UNIVERSITY OF Southampton

UK QE reconsidered: the real economy effects of monetary policy in the UK, 1990-2012 – an empirical analysis

by Giovanni Bernardo, Josh Ryan-Collins and Richard A. Werner

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Giovanni Bernardo[1]
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1. Introduction

The turmoil in global financial assets markets following the announcements by Ben Bernanke that the Federal Reserve's Quantitative Easing (or Large Scale Asset Purchase) Program may be slowed[4] has raised further questions about the effectiveness of such so called 'unconventional' monetary policies pursued by central banks to deal with the North Atlantic Financial Crisis of 2007-09 and resulting global downturn. One implication of this market volatility is that Q.E. may artificially inflate financial asset prices, with resulting temporary confidence effects, but make little difference to macroeconomic fundamentals.

Unfortunately, much of the existing literature on QE does not specifically examine the impact of QE on key broader macroeconomic variables, such as nominal demand, GDP growth and inflation. This is despite the fact that some central banks, including the Bank of England,

[1] University of Pisa, Department of Economics

[2] Centre for Banking, Finance and Sustainable Development, School of Management, University of Southampton, Southampton SO17 1BJ, jjrc1c11@soton.ac.uk

[3] Centre for Banking, Finance and Sustainable Development, School of Management, University of Southampton, School of Management, Southampton SO17 1BJ, werner@soton.ac.uk

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[4] The FTSE 100 suffered its worst monthly fall for more than a year in June 2013, losing £94bn, whilst the price of gold recorded its biggest quarterly decline for 45 years (The Guardian, 29 June 2013).

made it clear that these were the ultimate goals of the policy.[5] Empirical studies of QE type policies have been criticised for instead focusing on the effect of policy on *intermediate* variables – typically financial asset prices or yields, medium and long-term interest rates or changes in broad money (Lyonnet and Werner 2012; Martin and Milas 2012). The effects of such changes on nominal GDP are sometimes hypothesised – using concepts such as 'portfolio rebalancing' (section 2) – rather than empirically tested. Another problem with existing studies is the time period over which analysis is conducted. Many studies, in particular event studies and VAR models, focus on the crisis and post-crisis period, a time of extraordinary economic and financial dislocation, which creates counterfactual and attribution problems and fails to capture typical macroeconomic lag dynamics.

In this paper we address these two issues. To address the first problem, and following Voutsinas and Werner's methodological approach (2010) and Lyonnet and Werner's study of UK QE (2012), we examine the impact of various different monetary policy instruments (including so called 'unconventional' instruments such as Quantitative Easing) directly on nominal GDP growth, with this latter as the dependent variable. Secondly, we use a quarterly time series from the first quarter of 1990 and up to the last quarter of 2012 (92 observations in total) in order to better capture time dynamics and the effects of shocks (Lyonnet and Werner's study ran from 1995-2010).

We employ the Hendry 'general-to-specific' econometric methodology (following Hendry and Mizon, 1978) to develop a reduced form parsimonious model based on actual historical relationships between variables. The results show that disaggregated bank credit to the real economy (households and firms) has the most significant impact on nominal GDP growth, confirming Lyonnet and Werner's (2012) findings, Werner's Quantity Theory of Credit (1992, 1997; 2005) and the 'credit theory of money' approach (Mitchell-Innes 1914; Wray 1994; Werner, 2005; Ryan-Collins et al 2012).

The paper is laid out as follows: Section 2 reviews existing studies of QE and equivalent unconventional monetary policy interventions since the 2007-2009 crisis. Section 3 describes our empirical methodology. Section 4 describes our data and Section 5 our results. Diagnostic tests of the results are laid out in Section 6. Section 7 interprets our results and Section 8 concludes with implications for monetary policy and suggestions for further research.

2. The QE transmission mechanism and review of existing studies

Hypthesised impact of QE

Quantitative Easing involves central banks engaging in large scale asset purchases (LSAPs) in order to provide greater liquidity to markets and/or to push down medium and long term interest rates once the short-term central bank rate has reached the so called 'zero lower bound'.[6] The literature on QE has identified four main channels, or 'transmission

[5] As pointed out by Lyonnet and Werner (2012), the Bank of England has been explicit in stating the purpose of its QE program was to "increase nominal spending growth" in order to maintain inflation at the 2% target (Joyce, Lasaosa, Stevens and Tong 2010: 1); see also its short film, 'Quantitative Easing Explained' (Bank of England 2010).

