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Growth in a Time of Austerity: Evidence From the UK

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GROWTH IN A TIME OF AUSTERITY: EVIDENCE FROM THE UK

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Abstract

A recent recovery in the United Kingdom comes after a program of austerity measures announced by the incoming coalition government in 2010. Can the recent pick up in economic activity be attributed to this controversial fiscal policy? This paper uses an empirical approach to test the causal relationship between debt and growth for the case of the UK using monthly time series data between 1995 and 2013. This time series perspective makes use of Granger-causality and co-integration tests that allow for non-stationarity in macroeconomic time series data. We find that controlling for structural breaks in this way leads us to the finding of no empirical support for the hypothesis that fiscal discipline can restore economic activity after a recession.

Keywords: Austerity, Growth, Fiscal Policy, Financial Crisis, Granger Causality

JEL Classification:E60, E62, N10

1. Introduction

The European sovereign debt crisis which took hold in 2010 brought an increase in uncertainty for global financial markets already unnerved by a financial crisis that had begun a couple of years earlier. A concern with the ability of governments across the Eurozone to service their public debt fuelled the acceleration of an existing pan European slump in economic activity. For the United Kingdom this global event coincided with a general election and consequently the incoming coalition government had an immediate and pressing need to calm financial markets. In order to achieve this, the freshly elected government announced a programme that has come to be known as austerity, an intent of a long term reduction in public spending as a percentage of GDP.[1]

Since this time and six years forward we have seen growth return to more normal levels in the UK, raising the question of whether or not the recent recovery can be attributed in any way to the change in fiscal discipline or whether this policy can ever be considered a suitable tool to kick-start the economy from a recession in the UK. This paper is motivated by the seminal contribution of Reinhart and Rogoff (2010) whose study has focussed a debate around the issue of fiscal discipline and rates of growth in income. Using high frequency data for the UK we

[1] See Konzelmann (2012) for an in depth discussion on concept of austerity as a measure of fiscal discipline and how this measure has transformed from being a means to achieving macroeconomic stabilisation to becoming an objective in its own right.

statistically test the proposition that there is any relation between the level of public debt and the rate of growth in gross domestic product for the case of the UK. Put another way, if there is any statistical supporting evidence for the policy of austerity measures introduced by the UK coalition government of 2010.

The influential study by Reinhart and Rogoff (2010) found a link between public debt and economic growth using evidence that suggested the existence of a debt-threshold (of 90%) at which economic growth is significantly impeded. In an environment of surging public debt and crumbling growth rates international organisations and policy-makers have found their own interpretation of studies such as this to legitimise rigorous public spending cuts during the financial crisis (Minea and Parent, 2012). The effectiveness and legitimacy of the policy of austerity has been widely discussed in both the public, economic and political arenas, the findings in Reinhart and Rogoff (2010) have also provoked an extensive discussion in the field of applied economics. Their statistical claims are not without support, in fact several other panel type studies such as Cecchetti et al. (2011), Casni et al. (2014), Baum et al. (2012) and Woo and Kumar (2010) offer fair to mixed support of the debt-to-GDP threshold hypothesis.

Contrary to this, authors such as Chang and Chiang (2012), Panizza and Presbitero (2012) and Kourtellos et al. (2013) have found positive coefficients on the relation between debt and growth, no causal link, and a similar relation that only exists in low democracy countries, respectively. The Reinhart and Rogoff (2010) study has also been challenged on technical grounds through the work of Herndon et al. (2013) who replicated the study and discovered coding errors, selective exclusion of data and unconventional weighting methods. A replication of the study with corrected data found that the effect of the 90% debt-to-GDP threshold on growth becomes neglectfully small.

Our contribution to this debate makes use of the natural austerity experiment in the UK, a time series perspective, further hindsight and higher frequency monthly macroeconomic data made available by the National Institute of Economic and Social Research (NIESR) between 1995 and 2013. For our empirical investigation we control for structural breaks using endogenous breakpoint test methods before employing an augmented Toda and Yamamoto (1995) Granger causality and Johansen et al. (2000) co-integration framework to test for a statistical causal link between the debt to GDP ratio and economic growth. Firstly we find that there is consistency across tests predicting two important break dates for the debt to GDP ratio for the UK showing severe changes in the level in 2008 and 2010. Secondly that for the full sample the tests provide strong evidence of a bidirectional relationship between the two variables when there is no control for structural breaks. In a sub sample analysis this finding is upheld for the pre crisis period but breaks down after 2009. Lastly, for the full sample, an analysis that controls for structural breaks suggests that there is no causal relationship in either direction for the two variables, a finding that confirms the importance of controlling for interventions in the testing procedure. The proceeding co-integration test also allowing for statistical intervention provides further support for the denial of causality. Accordingly we suggest that there is no evidence to support the use of changes in the debt to GDP ratio to influence economic activity and that the recent recovery in the UK may be largely due to other supply side policies or characteristic of the UK business cycle.

The rest of this paper is laid out as follows: In Section 2 we discuss the details of the regressions and methods used including a description of the data. Section 3 provides a brief discussion on the correlation comparisons between the corrected data set and our own monthly observations for the

UK Debt to GDP ratio and growth in GDP before reporting the results of the Granger-causality and co-integration tests. Section 4 concludes and provides motivation for further research in the area of a time series explanation for the recent economic growth experienced in the UK.

2. Methodology

We consider the claims made in Reinhart and Rogoff (2010) by giving a short introductory, exploratory data analysis motivated by Calhoun (2013). Similar to the discussion in Amann and Middleditch (2015), we compare different data sets of the UK with increasing frequency in order to evaluate the relationship between economic growth and public debt. For this purpose we define two debt regimes. The first one is associated with the debt threshold of a gross government debt-to-GDP ratio (also DoG from now on) of above 90% as postulated by Reinhart and Rogoff (2010). In addition to that, we also define a positive growth and a negative growth regime associated with a GDP growth rate (also PGR from now on) of +/- 0% to evaluate any changes in GDP growth rates with respect to the corresponding debt regime as well as any changes in the debt-to-GDP ratio considering the given growth regime.

