Trend growth rate: CBO's projected 5-year-ahead real GDP growth. The series was obtained by the biannual CBO budget report available from the website of the CBO.

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Table 1: Baseline results

Fiscal variable	annual data		semiannual data	
	def_{t+5}	$debt_{t+5}$	def_{t+5}	$debt_{t+5}$
constant	4.66*** (0.74)	3.85*** (0.99)	4.32*** (0.76)	3.43*** (1.22)
π^e	1.31*** (0.13)	1.37*** (0.14)	1.18*** (0.16)	1.20*** (0.17)
<i>div yield</i>	-0.04 (0.17)	-0.07 (0.18)	0.11 (0.17)	0.20 (0.18)
<i>trend growth</i>	-0.4/ (0.28)	-0.61* (0.29)	-0.39 (0.31)	-0.46 (0.39)
f_{t+k}	0.21*** (0.06)	0.02* (0.01)	0.18*** (0.07)	0.02 (0.01)
R_{adj}^2	0.88	0.85	0.85	0.82
DW	1.16	1.03	0.59	0.51

***(**)[*] stands for 1% (5%) [10%] significant, standard errors in parenthesis; the dependent variable is the five-year-ahead 10-year forward rate; DW is the Durbin-Watson test statistic.

Table 2: Nonlinearity results: square

Fiscal variable	annual data		semiannual data	
	def_{t+5}	$debt_{t+5}$	def_{t+5}	$debt_{t+5}$
constant	4.89*** (0.66)	4.09*** (1.53)	4.71*** (0.46)	4.93*** (1.13)
π^e	1.13*** (0.13)	1.36*** (0.16)	1.17*** (0.10)	1.34*** (0.12)
<i>div yield</i>	0.09 (0.16)	0.09 (0.19)	0.12 (0.09)	0.12 (0.12)
<i>trend growth</i>	-0.62** (0.26)	-0.65* (0.36)	-0.70*** (0.16)	-0.76*** (0.24)
f_{t+k}	0.09 (0.07)	0.01 (0.05)	0.04 (0.04)	-0.03 (0.04)
f_{t+k}^2	0.06*** (0.02)	0.00 (0.00)	0.06*** (0.02)	0.00 (0.00)
R_{adj}^2	0.90	0.85	0.89	0.85
DW	1.38	1.02	0.73	0.56

***(**)[*] stands for 1% (5%) [10%] significant, standard errors in parenthesis; the dependent variable is the five-year-ahead 10-year forward rate; DW is the Durbin-Watson test statistic.

Table 3: Nonlinearity results: threshold, annual data

Fiscal variable	$debt_{t+5}$		def_{t+5}	
Parameter	Lower regime	Upper regime	Lower regime	Upper regime
constant	5.06*** (0.95)		5.35*** (0.77)	
π^e	1.31*** (0.13)		1.29*** (0.12)	
<i>divyield</i>	-0.05 (0.13)		-0.06 (0.14)	
<i>trend growth</i>	-0.64*** (0.24)		-0.59* (0.25)	
f_{t+k}	0.01 (0.01)	0.05*** (0.01)	0.07 (0.08)	0.42*** (0.09)
γ	$def_{t+5} = 4.72$		$def_{t+5} = 4.72$	
R_{adj}^2	0.89		0.89	
<i>DW</i>	1.29		1.32	
Linearity Test	17.01 (p-value 0.00)		9.27 (p-value 0.00)	

***(**)[*] stands for 1% (5%) [10%] significant, standard errors in parenthesis; the dependent variable is the five-year-ahead 10-year forward rate; *DW* is the Durbin-Watson test statistic. 2,000 replications were used in the bootstrap for the linearity test.

Table 4: Nonlinearity results: threshold, semiannual data

Fiscal variable	$debt_{t+5}$		def_{t+5}	
Parameter	Lower regime	Upper regime	Lower regime	Upper regime
constant	4.58*** (0.60)		4.74*** (0.47)	
π^e	1.21*** (0.10)		1.21*** (0.09)	
<i>divyield</i>	0.17* (0.10)		0.11 (0.09)	
<i>trend growth</i>	-0.67*** (0.16)		-0.63*** (0.16)	
f_{t+k}	0.00 (0.01)	0.02*** (0.01)	0.02 (0.05)	0.31*** (0.06)
γ	$def_{t+5} = 3.37$		$def_{t+5} = 3.37$	
R_{adj}^2	0.88		0.89	
<i>DW</i>	0.66		0.68	
Linearity Test	14.10 (p-value 0.00)		13.63 (p-value 0.00)	

***(**)[*] stands for 1% (5%) [10%] significant; standard errors in parenthesis the dependent variable is the five-year-ahead 10-year forward rate; *DW* is the Durbin-Watson test statistic. 2,000 replications were used in the bootstrap for the linearity test.

