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FINANCIAL STRESS AND THE IMPACT OF PUBLIC DEBT ON UK GROWTH IN HIGH VERSUS LOW-GROWTH REGIMES: 1850–2013

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Financial stress and the impact of public debt on UK growth in high versus low-growth regimes: 1850-2013

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Abstract

Using a long historical dataset, we estimate a Threshold Vector Autoregression (T-VAR) model for the UK based on a financial stress measure, the debt-to-GDP ratio, borrowing costs and real GDP growth. Our model allows for the impact of debt/GDP to vary between periods of high and low economic growth. We find that financial stress depresses growth much more in the low as opposed to the high-growth regime. We also find that positive shocks to debt/GDP depress economic growth and raise borrowing costs; again, the impact is much stronger when growth is low. This is an important finding as economists and policy-makers are currently debating whether it makes sense to proceed swiftly with fiscal consolidation when economic conditions remain weak.

Keywords: Debt, financial stress, GDP growth regimes

JEL: C2, H3, H6

1. Introduction

Following from the recent financial crisis and its adverse impact on world's economic growth, fiscal stimulus packages have been pursued in an attempt to drive the world economy out of recession. As a result, sovereign debt-to-GDP ratios have been on the rise. According to International Monetary Fund's (IMF) *World Economic Outlook* (October, 2013), real GDP growth in advanced economies (composed of 35 countries) dived from 2.73% in 2007 to -3.43% in 2009 and then recovered slightly to 1.17% in 2013, whereas gross government debt in advanced economies shot up from 72.86% of GDP in 2007 to 93.05% in 2009 and then further up to 107.65% in 2013. UK real GDP growth dived from 3.36% in 2007 to -5.14% in 2009 and then recovered slightly to 1.90% in 2013 whereas gross government debt shot up from 43.70% of GDP in 2007 to 68.00% in 2009 and then further up to 92.14% in 2013.

Against this background, a lively debate has emerged on whether higher debt impacts negatively on GDP growth and whether this effect is stronger at higher debt-to-GDP ratios. Indeed, Reinhart and Rogoff (2010) document a negative correlation between sovereign debt and growth above the 90% debt-to-GDP threshold for 44 countries over a period of 200 years. According to their results, median growth rates for countries with public debt over roughly 90 percent of GDP are about one percent lower than otherwise and average growth rates are several percent lower. They also note that the relationship between public debt and growth is remarkably similar across emerging markets and advanced economies.

The above finding has been challenged by Herndon *et al*. (2013) who identify coding errors in the work of Reinhart and Rogoff (2010). Looking at post-war data for 20 advanced economies, Herndon *et al*. (2013) fail to conclude that high public debt-to-GDP ratios consistently reduce growth [1]. Focussing on 12 Euro-area countries over the 1990-2010 period, Baum *et al*. (2013) employ panel data techniques to show that (i) for high debt-to-GDP ratios (in excess of 95%), additional debt impacts negatively on economic growth and (ii) the impact of debt on long-term real borrowing costs is positive above the 70% debt-to-GDP ratio. Using a panel Vector Autoregression (VAR)

[1] According to Herndon *et al*. (2013), the average real GDP growth rate for countries carrying a public-debt-to-GDP ratio of over 90 percent is actually 2.2 percent, not -0.1 percent as published in Reinhart and Rogoff (2010).

on 20 developed countries (over the 1954-2008 period) and 10 developed countries (over 1905-2008), Lof and Malinen (2014) fail to find any statistically significant effect of debt on economic growth for any elevated level of debt.

As a result of the recent crisis and its negative economic impact, fresh academic work has increasingly focussed on improving macroeconomic modelling by taking into account measures of financial stress. Amongst others, Baxa *et al*. (2013) show that central banks in the USA, the UK, Australia, Canada, and Sweden lower policy rates in the face of high financial stress. Cardarelli *et al*. (2011) show that, for advanced economies, financial turmoil in the form of banking distress is more likely to be associated with deeper and longer downturns than stress mainly in securities or foreign exchange markets. Afonso and Martins (2012) use monthly data (over the 1969-2010 period) for the US and Germany to examine the relationship between fiscal policy, monetary policy and the yield curve in a VAR model which also includes financial stress conditions.

Our paper examines the impact of the debt burden on GDP growth. In doing so, we recognize the importance of financial stress episodes by setting up a 4-variable (VAR) model based on the debt-to-GDP ratio, GDP growth, borrowing costs and a measure of international financial stress. The model, estimated on a long historical UK dataset, allows for the impact of debt to vary between periods of high and low economic growth; the switch between regimes is endogenously determined by the model. We have two main findings. Positive shocks to financial stress have a stronger negative effect on UK growth when the latter is low. Furthermore, positive shocks to debt depress economic growth and raise borrowing costs; again, the impact is stronger in the low-growth regime. This is an important finding as economists and policy-makers are currently debating whether it makes sense to proceed swiftly with fiscal consolidation when economic conditions remain weak.

The paper proceeds as follows. Section 2 discusses in detail our dataset and provides estimates of our empirical model. Section 3 assesses the robustness of our results to alternative specifications. Section 4 of the paper concludes.