Furthermore, for an especially derived monthly UK data set featuring public debt figures as well as GDP growth rates, we employ time series econometric methods to evaluate the relationship between these two variables. As the latest economic behaviour of the UK is severely affected by the financial crisis of 2007/08 and its aftermath, we put special emphasis on the consideration of structural breaks in our testing framework. In doing so, we employ various unit root tests allowing for (multiple) endogenously determined structural breaks. Furthermore, we apply a modified flexible Granger-causality testing framework allowing different orders of integration among the variables in question introduced by Toda and Yamamoto (1995, TY procedure from now on) which we augment to allow for structural breaks. In a final step, we employ the Johansen et al. (2000) cointegration test, also allowing for structural breaks.

2.1. Model discussion

In order to analyse the causal relationship of our bivariate system we first estimate an augmented VAR model to test for causality following the suggested procedure in Toda and Yamamoto (1995). We furthermore augment this method by allowing for (multiple) exogenous structural breaks following Stern and Enflo (2013) which we specify through the previously obtained results of the unit root testing framework. As for the unit root tests we employ the Augmented Dickey-Fuller Test (Dickey and Fuller, 1979, 1981, ADF test from now on), the Phillips-Perron Test (Phillips and Perron, 1986, PP test from now on) as well as the Kwiatkowski-Phillips-Schmidt-Shin Test (Kwiatkowski et al., 1992, also KPSS test from now on). Furthermore we employ the tests proposed by Zivot and Andrews (1992, also ZAUroot test from now on) and Perron (1997, PPUroot from now on) to allow for one endogenously determined structural break as well as the test proposed by Lee and Strazicich (2003) to allow for two endogenous structural breaks.[2]

More precisely we define our bivariate system as

[2]Results of all traditional ADF, PP and KPSS unit root tests are presented in tables B.5 to B.12 alongside the endogenous break point tests.

$$
\begin{aligned}
DoG_t &= \sum_{k=0}^{n}(\varsigma_k \triangle t_{k,t} + \delta_k t_{k,t}) \\
&+ \sum_{i=1}^{p} \alpha_{1,i} DoG_{t-i} + \sum_{j=p+1}^{p+m} \alpha_{2,j} DoG_{t-j} \\
&+ \sum_{i=1}^{p} \gamma_{1,i} PGR_{t-i} + \sum_{j=p+1}^{p+m} \gamma_{2,j} PGR_{t-j} + \varepsilon_{1,t} \\
PGR_t &= \sum_{k=0}^{n}(\varsigma_k \triangle t_{k,t} + \delta_k t_{k,t}) \\
&+ \sum_{i=1}^{p} \beta_{1,i} PGR_{t-i} + \sum_{j=p+1}^{p+m} \beta_{2,j} PGR_{t-j} \\
&+ \sum_{i=1}^{p} \delta_{1,i} DoG_{t-i} + \sum_{j=p+1}^{p+m} \delta_{2,j} DoG_{t-j} + \varepsilon_{2,t},
\end{aligned}
\tag{1}
$$

where $\alpha, \beta, \gamma, \delta$ are the coefficients of the system to be estimated for the variables *DoG* and *PGR* respectively. Furthermore, p denotes the lag length selected through the lag length criteria test plus additional lags added afterwards to eliminate any autocorrelation in the residuals and m corresponds to the maximum order of integration of the processes for each individual series. Furthermore, n denotes the number of structural breaks allowed for in the data and $\triangle$ is the first-difference operator. Expanding the sum, t_0 is a simple linear trend and $\triangle\ t_0$ equals a constant term corresponding to α_0/β_0 in Equation (1) . For $k > 0$, $\triangle t_k$ is equal to a vector containing zeros up to and including the break point period $t*$, and unity afterwards. Consequently, t_k is equal to zero up to and including the break point period and increasing in unit steps afterwards.[3]

We test H_0 of non-Granger-causality of PGR_t on DoG_t using

$$H_0 : \gamma_{1,i} = 0 \ \forall \ i = 1, ..., p$$

where γ_i are the p lagged coefficients of *PGR* in Equation (1) and m is the number of additional lags added to the system as specified in Table B.4 as well as the structural break component. The test for non-causality of DoG_t on PGR_t is calculated in a similar fashion. The exogenous coefficients $\gamma_{2,j}$ and $\delta_{2,j}$ for $j = p + 1, ..., p + m$ are not considered for this purpose. As for the cointegration testing framework, we implement a cointegration test allowing for structural breaks following the $Hl(r)$ test in Johansen et al. (2000) and follow the discussion in Giles (2011) and Joyeux (2001). Similarly to the TY procedure allowing for structural breaks, we define the same VAR(p) system as before and, in addition, the two variables

[3]We conducted these tests with and without allowing for a long-term trend in the above specification.

$$i_{2,t} = \begin{cases} 1 & \text{if } t = t^* + 1 \\ 0 & \text{else} \end{cases} \quad \text{and} \quad d_{2,t} = \begin{cases} 0 & \text{if } t \leq t^* \\ 1 & \text{if } t \geq t^* \end{cases} \tag{2}$$

where t^* denotes the break point period for $t = 1, ..., T$. For the cointegration test allowing for one structural break, we include (i) a linear trend c, (ii) $d_{2,t-k}$ where k is designated the maximum lag length, (iii) an interaction term $c \times d_{2,t-k}$ as well as (iv) $i_{2,t-l}$ where $l = \{0, 1, ..., k-1\}$ with k defined as above as exogenous variables to the system. For the cointegration test allowing for two structural breaks, the same dummy variables as above were defined, however, instead of only one break point t^*, two break points, t_1^* and t_2^* were used to define the newly generated set of dummy variables appropriately. For hypothesis testing, the critical values are derived as discussed by Giles (2011) which depend on the position of the previously defined exogenous break point(s).