Table 5: Nonlinearity results: threshold, annual data

Fiscal variable	$debt_{t+3}$		def_{t+3}	
Parameter	Lower regime	Upper regime	Lower regime	Upper regime
constant	5.19*** (1.18)		5.25*** (0.83)	
π^e	1.55*** (0.15)		1.54*** (0.15)	
$divyield$	-0.24 (0.22)		-0.19 (0.23)	
$trend\ growth$	-0.83*** (0.29)		-0.91*** (0.29)	
f_{t+k}	0.00 (0.02)	0.05*** (0.02)	-0.08 (0.10)	0.39*** (0.11)
γ	$def_{t+3} = 4.47$		$def_{t+3} = 4.47$	
R_{adj}^2	0.89		0.88	
DW	1.66		1.70	
Linearity Test	16.45 (p-value 0.00)		14.17 (p-value 0.00)	

***(**)[*] stands for 1% (5%) [10%] significant, standard errors in parenthesis; the dependent variable is the three-year-ahead 5-year forward rate; DW is the Durbin-Watson test statistic. 2,000 replications were used in the bootstrap for the linearity test.

Table 6: Nonlinearity results: threshold, semiannual data

Fiscal variable	$debt_{t+3}$		def_{t+3}	
Parameter	Lower regime	Upper regime	Lower regime	Upper regime
constant	5.04*** (0.78)		4.54*** (0.47)	
π^e	1.57*** (0.11)		1.55*** (0.09)	
<i>divyield</i>	0.02 (0.10)		0.07 (0.09)	
<i>trend growth</i>	-1.00*** (0.19)		-1.04*** (0.16)	
f_{t+k}	-0.01 (0.01)	0.01 (0.01)	0.14 (0.05)	0.22*** (0.08)
γ	$def_{t+3} = 3.51$		$def_{t+3} = 3.51$	
R^2_{adj}	0.88		0.89	
<i>DW</i>	0.88		1.01	
Linearity Test	8.51 (p-value 0.01)		17.75 (p-value 0.00)	

***(**)[*] stands for 1% (5%) [10%] significant, standard errors in parenthesis; the dependent variable is the three-year-ahead 5-year forward rate; DW is the Durbin-Watson test statistic. 2,000 replications were used in the bootstrap for the linearity test.

Table 7: Limits of b , z and dp (Selected results)

d	2%	2%	2%	4%	4%	4%	6%	6%	6%
Scenario	A	B	C	A	B	C	A	B	C
b^*	0.308	0.308	0.308	0.615	0.615	0.615	0.923	0.923	0.923
z^*	0.024	0.024	0.024	0.049	0.049	0.049	0.073	0.078	0.082
dp^*	-0.004	-0.004	-0.004	-0.009	-0.009	-0.009	-0.013	-0.018	-0.022

d	8%	8%	8%	10%	10%	10%	12%	12%	12%
Scenario	A	B	C	A	B	C	A	B	C
b^*	1.231	1.231	1.231	1.538	1.538	1.538	1.846	1.846	1.846
z^*	0.097	0.114	0.128	0.122	0.156	0.184	0.146	0.202	0.250
dp^*	-0.017	-0.034	-0.048	-0.022	-0.056	-0.084	-0.026	-0.082	-0.130