2. Data and methodology

We use UK annual data for the period 1850-2013. Let $X_t = [\sigma_t, (Debt / GDP)_t, i_t, y_t]'$ be a (4x1) vector of endogenous variables. $(Debt/GDP)_t$ denotes the public debt (gross government debt)-to-GDP ratio. This is available from the International Monetary Fund (IMF) historical database. Annual real GDP growth (denoted by y_t), the long-term government bond yield and CPI inflation are available from the Bank of England historical database. In what follows, we use the long-term real interest rate (long-term government bond yield less CPI inflation; this is denoted by i_t) [2]. The financial stress variable (denoted by σ_t) is a composite measure of financial turmoil/crisis (which draws heavily on Reinhart and Rogoff, 2009). This is a world financial stress measure which takes into account banking, currency, stock market, debt, and inflation incidences in the world (we discuss alternative stress measures in Section 3). For a given country in a given year, the index is bounded between zero and five, emerging as the sum of the number of types of incidences the country experienced. Therefore, the index takes the value of 0 if the country did not experience any of the five incidences above and the value of 5 if it did experience all five incidences (see also Legrenzi and Milas, 2013). The index pools together world's 16 largest economies with country specific weights given by their relative GDP share of the total GDP (based on Purchasing Power Parity). **Figure 1** plots the data [3].

We define the Threshold VAR (T-VAR) model as follows

$$(1) \quad X_t = B_0(h) + B_1(h)X_{t-1} + B_2(h)X_{t-2} + \cdots + B_p(h)X_{t-p} + v(h)_t$$

and

[2] See http://www.imf.org/external/pubs/cat/longres.cfm?sk=24332.0 and

http://www.bankofengland.co.uk/publications/Pages/other/monetary/mpreadinglistf.aspx.The dataset has been updated to include data for 2012-2013 using IMF's World Economic Outlook database (available from http://www.imf.org/external/pubs/ft/weo/2013/02/weodata/index.aspx).

[3] Preliminary analysis suggested that real GDP growth is stationary series using conventional Augmented Dickey Fuller (ADF) tests: Assuming a constant and 4 lags (based on the Akaike Information Criterion), the ADF test statistic for real GDP growth is equal to -6.24 (p-value=0.00). The evidence of Debt/GDP stationarity is less clear. Assuming a constant and 4 lags (based on the Akaike Information Criterion), the ADF test for Debt/GDP is equal to -2.78 (p-value=0.06). p-values are the MacKinnon (1996) one-sided p-values. On the other hand, allowing for a break in the intercept, a Zivot-Andrews (1992) unit root test (using 3 lags) delivers stationarity for Debt/GDP as the t-statistic is equal to -5.16 (5% critical value=-4.80) with a break identified in 1915.

(2) $X_t = B_0(l) + B_1(l)X_{t-1} + B_2(l)X_{t-2} + \cdots + B_p(l)X_{t-p} + v(l)_t,$

for $s_t \in \{h, l\}$, where $X_t = [\sigma_t, (Debt\ /\ GDP)_t, i_t, y_t]'$ is the (4x1) vector of endogenous variables discussed above, $B_0(s) = A_0(s)^{-1}\bar{A}(s)$, $B_j(s) = A_0(s)^{-1}A_j(s)$ for $j = 1, \ldots, p$ are (4x4) parameter matrices and $v(s)_t = A_0(s)^{-1}u_t$ is a (4x1) vector of errors. This model assumes regime-switching behaviour with respect to high versus low growth, so

(3) $$\begin{Bmatrix} s_t = h \quad if \quad y_{t-d} > \bar{y} \\ s_t = l \quad if \quad y_{t-d} \leq \bar{y} \end{Bmatrix},$$

where $\bar{y}$ is the threshold value of real GDP growth. To analyze the T-VAR model, we start by testing the null of a linear VAR model against the alternative of a T-VAR model using Tsay's (1998) test statistic. Then, we estimate the threshold value ($\bar{y}$) and the delay parameter (d). Last, we estimate the remaining parameters of the T-VAR model in (1) and (2), respectively. We select a VAR lag length of p=2 using the AIC. The Tsay (1998) procedure tests the null of a VAR model against the alternative of a T-VAR model. The null hypothesis is $H_0: B_k(l) = B_k(h)$ for $k = 0,1, \ldots, p$. To implement the test, the data are re-ordered according to ascending values of the threshold variable. A single regime linear VAR model for X_t is then estimated using the first m_0 observations of the re-ordered sample. These estimates are then used to test for parameter stability across the full sample. We calculate the test statistic for a range of possible values of the delay parameter d and for different values of m_0. However, we restrict the set of possible break points by insisting that at least 20% of the sample is in each regime (see Balke, 2000). If there is evidence of a break, we select the values of $\bar{y}$ and d that maximize the test statistic, following Tsay (1998). Having done so we perform a grid search over a range of values of $\bar{y}$, selecting the value that maximizes the log likelihood function of the model.