2.2. *The Data*

We make use of two different data sets. We use a corrected data set of the Reinhart and Rogoff (2010) study provided by Herndon et al. (2013).[4] Additionally, we employ a more recent monthly data set for the period of 1995M01 to 2013M12. For monthly GDP growth rates for the UK, an estimated monthly GDP index provided by the National Institute of Economic and Social Research (NIESR) and following the methodology described in Mitchell et al. (2005) was used to calculate GDP growth rates. For monthly data on public debt, *Public Sector Net Debt* (PSND) published by the Office of National Statistics (ONS) is used.[5]

3. Empirical Results

Figure 1 plots the debt-to-GDP ratio vs the GDP growth rate in percent for the UK and considers the corrected Reinhart and Rogoff (2010) data set (red) as well as the monthly data set derived for this paper (blue). The horizontal line reflects the 90% debt threshold level and the vertical line corresponds to a 'recession line' at a GDP growth level of 0%. Following the line of argument in Reinhart and Rogoff (2010) with public debt over 90% severely affecting growth figures negatively, we would expect to find a higher density of data points in the upper left and lower right quadrant of Figure 1. However, upon inspection, Figure 1 reveals everything but a clear-cut relation: It becomes apparent that there seems to exist a time-dependent rather than debt-level dependent relation for the UK: For the earlier periods in the Reinhart and Rogoff (2010) data, higher DoG as well as GDP growth rates can be observed. For later periods, we generally observe lower debt levels and a lower debt-to-GDP ratio.

Furthermore, the blue dots in Figure 1 closely depict the unfolding of the financial crisis of 2007/08 and seemingly follow a reverse path compared to the Reinhart and Rogoff (2010) data set: Relatively low debt levels and moderate growth rates characterising the late 1990s to mid-2000s were followed by a remarkable setback of GDP growth rates and, subsequently, a rise in the gross

[4] *R* code and data for Herndon et al. (2013) is provided at `http://www.peri.umass.edu/fileadmin/pdf/working_papers/working_papers_301-350/HAP-RR-GITD-code.zip`.

[5] More details on the derivation of the data set is provided in Appendix A.

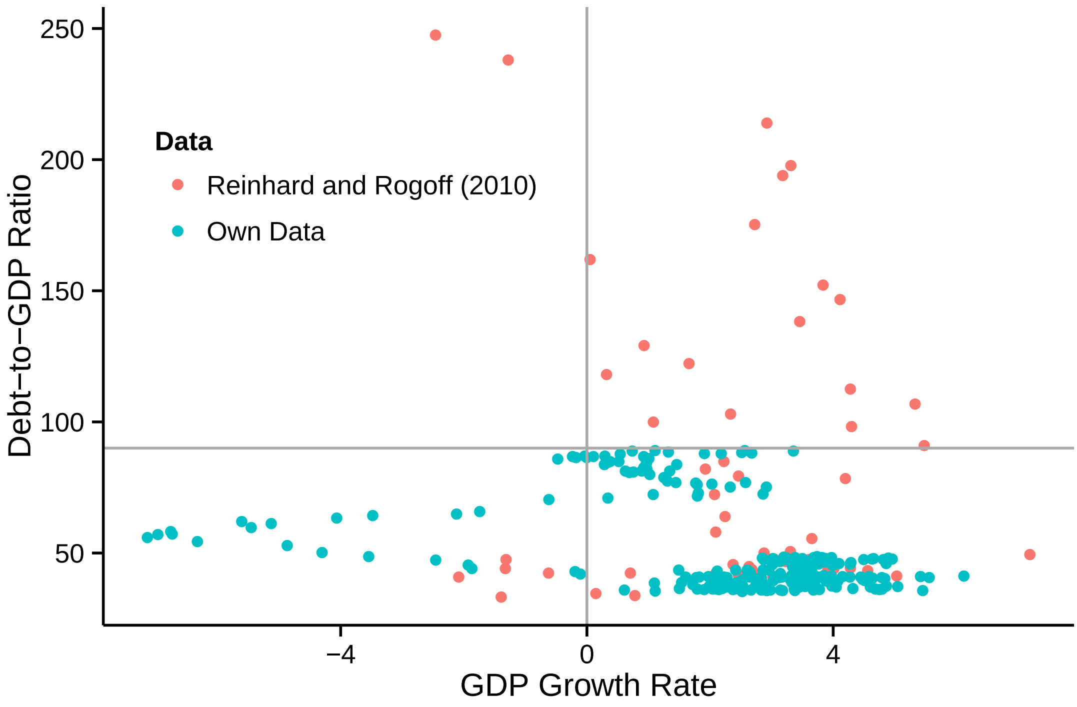

Figure 1: Correlation between DoG and PGR

debt level. Comparing both data sets in Figure 1 it appears that even though the financial crisis is to be marked as an exceptional event, the aftermath of the crisis cannot be equally described as particularly noteworthy: For the same level of debt of slightly below 100%, both data sets report similar growth rates yet corresponding to different periods. Consequently, as the above explanatory analysis shows, it was not the high level of public debt that brought GDP growth to a decline, it was the financial crisis that triggered changes in both macro variables and led to a significant increase in DoG. Therefore, if indeed a negative threshold link between gross debt and GDP as postulated in Reinhart and Rogoff (2010) existed, in case of the UK which experienced a level shift in gross debt to slightly above 90% due to the crisis, the present high debt level should have a more negative effect on GDP growth as at the pre-crisis level of DoG. That is, one would not expect GDP growth to return to a similar rate as before the crisis. In the light of the above, we now investigate the link between DoG and PGR by means of time series tools of analysis. In order to do so, a monthly data series spanning 1995M01 to 2013M12 is used to closely analyse the possibility of causality links between the variables in question.

Figure 2 plots the monthly debt-to-GDP ratio as well as the monthly GDP growth rate against time. In both series the impact of the financial crisis 2007/08 can be seen very clearly. Whereas the GDP growth rate experiences a sharp setback with quick recovery afterwards, the debt-to-GDP ratio was subject to a severe shift in levels due to the crisis.