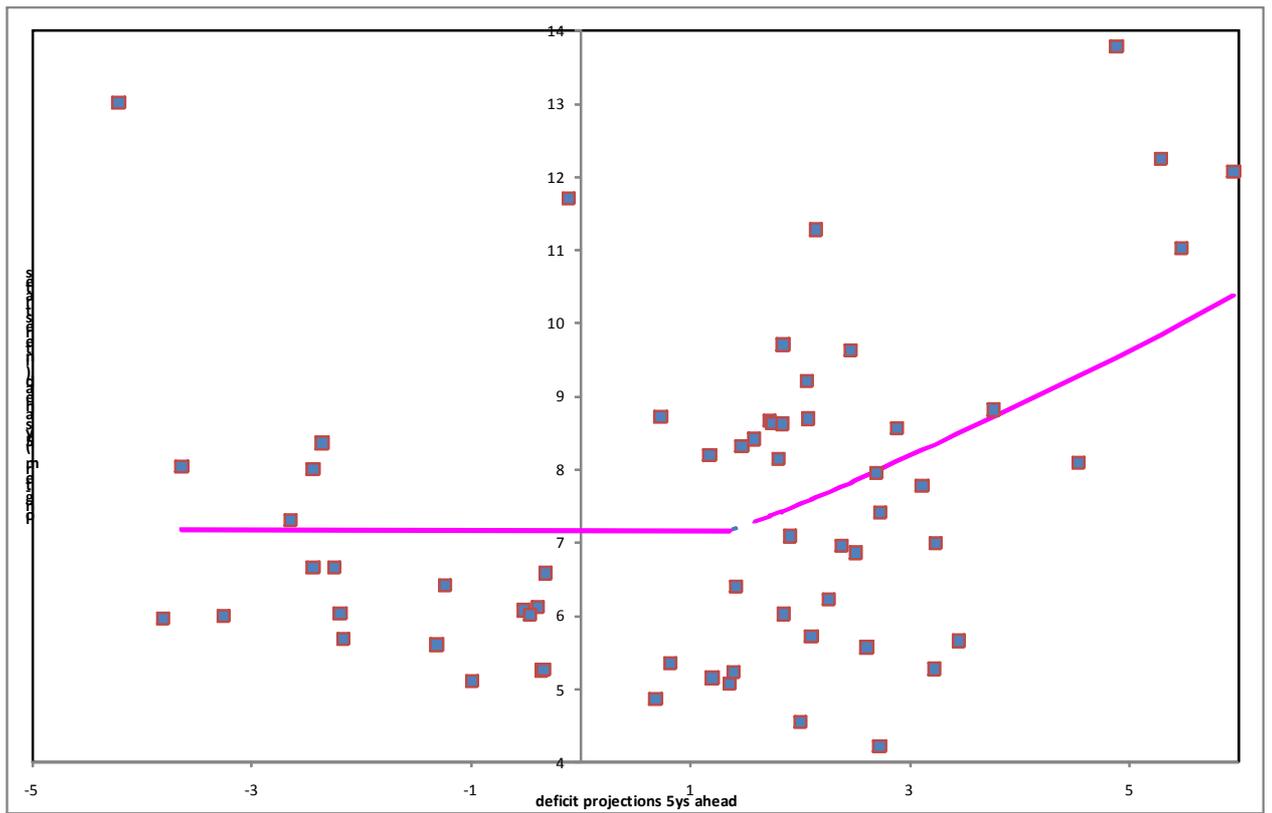


Figure 1: Deficit projections and forward rates

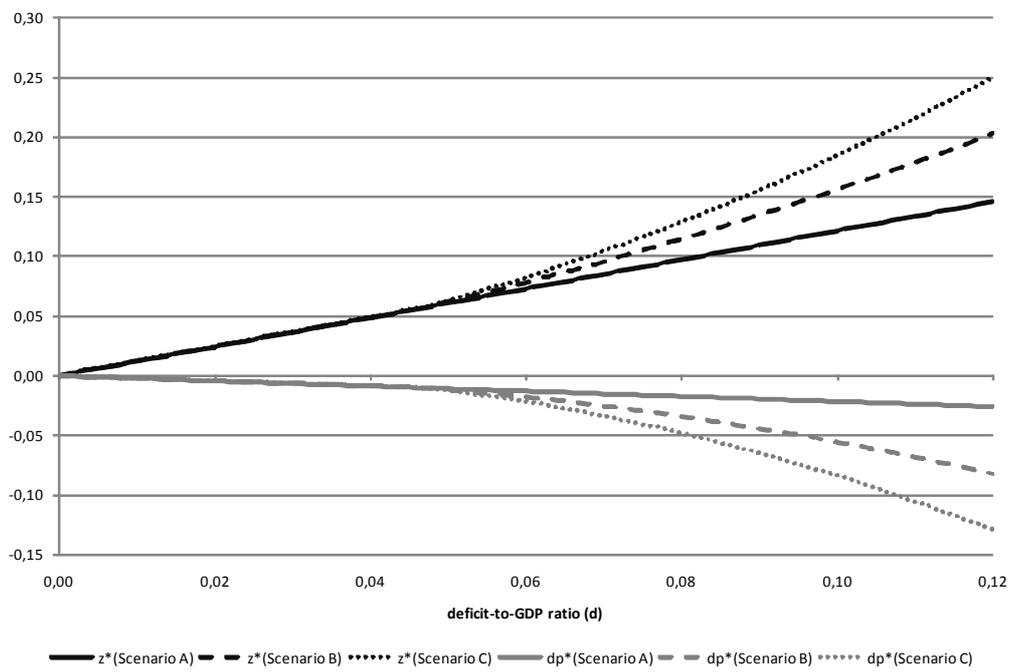


Figure 2: Limits of z and dp

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Fiscal policy, trigger points and interest rates: Additional evidence from the U.S.

Abstract

We empirically investigate whether the relationship between interest rates and public deficits/debt may be nonlinear for the U.S. Using threshold estimation, we find evidence of level-dependent effects on interest rates, implying a significant effect of projected deficits and debt in the U.S. only if the deficit surpasses approximately 5% of GDP.

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