Table 1 reports significance levels of the Tsay (1998) test for a range of values of $\bar{y}$ and d (all estimations have been implemented in version 8.20 of the RATS econometric software). The strongest rejections in favour of a T-VAR occur for d=1 (followed by d=4) and this is chosen as the delay parameter. Given this estimate of d, we estimate the regime threshold at $\bar{y}$=2.20% which is close to the sample median and the sample mean of UK growth (2.27% and 1.95%, respectively). With this in mind, our model distinguishes between a high growth (above 2.20%) regime and a low growth (below 2.20%) regime.

We next proceed by estimating the parameters in (1)-(2) using OLS. The main strand in the literature identifies fiscal shocks by ordering the fiscal variable first in a Choleski decomposition. We place the variables as these appear in X_t, that is, Debt/GDP prior to the interest rate and GDP growth (we explore an alternative identification strategy in the next section). The financial stress variable is treated as the most exogenous variable and is therefore ordered first.

The estimated impulse response functions documenting the median response of the endogenous variables to a one standard deviation shock to the Debt/GDP ratio are reported in **Figure 2A-2B** (with one standard deviation error bounds) based on 1000 Monte Carlo draws. A positive debt/GDP ratio shock depresses output growth in both regimes. It also results in a higher real interest rate (see also Baum *et al*., 2013; Engen and Hubbard, 2005). The impact on growth and the real interest rate is much stronger when the economy is already weak. From **Figure 3A-3B**, financial stress shocks impact negatively on GDP growth in both regimes; the impact is much stronger and more lasting (up to 3 years) in the low-growth regime [4].

The differences between the impact of DEBT/GDP and financial stress shocks in the high and low-growth regimes are further highlighted by the respective variance decompositions (detailed results for all variables are available on request). In the high-growth regime, shocks to DEBT/GDP explain 11% of the variance of output growth at a 3-year horizon. At the same time, shocks to financial stress explain 6% of the variance of output growth. In the low-growth regime, the impact of DEBT/GDP and financial

[4] Bruneau *et al*. (2012) identify significant reciprocal links between financial fragility (measured by corporate bankruptcies) and the French business cycle (proxied by the output gap) within a VAR model.

stress shocks on GDP growth are considerably higher. Shocks to DEBT/GDP explain 18.5% of the variance of output growth, whereas shocks to financial stress explain 11% of the variance of output growth.

3. Robustness checks

Our Choleski "structure" treats GDP growth as the most endogenous variable. As an alternative, we use generalized impulse responses (Pesaran and Shin, 1998) that do not require orthogonalization of shocks and are invariant to the ordering of the variables in the VAR. **Figure 4A-4B** plots the median responses to a one standard deviation shock to the Debt/GDP ratio (with one standard deviation error bounds); again, the negative impact on GDP growth is stronger in the low-growth regime.

Next, we look at the impact of Debt/GDP shocks on the *output gap* (output relative to potential). The output gap is plotted in **Figure 5**. The output gap is notoriously difficult to estimate. What we do is the following: For 1850-1954, we pool together information from different filters. In particular, we proxy the output gap by the median of (i) output gap using a Hodrick-Prescott trend, (ii) output gap using a cubic trend and (iii) output gap using the full sample asymmetric Christiano-Fitzgerald (2003) filter. From 1955 onwards, we use the output gap measure available from the Office for Budget Responsibility (see http://budgetresponsibility.org.uk/data/). The VAR model chooses p=2 lags (based on the AIC). The Tsay (1998) test selects d=1 and an output gap threshold of 0.38% (the sample median and the sample mean of the series are equal to -0.07% and -0.25%, respectively). The estimated impulse response functions (in **Figure 6A-6B**) show a more lasting negative Debt/GDP impact on output when the latter is below potential (output gap < 0.38%) than above potential (output gap > 0.38%).

Next, we proxy international financial stress by the spread between Moody's Baa and Aaa corporate bond yield [5]. The series (plotted in **Figure 7**) is available from 1919 and comes from the Federal Reserve Bank of St. Louis database (http://research.stlouisfed.org/fred2/); its correlation with the world financial crisis

[5] Other measures of financial stress such as the IMF financial stress index (Balakrishnan *et al*., 2009), the Federal Reserve Bank of Kansas City financial stress index (Hakkio and Keeton, 2009) and a measure of financial stress in emerging economies (Cevik *et al*., 2013) are only available for the post 1980 period.

index used above is equal to 0.393. In this case, the VAR model (which is estimated over the 1919-2013 period) chooses p=2 lags (based on the AIC). The Tsay (1998) test selects d=1 and an output growth threshold of 2.25%. Again, (see **Figure 8A-8B**), the negative impact of DEBT/GDP on GDP growth is stronger in the low-growth regime. Finally, we estimate our model conditional on exogenous dummy variables for World War I and World War II; results (available on request) are qualitatively similar to those reported here.

4. Conclusions

Using a T-VAR model, we show that positive shocks to financial stress have a stronger negative effect on UK growth when the latter is low. Furthermore, positive shocks to debt depress economic growth and raise borrowing costs; again, the impact is stronger in the low-growth regime. Our findings do not necessarily mean that the government's agenda to deal with the rising public finance burden in the current economic environment of low growth is fully justified. The idea that debt is bad for growth is consistent with a wide range of views, from "debt reduces growth because it disrupts the flow of capital to its most efficient use" to "debt reduces growth because it reduces investment in essential national infrastructure". This, however, does not necessarily imply that a swift reduction in debt is the best policy option. The benefits of austerity in terms of lower debt have to be offset against the likely costs of lower output and higher unemployment, leading to lower levels of human and physical capital. This remains an open issue for academics and policy-makers to debate.