This description of the data is backed by empirical evidence. When undertaking a structural

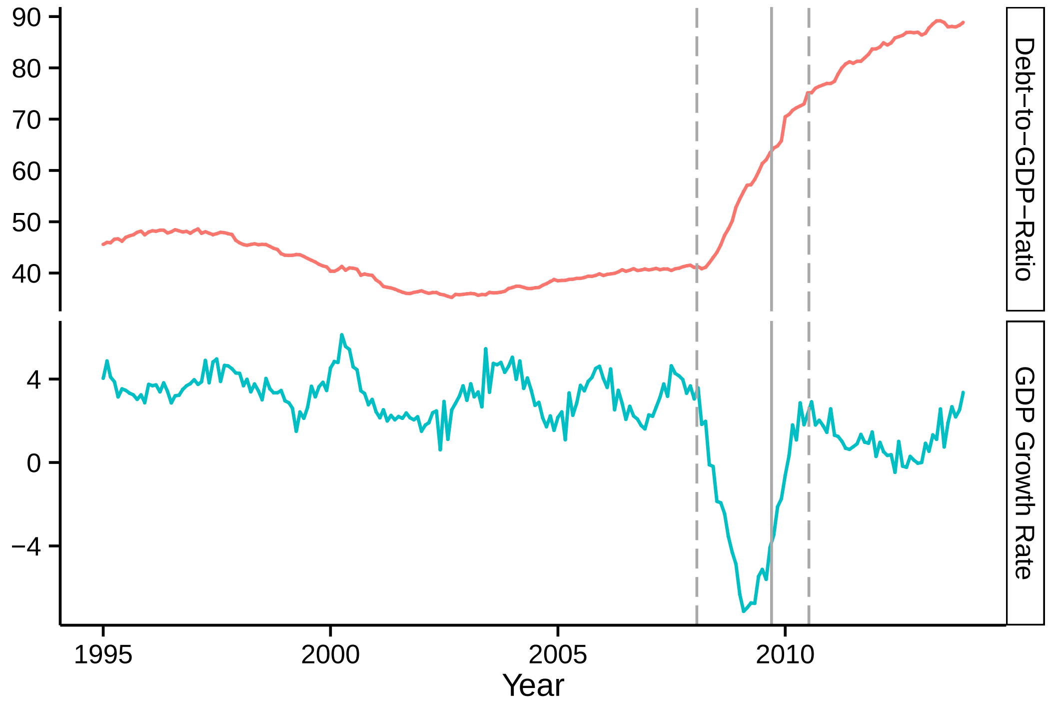

Figure 2: Debt-to-GDP Ratio and GDP Growth Rate Versus Time

break analysis, break points are derived which correspond to the vertical lines in Figure 2 and are also presented in Table B.3. 2009M07 is identified as the strongest break date for the variable DoG allowing for only one break. This is of no surprise, as this date reflects the 'mid-point' of the considerable increase in government gross debt materialising through the financial crisis. For the variable PGR and allowing for two break points, the dates 2008M03 and 2010M03 are selected.[6] These selected breaks make economic sense as they flag the beginning and the end of the financial crisis with growth rates recovering after a severe slump in 2009.

To begin with the time series analysis, both series are analysed neglecting the possibility of structural breaks in either series. This is done in order to point out the differences in results when (not) taking structural breaks into account. In the next step, tests proposed by Perron (1997) as well as Zivot and Andrews (1992) allowing for one endogenous break, are undertaken. Lastly, given the characteristics of both series as described before and the results of the break point regression analysis, an additional unit root test is applied to either series that allows for two endogenously determined structural breaks, the Lee and Strazicich (2003) test. Results for this test are summarized in tables B.5 to B.12. What we conclude from this extensive unit root test exercise is that structural breaks indeed play a crucial role in analysing the data set at hand and not accounting for them

[6]The second break point of the PGR series was initially found at 2011M01. However, through investigating Figure 2, it was decided to shift the second break date to 2010M03 as this identifies the financial crisis of 2007/08 more accurately.

can seriously affect the results of any further analysis: Using various unit root test procedures, it becomes apparent that the structural breaks in both series are an immediate consequence of the financial crisis. Given the results of all three unit root tests with structural breaks, both series are most likely to be integrated of order one with (a) structural break(s).

As a consequence, depending on the results reported for each sample, different test procedures are considered for all further analysis which is summarised in Table B.4. As a robustness check, the same analysis of two different groups of sub-samples was undertaken. Building on the break point regression results in Table B.3, these are defined according to the empirically determined break point of variable DoG allowing for one break point (the corresponding sub-samples are called pre- and post-crisisI and split the sample in 2009M07) and PGR allowing for two break points (pre- and post-crisisII spanning 1995M01 to 2008M03 and 2010M03 to 2013M12 respectively). Concerning the timing of these breaks, we show that the endogenously determined break points are selected quite consistently around the time of the financial crisis and also reflect the nature of both series. Therefore, for any further analysis, special emphasis has to be put on the correct incorporation of these structural breaks.[7]

3.1. Testing for Granger-Causality in the Presence of Unit Root Processes and Structural Breaks

In the presence of nonstationarity and a possible cointegrating relationship among variables, the causality test proposed in Granger (1969) is inadequate. Given this and because our analysis puts special emphasis on the inclusion of structural breaks, we employ a modified flexible Granger-causality testing framework allowing for structural breaks and different orders of integration among the variables in question. This methodology was first introduced by Toda and Yamamoto (1995), and we augment this procedure by allowing for (multiple) exogenous structural breaks following the approach presented in Stern and Enflo (2013).

We apply the standard Toda and Yamamoto (1995) procedure to all sample periods (both subsamples as well as the full sample). Furthermore, in order to analyse the entire sample more thoroughly, an augmentation of the TY procedure following Stern and Enflo (2013) with break points in 2009M07 as well as 2008M03 and 2010M03 are proposed and implemented.

For each test, the assumed order of m can be verified in the last column of Table 1. For cases where no definite conclusion on the order of integration of the variables could be reached, different values for the maximum order of integration were used to cross-validate the results. However, these allowances change neither the direction nor the statistical evidence presented in Table 1. Scenarios where the maximal order of integration was subject to uncertainty are denoted $\bullet$ and $\circ$ as elaborated in Table 1 or Table B.4.