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Table 1: *p*-values for the Tsay test

	$m_0 = 60$	$m_0 = 100$	$m_0 = 130$
$d = 1$	0.000	0.000	0.003
$d = 2$	0.000	0.142	0.144
$d = 3$	0.001	0.201	0.013
$d = 4$	0.000	0.010	0.000

Figure 1: Historical UK data and Financial stress index, 1850-2013

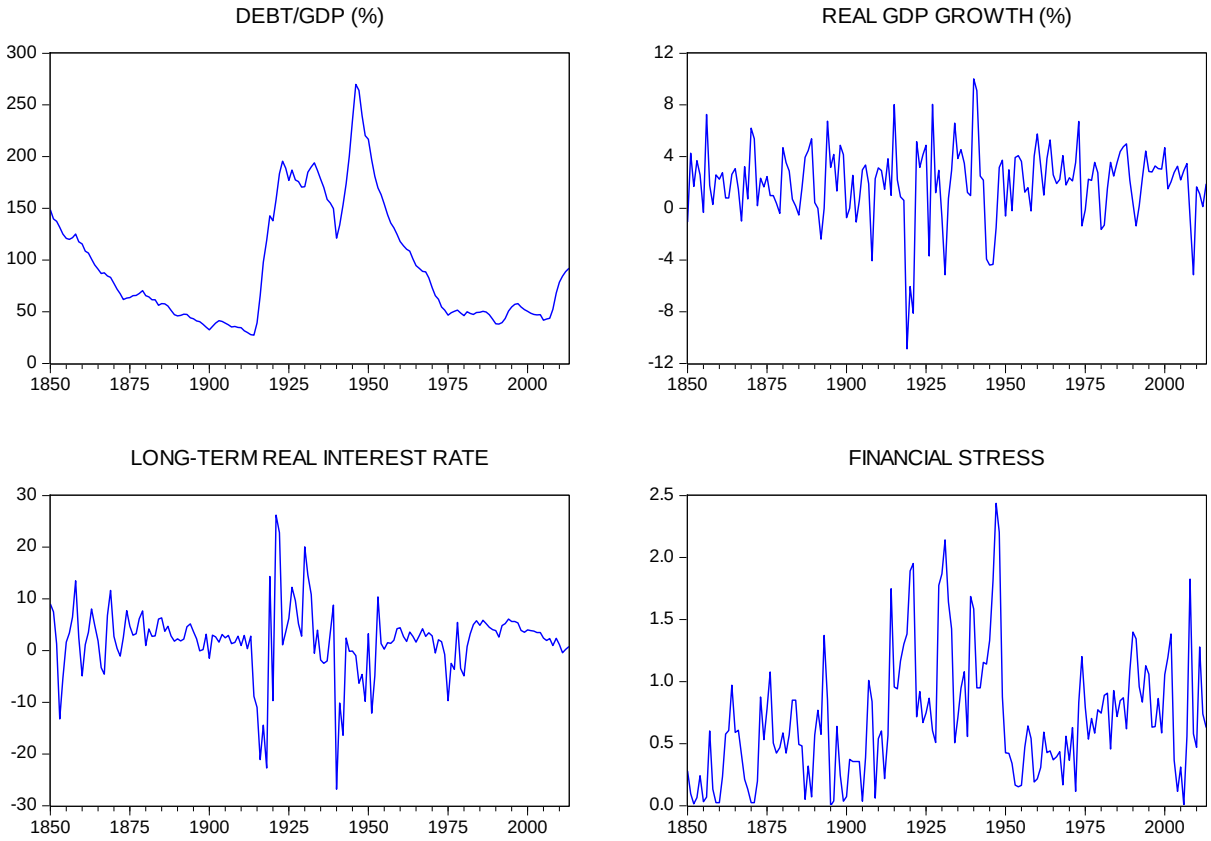
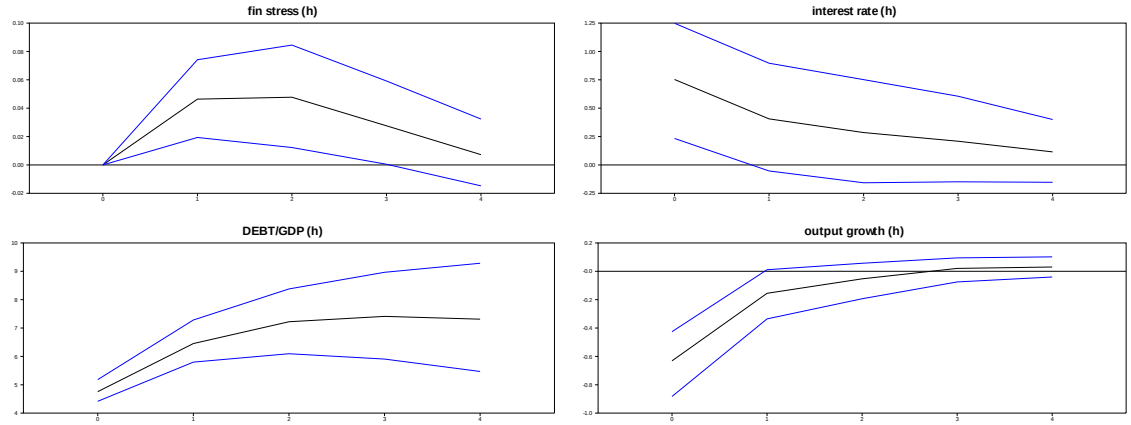
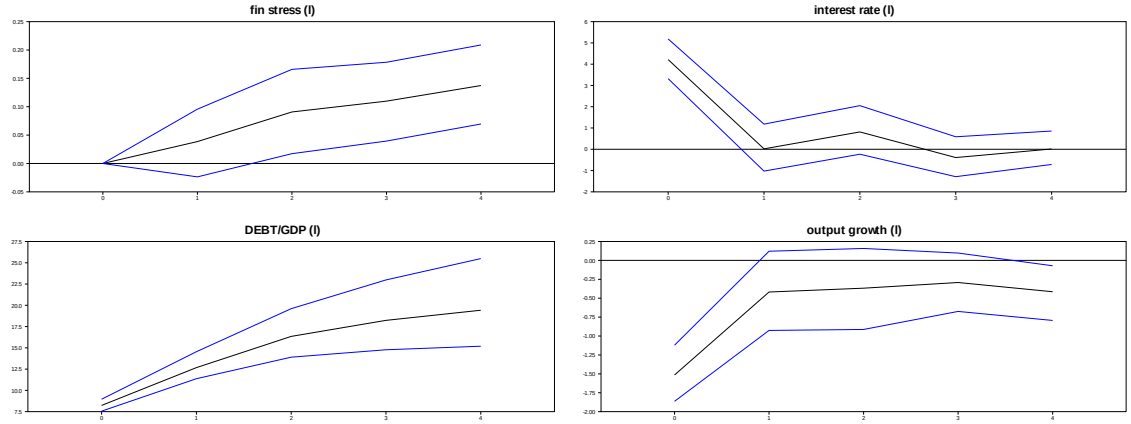


Figure 2A: Responses to Debt/GDP shocks. High-growth regime



Responses to DEBTGDP

Figure 2B: Responses to Debt/GDP shocks. Low-growth regime



Responses to DEBTGDP

Figure 3A: Responses to financial stress shocks. High-growth regime

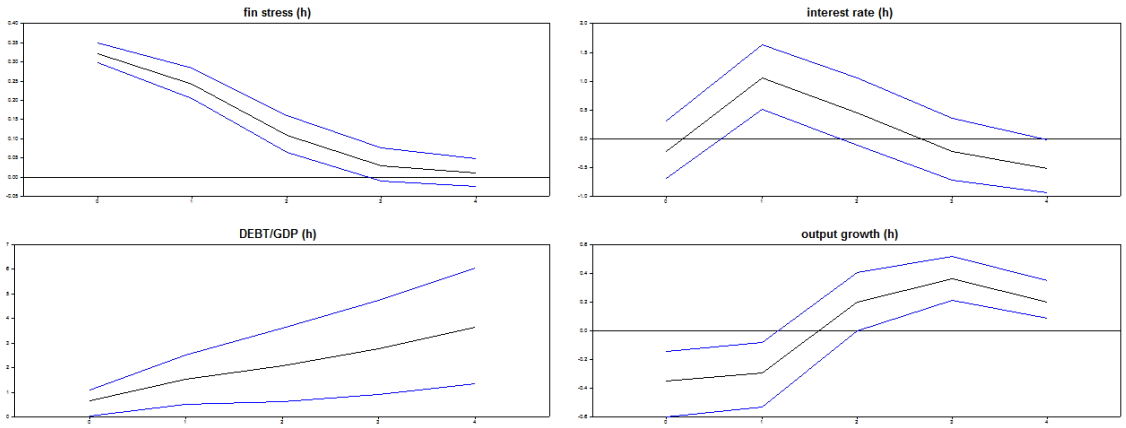


Figure 3B: Responses to financial stress shocks. Low-growth regime

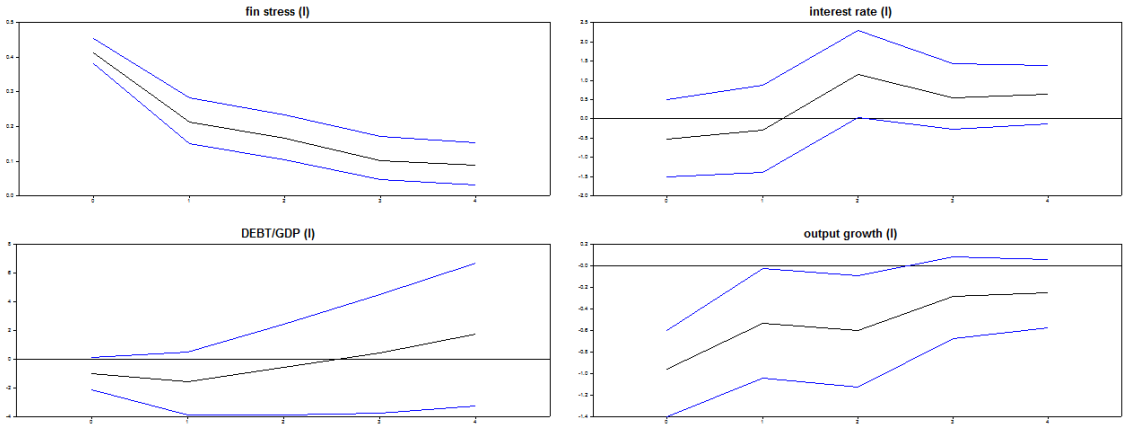