3.1.1. Results of the Toda and Yamamoto (1995) Procedure

When examining the Granger-causality between the GDP growth rate and the level of gross government debt for the full sample, a statistically significant causal relationship for these two

[7] Unit root model specification as well as the autocorrelation of the residuals were tested and the lag length automatically selected using the Schwarz Information Criterion for the ADF test. For the KPSS and PP tests, the spectral estimation was conducted using the default Bartlett kernel with the automatic bandwidth selection through the Newey-West estimator.

variables is found. Put differently, we find that in both cases past values of the other variable can statistically explain the other variable. In fact, for the full sample not allowing for any breaks in either series, the null hypothesis that DoG does not Granger-cause changes in PGR is rejected at the 1% level of significance. The same is true for the hypothesis that PGR does not Granger-cause DoG, thereby confirming a bidirectional relation. This also holds true if one allows for a structural break in 2009M07. Again, both null hypotheses of non-Granger-causality are rejected at the 1% level. For the case of two breaks, however, a rather different picture can be drawn which makes it worth considering the sub-sample analysis first.

Concerning the question whether the relationship between both variables in question has changed due to the financial crisis, the previously reported bidirectional causation remains statistically significant for the pre-crisisI period. Here, again H_0 of DoG not-Granger-causing PGR is rejected at the 1% level and the hypothesis PGR not-Granger-causing DoG at the 10% level. Nonetheless, when looking at the second sub-sample, an interesting pattern emerges. The statistically strong evidence of bidirectional causation in the full sample cannot be confirmed for sub-sampleII. In other words, when accounting for the financial crisis and its immediate aftermath, there is no statistical evidence of any Granger-causality in either direction. This evidence is strongly supported by what is found by including two breaks for 2008M03 and 2010M03 and investigating the full sample from 1995M01 to 2013M12. For this test set-up, no Granger-causality link in either direction can be reported. The interesting result that can be gathered from this is that, if controlling for the financial crisis, a neutral relationship between both variables is reported through the TY procedure.[8]

We argue that the direction of Granger-causality strongly depends on the time period(s) looked at and the way the financial crisis is dealt with. Not accounting for the fact that the crisis struck both series differently, an incorrect pattern of causality may be invoked. This becomes quite clear when comparing both sub-samples. In sub-sampleI the immediate effects of the crisis were simply 'split' and inherited by the corresponding sub-samples. It is interesting to see, that for the pre-crisisI but not the post-crisisI period, the same causality links as for the full sample with none/one breaks could be reported. Yet, sub-sampleII which neglects the slump-and-recovery path of PGR as well as the level-shift in DoG, fails to provide similar causality links. That means that, excluding 24 observations which correspond to the financial crisis and its immediate aftermath, the strong case of a bidirectional Granger-causality link becomes statistically insignificant.

3.2. Cointegration in the Presence of Structural Breaks

We compare the findings of the Johansen's cointegration test when allowing for no/one/two structural breaks. The motivation for this stems from the borderline rejection of non-stationarity for PGR when testing for unit roots with one and two structural breaks in level in order to see if

[8]Furthermore, the structural change augmentation as proposed by Stern and Enflo (2013) includes a long-term time trend. In order to check the robustness of the results, all tests including structural breaks were conducted with and without this long-term trend variable. However, none of the adoptions either changed the direction or significance of the results. The same is true for varying the maximum order of integration, m: For all observed samples, both direction and significance compared to the results presented in Table 1 remain unchanged.

Table 1: Results of Granger-Causality Tests Following the TY Procedure

Full Sample, ...	DoG ⇒ PGR		PGR ⇒ DoG		Proposed value for m
...no breaks in either series	0.0218	*	0.0019	*	2
... one break in each series	0.0261	*	0.0077	*	1
... two breaks in each series	0.3415		0.1613		1
Sub-sample, ...					
... split in 2009M07					
pre-crisisI	0.016	*	0.082	o	2
post-crisisII	0.587		0.581		2•
.. split in 2008M03 and 2010M03					
pre-crisisII	0.914		0.884		1
post-crisisII	0.544		0.872		1•

Notes: The table reports p-values of the Wald test. Arrows denote the direction of Granger-causality. The levels of significance are denoted o,+ and * for the 10%, 5% and 1% level respectively. Scenarios where the maximum order of integration was subject to uncertainty with $m = \{1, 2\}$ are denoted •.

the results of the TY procedure can be confirmed when assuming that PGR is I(1) with breaks. The cointegration test without structural breaks is added to this set of tests to compare and cross-validate all results and follows Giles (2011) who argues that erroneously neglecting actual structural breaks in a cointegration analysis may produce misleading results.

Therefore, the cointegrating analysis presented in the forthcoming paragraphs is undertaken for the full data sample spanning 1995M01 to 2013M12 with, firstly, no structural break (in this standard case the cointegration test follows the procedure outlined in Johansen (1991, 1995)),secondly, one structural break in 2009M07 as well as, thirdly, two structural breaks in 2008M03 and 2010M03 which mark the corner stones of the financial crisis in both series. It has to be pointed out that in order to correctly undergo a cointegration analysis when not allowing for any structural breaks, a different approach would have to be used. This is because ADF, PP as well as KPSS tests consistently find DoG to be I(2) and PGR to be I(1). Therefore, if these results were assumed to be correct, one would have to implement a cointegration analysis allowing for these data features.[9] Yet, as further unit root tests have shown that both series can be assumed to be I(1) with (a) break(s), this approach is dismissed. Rather, the forthcoming analysis investigates what happens if one fails to consider the presence of structural breaks altogether. Both cointegration tests allowing structural breaks follow Johansen et al. (2000).

[9] See *exempli gratia* Kurita (2013) or Nielsen (2001).

With respect to the deterministic component of the system, it was defined to allow for a trend in both the VAR as well as the cointegration as we are explicitly interested in any trend associated with the relationship between both variables.