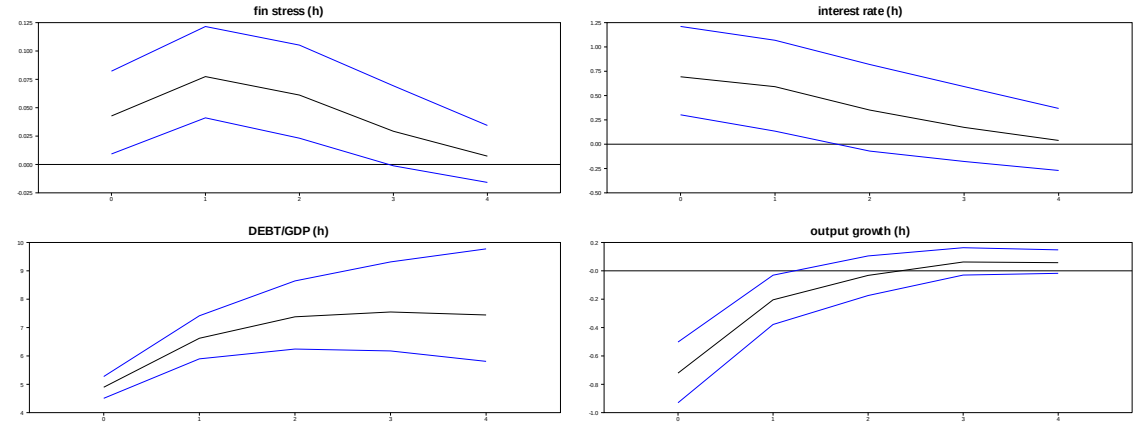
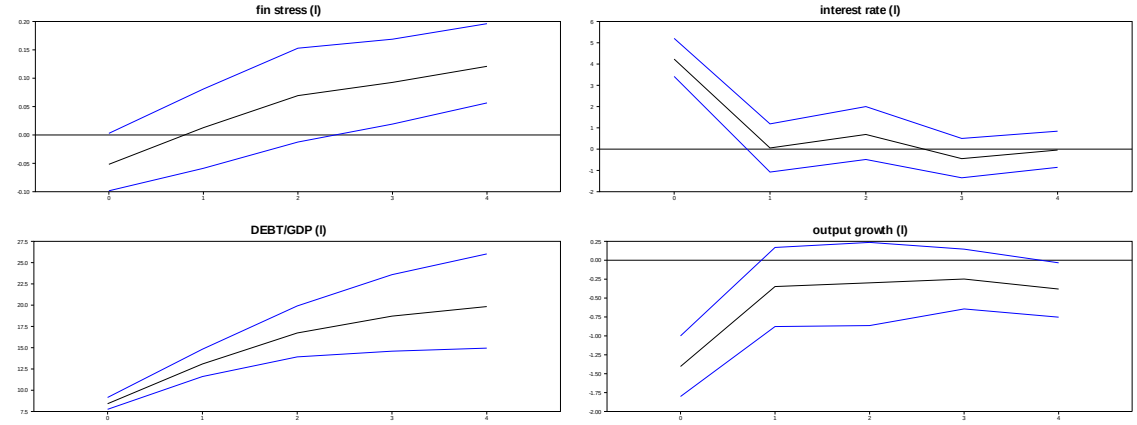


Figure 4A: Generalized Impulse Responses to Debt/GDP shocks (Pesaran and Shin 1998 methodology). High-growth regime



Responses to DEBTGDP

Figure 4B: Generalized Impulse Responses to Debt/GDP shocks (Pesaran and Shin 1998 methodology). Low-growth regime



Responses to DEBTGDP

Figure 5: Output gap (%)

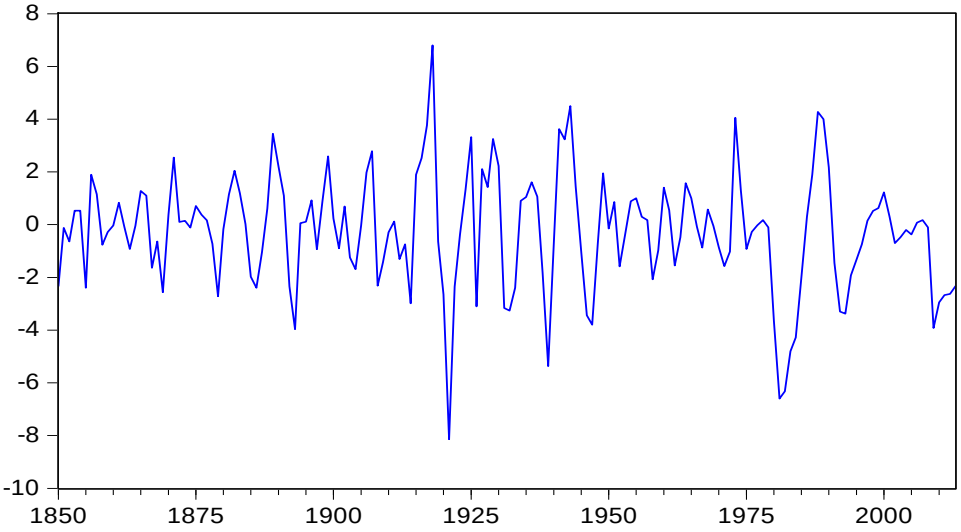
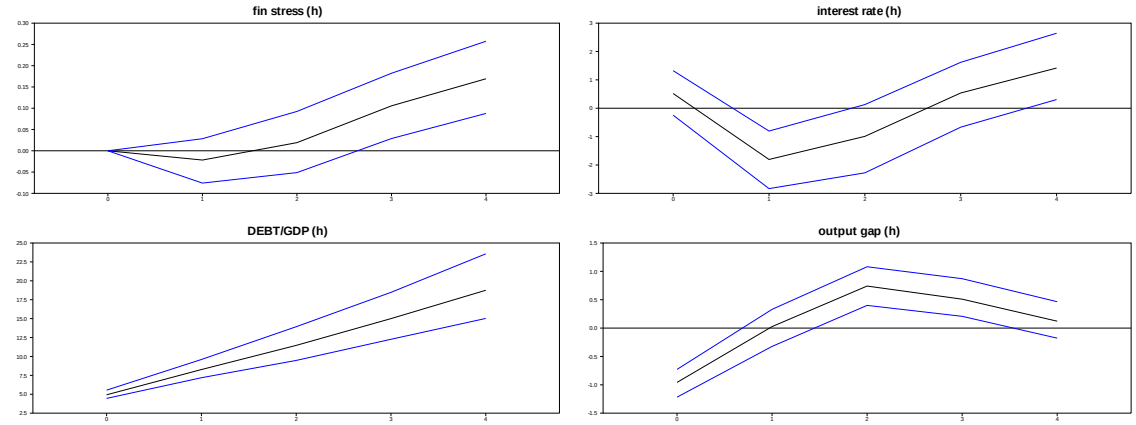
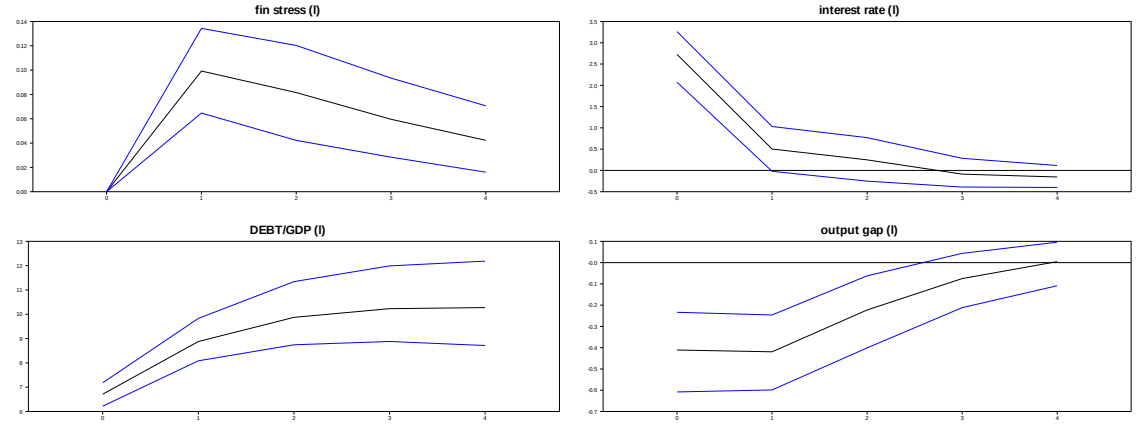


Figure 6A: Responses to Debt/GDP shocks. High output gap regime



Responses to DEBTGDP

Figure 6B: Responses to Debt/GDP shocks. Low output gap regime



Responses to DEBTGDP

Figure 7: Financial stress proxied by spread between Moody's Baa and Aaa corporate bond yield (%)