The cointegration test allowing for structural breaks is referred to as the $Hl(r)$ test in Johansen et al. (2000). In such a test scenario, the asymptotic distribution of the test is different compared to the critical values of the trace test and takes into account the position of break point(s) in the sample as well as the number of variables and the cointegrating rank to be tested (Johansen et al., 2000; Giles, 2011).

The results of the different cointegration tests are presented in Table 2. As can be seen there, if one does not allow for a structural break when testing for cointegrating relationships, Johansen's test finds very strong evidence of such a relationship between both variables: The null hypothesis of no cointegrating relationship between both variables is rejected at a 1% level of significance. More precisely, the trace statistic in Table 2 indicates the presence of one cointegrating vector. This result confirms the findings of the TY procedure which concluded that a bivariate causality between both variables at the 5% level is given. However, when allowing for one structural break in 2009M07, it can be seen that, even though the presence of a cointegrating relationship between both variables is confirmed; the trace statistic is very close to the 5% critical value. Once more, these results are in line with the findings in Table 1. More interestingly, however, and again in line with previous findings, when allowing for two structural breaks in 2008M03 and 2010M03, the Johansen cointegration test fails to reject H_0 of no cointegrating relationships between both series at the 5% interval. Again, this is confirmed through the results of the TY procedure with two structural breaks.

Table 2: Results Cointegration Test

No. of Breaks	Hypothesized No. of CE(s)	Trace Statistic	5% Critical Value
None	None	52.359	25.872+
	At most 1	5.729	12.518
One	None	38.070	35.022+
	At most 1	9.163	17.684
Two	None	39.020	41.757
	At most 1	5.667	21.512

Notes: The table reports the trace statistic of the Johansen (1991, 1995) as well as the Johansen et al. (2000) cointegration tests. The levels of significance are denoted + for the 5% level respectively.

These results are very encouraging. Not accounting for structural breaks in the cointegration testing framework may result in useless and incorrect results. We believe that this is the correct point to stop the analysis as for both cases where a cointegrating relationship was reported, there is strong empirical evidence for the claim that this relationship is solely due to not having accounted for the financial crisis.

We conclude that when properly controlling for the financial crisis through endogenously determined break points from various analysis tools, no empirical evidence of a causality relation between the gross debt level and the GDP growth rate can be reported through either a Granger-causality test following Toda and Yamamoto (1995) or cointegration tests allowing for structural breaks.

4. Conclusion

In this paper we have tested for a statistical causal link between public debt and growth for the UK between 1995 and 2013. In doing so, we utilise a Granger-causality and co-integration test that allows us to control for structural breaks caused by the seismic shocks that appear in the most recent time series data. Our contribution to this popular debate on fiscal discipline is to specifically test the case of the UK motivated by the coalition government's 2010 announcement to follow a policy of austerity measures. This controversial policy has been the focus of a fierce debate centred around the seminal contribution of Reinhart and Rogoff (2010) that higher levels of debt impede economic activity. This study contributes by offering a time series perspective on austerity that makes use of monthly time series data for the UK, an approach that allows us to capture the intra quarterly fluctuations displayed by the widely available monthly time series for UK government debt.

We find that, through a preliminary investigation of the corrected Reinhart and Rogoff (2010) data set, there is little support for the hypothesis that higher debt regimes have a negative impact on growth and that the time series perspective suggests there is in fact a reverse causality that higher debt is caused by episodes of economic slumps. Using monthly time series data for growth in GDP and the debt to GDP ratio for the UK we find two structural breaks that mark the beginning and end of the financial crisis. Furthermore, we test both series using a Granger-causality Toda and Yamamoto (1995) test and a Johansen et al. (2000) cointegration test and find that for the case of the UK there is no evidence of a causal relation of the two variables in either direction only when one correctly accounts for these recent structural breaks in the data and the financial crisis.

Our results suggest that a failure to control for these interventions could result in the misleading implication that fiscal discipline can assist an economic recovery. Our findings are consistent with Puente-Ajovín and Sanso-Navarro (2015) on austerity measures who find little support for this policy as a growth regenerator. We suggest instead that the recent recovery may have been assisted by other supply side measures taken by the coalition or by the natural forces of the UK specific business cycle. In future research it might be interesting to look further at how other macroeconomic time series, constructed or otherwise, can contribute to the explanation of the short run dynamics displayed by the UK business cycle if the debt to GDP ratio is discounted. One avenue of research might be to show how country specific economic volatility measures can contribute towards or influence the short run movements in the economy, and although this is on our research agenda we hope to encourage participation in the area of the time series measurement of macroprudential policy.

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Appendix A. Data Manipulation

Derivation of Monthly Debt-to-GDP Ratio. Quarterly gross debt as well as quarterly and monthly PSND data is freely available online. For the gross government debt ratio, *general government total gross debt in percent of GDP at current prices* from the Quarterly Public Sector Debt data from OECD.StatExtracts set is used. [10] Public Sector Net Debt on a monthly/quarterly basis as a % of monthly/quarterly GDP is provided by ONS.[11]

In order to generate a monthly gross debt measure, in a first step, the difference between the quarterly OECD gross debt measure and the quarterly PSND measure by ONS was extracted. In a next step, this difference is then disaggregated from quarterly to monthly data using the Chow-Lin method for interpolation. The newly derived monthly difference is added to the monthly PSND series to generate a close approximation of a monthly gross debt measure which, in a last step, is seasonally adjusted using the Census X-13 seasonal adjustment programme developed by the United States Census Bureau. Figure A.3 below compares the approximated, monthly DoG series with the quarterly OECD gross debt measure.