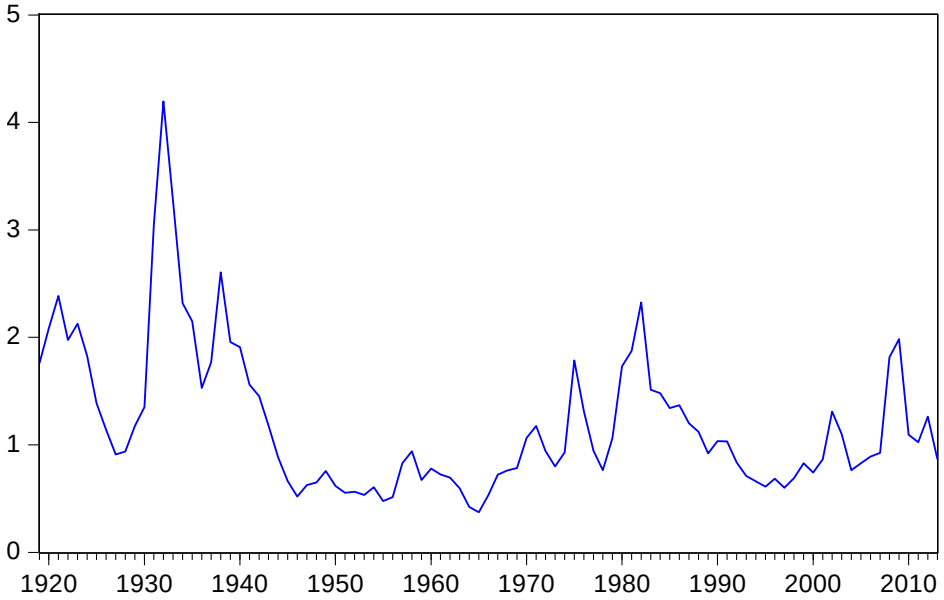
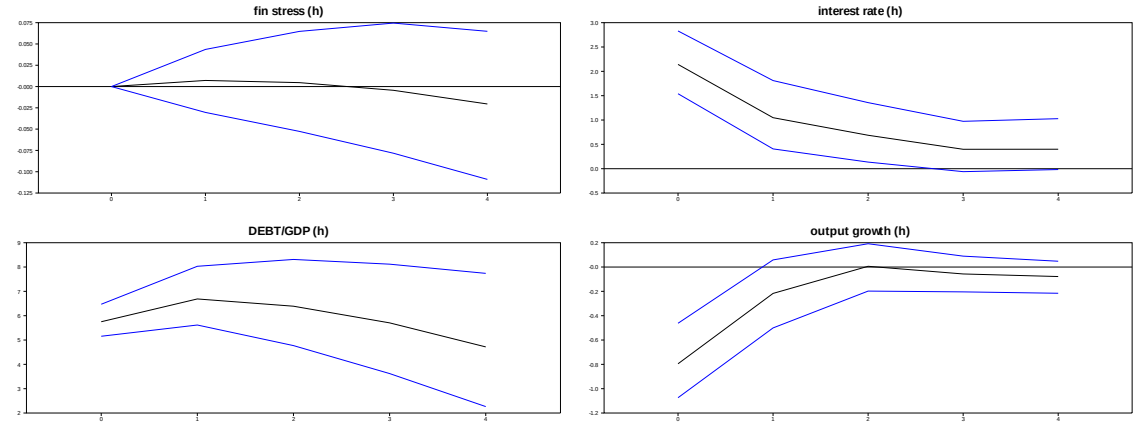
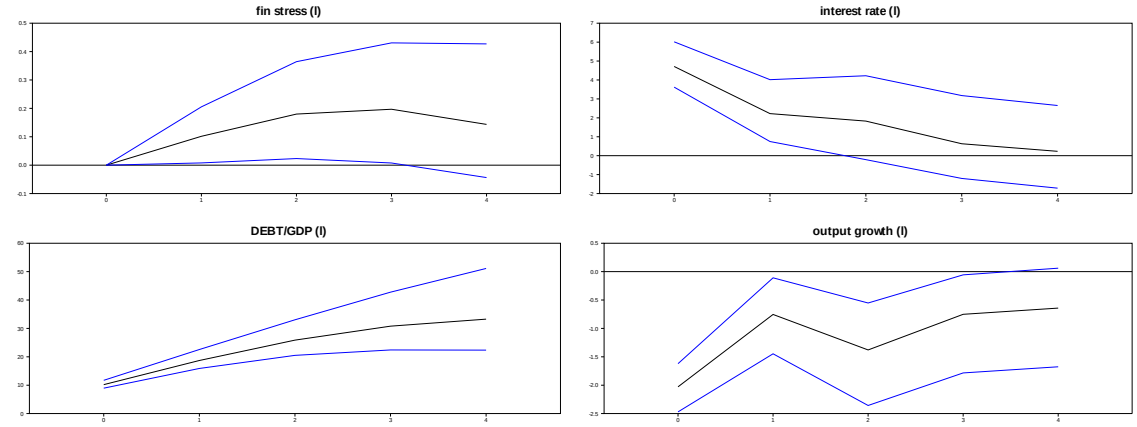


Figure 8A: Responses to Debt/GDP shocks. High-growth regime. (Financial stress proxied by spread between Moody's Baa and Aaa corporate bond yield)



Responses to DEBTGDP

Figure 8B: Responses to Debt/GDP shocks. Low-growth regime. (Financial stress proxied by spread between Moody's Baa and Aaa corporate bond yield)



Responses to DEBTGDP