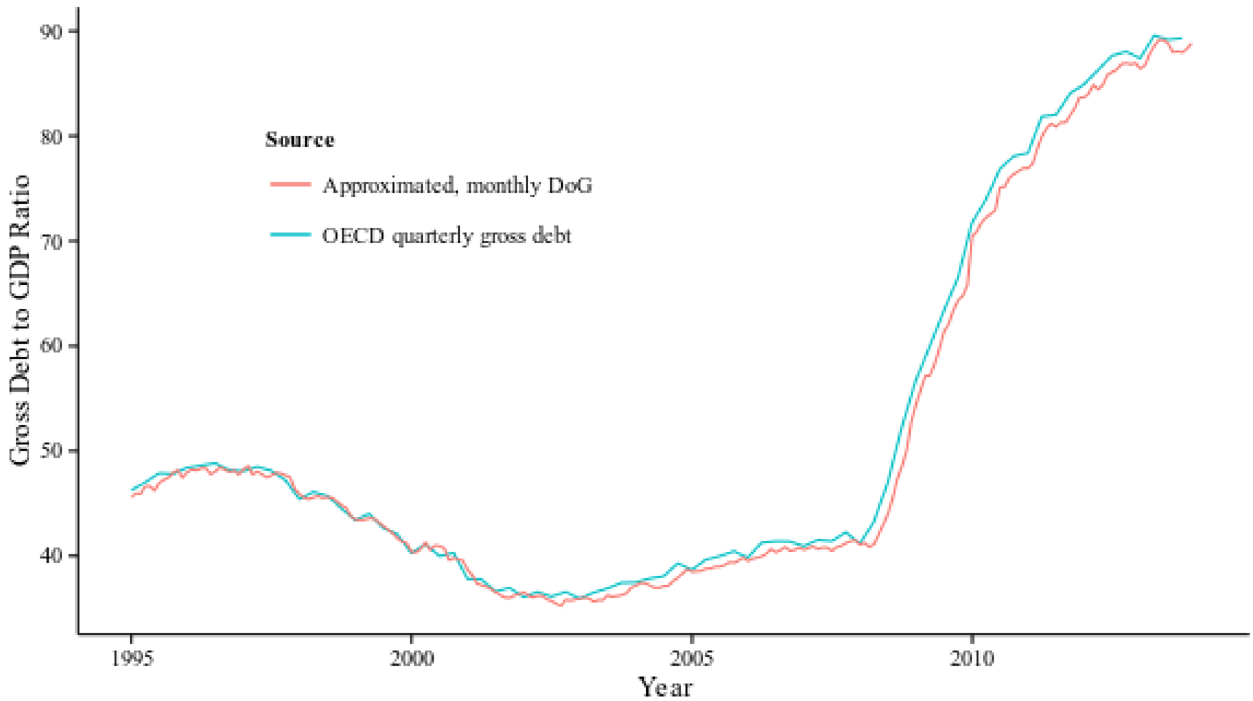

Figure A.3: Comparison of OECD quarterly gross debt-to-GDP ratio *vis-a-vis* the approximated monthly measure.

[10] See http://stats.oecd.org/Index.aspx?DataSetCode=QASA_TABLE7PSD.

[11] See http://www.ons.gov.uk/ons/datasets-and-tables/downloads/csv.csv?dataset=pusf.

Appendix B. Tables

Table B.3: Results Break Point Regression

Max. Number of Allowed Breaks	DoG	PGR
1	2009M07	2008M05
2	2008M12 2010M10	2008M03 2010M03

Table B.4: Summary of Testing Procedures

Full Sample, ...	Unit Root Tests	Results	Further analysis
...no breaks in either series	standard ADF, PP and KPSS tests	DoG is I(2) PGR is (1)	TY p.
...one break in each series	PPUroot and ZAUroot test	DoG is I(1) PGR is I(1)◦	Cointegration analysis with structural breaks and TY p.
...two breaks in each series	Lee and Strazicich(2003): Minimum LM Unit Root Test with two structural breaks	DoG is I(1) PGR is I(1)◦	Cointegration analysis with structural breaks and TY p

Sub-samples, ... split in 2009M07:			
pre-crisis I	standard ADF, PP and KPSS tests	DoG is I(2) PGR is I(1)	TY p.
post-crisis I		DoG is I(1) PGR is I(2)•	TY p.
... split in 2008M03 and 2010M03			
pre-crisis II	standard ADF, PP and KPSS tests	DoG is I(1) PGR is I(0)	TY p. as
post-crisis II		DoG is I(1)• PGR is I(1)•	TY p. as

Notes: Results where no definite conclusion on the order of integration was derived are designated • or ◦ in the above table if $m = \{0, 1\}$ or $m = \{1, 2\}$ respectively.

Table B.5: Results of Traditional Unit Root Tests, Full Sample

		DoG			PGR		
		Levels	1st diff	2nd diff	Levels	1st diff	2nd diff
ADF Test	Intercept & Trend	-1.70	-2.74	-13.87 *	-3.07	-6.54 *	-
	Intercept	-0.51	-2.25	-13.91 *	-1.93	-6.54 *	-
	None	0.58	-2.11 +	-13.94 *	-1.51	-6.54 *	-
PP Test	Intercept & Trend	-0.40	-11.33 *	-	-3.13	-21.26 *	-
	Intercept	1.54	-10.30 *	-	-2.79 o	-21.27 *	-
	None	2.50	-10.01 *	-	-2.03 +	-21.30 *	-
KPSS Test	Intercept & Trend	0.47 *	0.16 +	0.06	0.08	-	-
	Intercept	1.14 *	0.93 *	0.07	0.78 *	0.05	-

Notes: Table contains t-Stats (ADF and PP Test) and LM-Stats (KPSS Test). Significant results on the 1%, 5% and 10% level of significance designated *, + and o respectively. Values are rounded.

Table B.6: Results of Traditional Unit Root Tests, Pre-crisisI Period

		DoG			PGR		
		Levels	1st diff	2nd diff	Levels	1st diff	2nd diff
ADF Test	Intercept & Trend	3.98	-2.01	-10.17 *	-2.17	-5.18 *	-
	Intercept	-0.64	-0.933	-9.98 *	-1.30	-5.06 *	-
	None	0.70	-0.82	-9.99 *	-1.22	-5.00 *	-
PP Test	Intercept & Trend	3.79	-8.14 *	-	-1.65	-19.22 *	-
	Intercept	0.89	-7.13 *	-	-0.81	-19.03 *	-
	None	1.06	-6.82 *	-	-1.23	-18.93 *	-
KPSS Test	Intercept & Trend	0.36 *	0.23 *	0.07	0.16 +	0.08	-
	Intercept	0.43 +	0.72 *	0.23	0.58 +	0.20	-

Notes: Table contains t-Stats (ADF and PP Test) and LM-Stats (KPSS Test). Significant results on the 1%, 5% and 10% level of significance designated *, + and o respectively. Values are rounded.

Table B.7: Results of Traditional Unit Root Tests, Post-crisisI Period

		DoG			PGR		
		Levels	1st diff	2nd diff	Levels	1st diff	2nd diff
ADF Test	Intercept & Trend	-1.92	-7.26 *	-	-3.01	-1.73	-9.37 *
	Intercept	-3.85 *	-	-	-2.84 o	-1.91	-9.40 *
	None	4.31	-1.66 o	-7.67 *	-2.33 +	-1.83 o	-9.48 *
PP Test	Intercept & Trend	-2.14	-7.96 *	-	-2.86	-10.22 *	-
	Intercept	-6.95 *	-	-	-3.10 +	-10.06 *	-
	None	3.50	-4.76 *	-	-2.40 +	-9.76 *	-
KPSS Test	Intercept & Trend	0.24 *	0.11	-	0.12 o	0.19 x	0.07
	Intercept	0.94 *	0.71 +	0.23	0.24	0.26	-

Notes: Table contains t-Stats (ADF and PP Test) and LM-Stats (KPSS Test). Significant results on the 1%, 5% and 10% level of significance designated *, + and o respectively. Values are rounded.

Table B.8: Results of Traditional Unit Root Tests, Pre-crisisII Period

		DoG			PGR		
		Levels	1st diff	2nd diff	Levels	1st diff	2nd diff
ADF Test	Intercept & Trend	0.11	-11.26 *	-	-4.65 *	-	-
	Intercept	-0.98	-11.11 *	-	-4.38 *	-	-
	None	-1.19	-11.06 *	-	-1.20	-5.61 *	-
PP Test	Intercept & Trend	-0.26	-11.54 *	-	-5.36 *	-	-
	Intercept	-1.04	-11.48 *	-	-21.30 *	-	-
	None	-0.91	-11.46 *	-	-21.41 *	-	-
KPSS Test	Intercept & Trend	0.33 *	0.28 *	0.07	0.05	0.03	-
	Intercept	0.98 *	0.44 o	0.07	0.19	0.03	-

Notes: Table contains t-Stats (ADF and PP Test) and LM-Stats (KPSS Test). Significant results on the 1%, 5% and 10% level of significance designated *, + and o respectively. Values are rounded.

Table B.9: Results of Traditional Unit Root Tests, Post-crisisII Period

		DoG						PGR					
		Levels		1st diff		2nd diff		Levels		1st diff		2nd diff	
ADF Test	Intercept & Trend	-1.20		-3.80	+	-8.16	*	-2.20		-2.61		-8.98	*
	Intercept	-2.78	o	-5.49	*	-		-2.38		-2.87	+	-8.70	
	None	4.67		-2.65	*	-		-1.15		-2.30	*	-	
PP Test	Intercept & Trend	-1.08		-8.18	*	-		-3.18		-11.92	*	-	
	Intercept	-4.48	*	-		-		-3.21	+	-11.94	*	-	
	None	4.01		-4.03	*	-		-0.60		-11.87	*	-	
KPSS Test	Intercept & Trend	0.23	*	0.15	*	0.14	*	0.19	+	0.14	o	0.07	
	Intercept	0.85	*	0.52	+	0.15		0.22		0.18		0.01	

Notes: Table contains t-Stats (ADF and PP Test) and LM-Stats (KPSS Test). Significant results on the 1%, 5% and 10% level of significance designated *, + and o respectively. Values are rounded.

Table B.10: Results of Perron (1997) Unit Root Tests

		Break in Intercept		Break in Intercept and Trend	
		t-Stat	Break Point	t-Stat	Break Point
DoG	Levels	-5.958*	2008M04	-3.353	2004M12
	1st diff	-6.738*	2010M01	-8.766*	2008M04
PGR	Levels	-6.054*	2007M08	-7.832*	2008M02
	1st diff	-6.122*	2009M02	-6.205*	2009M02

Notes: Table contains t-Statistic of both tests and the endogenously chosen break point. Significant results on the 1%, 5% and 10% level of significance designated *, + and o respectively. Values are rounded.

Table B.11: Results of Zivot and Andrews (1992) Unit Root Tests

		Break in Intercept		Break in Intercept and Trend	
		t-Stat	Break Point	t-Stat	Break Point
DoG	Levels	-5.972*	2008M05	-3.318	2005M01
	1st diff	-6.214*	2008M04	-8.832*	2008M05
PGR	Levels	-5.457*	2007M09	-6.988*	2008M03
	1st diff	-5.02+	2009M03	-5.120+	2009M04

Notes: Table contains t-Statistic of both tests and the endogenously chosen break point. Significant results on the 1%, 5% and 10% level of significance designated *, + and o respectively. Values are rounded.

Table B.12: Results of Lee and Strazicich (2003) Unit Root Tests

	Levels			1st Differences		
H_0:	Unit Root with Two Breaks			Unit Root with Two Breaks		
H_1: for DoG	Break Model: Trend-stationary with Two Breaks			Crash Model: Level-stationary with Two Breaks		
H_1: for PGR	Crash Model: Level-stationary with Two Breaks			Crash Model: Level-stationary with Two Breaks		
Variable	Test Statistic	Break Point 1	Break Point 2	Test Statistic	Break Point 1	Break Point 2
DoG	-4.013	2004M11	2009M12	-6.2629^{*}	2002M08	2007M12
PGR	-4.577^{+}	2006M03	2010M04	-4.9113^{*}	2002M02	2010M06

Notes: Significant values at the 1% and 5% level are designated * and $^{+}$ respectively.