[6] For a comprehensive articulation of the theoretical foundations of conventional monetary policy, see Woodford (2003). For a review of the origins of the term Quantitative Easing, see Lyonnet and Werner (2012);

mechanisms', through which QE is thought to impact on the economy; the 'signalling channel', the portfolio rebalancing effect' the 'bank lending' or 'liquidity' channel and the 'wealth effect' (Bowdler and Radia 2012: 608).

i) Signaling channel

Since QE as practiced is mainly focused on changing behavior in highly liquid financial markets, expectations play a strong role. Announcements by central bankers, even if quite vague, can have strong impacts on markets by revealing information about the likely future path of monetary policy, as has been quite evident in the recent announcements of Ben Bernanke.

ii) The portfolio rebalancing channel

The Bank of England has placed the most emphasis on the impact of QE on changes in investors' portfolios.[7] The purchase of gilts from financial investors by the APF creates new deposits for those investors. The increase in central bank reserves (narrow money) has led to an equal increase in bank deposits (broad money). The important question for assessing the macroeconomic impact is what they will do with these deposits. The theory is that this 'shock' to their portfolio will lead to investors rebalancing their holdings by seeking out similar kinds of financial assets. They may want to do this for a number of reasons. First, government bonds, particularly longer dated gilts (e.g. 10 or 25 years) will have a higher rate of return than deposits. Secondly, certain kinds of investors, in particular pension funds, will want to hold assets of longer maturity than deposits as they have correspondingly long-dated liabilities.

The hope is that investors will switch instead to corporate assets – bonds or equities (shares) – that will in turn support businesses operating in the real economy. However, investors have other options. They may choose to switch into foreign government bonds instead. They may simply buy existing corporate securities from other investors rather than newly issued securities from companies. Only in the latter case, known as the primary market, will companies receive more funds and this is only a fraction of the overall turnover of capital markets. They may choose to invest in derivatives based on commodities such as oil or food, which will have the effect of inflating the prices of these assets. Or they may in the end choose to simply hold the deposits, in which case QE will have made no contribution to nominal GDP at all.

If investors choose to purchase newly issued corporate assets, this will bring down the cost of issuing new equity or bonds for firms and mean it is likely they will be able to access more finance. However, it is then up to the firms to decide what to spend this new money on. It will only contribute to GDP transactions and growth if it is invested in new production. In the current environment in the UK, it appears larger firms may prefer to hold on to the deposits. The Office of National Statistics recently estimated that the UK companies were sitting on £750 billion in cash, 50 per cent of GDP (Guardian 2013). Or companies might use the funds

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QE has been implemented differently in different countries with different types of assets purchased by different Central Banks. For international reviews see Joyce et al (2012) and Fawley and Neely (2013).

[7] Note that this is not the same as the theoretical 'money multiplier' effect which assumes, wrongly, that banks will increase lending by a multiple of the increase in reserves. The theory behind portfolio rebalancing was first developed by the economist James Tobin writing in the 1960s (Tobin 1961, 1969).

to pay down existing bank loans. This will have the paradoxical effect of reducing the money supply.

iii) The wealth effect

An additional potential consequence of portfolio rebalancing is known as the ‘wealth effect’. As investors buy more equities this should push up their price, meaning holders of these assets will feel wealthier. They may choose to invest this additional wealth in consumption which would contribute to GDP growth (although it may not help the trade deficit if it involves buying goods that are imported). However, again it is not clear that asset holders will do this. They might just buy other kinds of existing assets or save the money. Furthermore the impact on consumption for any consumer will depend on whether they feel it is a long-term or merely a short-term improvement in their economic position, and how the current increase in wealth affects their confidence about their future financial prospects (the problem of ‘Ricardian equivalence’). It is also possible that banks, which also hold assets, will also feel a ‘wealth effect’ because the value of their capital will rise. They may then pass on this effect via charging lower rates of interest. As with the liquidity effect mentioned earlier, however, the Bank of England has downplayed such an impact, arguing that the banking sector has been too severely damaged by the crisis for this to make a significant difference.

iv) The bank lending channel

As commercial banks hold significantly higher levels of central bank reserves as a result of QE, it is possible that additional liquidity and reduced cost of funding will encourage banks to increase their lending to the real economy, creating credit for new GDP transactions. However, as Werner (2005) argued concerning Japan, banks’ credit extension was not limited by liquidity or reserve constraint – hence it is not obvious that increased liquidity or reserves will have a visible impact.

The first phase of QE in 2009, when £200 billion was injected in the space of just six months, may have supported bank lending, or at least prevented a further fall in credit creation, although the Bank of England has played down this effect in its analysis. A number of other schemes aimed more directly at improving banks’ balance sheets were also underway at the time, including the Government guaranteeing bonds issued by the banks (the credit guarantee scheme), the SLS, and the partial nationalisations of RBS and Lloyds via massive tax-payer-funded re-capitalisations. These interventions would appear to support the banking system more directly and hence prevent further contractions in lending.

Either way, the impact of expansion of central bank reserves on credit creation is indirect and dependent entirely on banks’ confidence. Their overall effect is likely to be limited, simply because banks were already holding excess reserves before the policy was adopted. It is not obvious that a significant increase in the amount of excess reserves will have any impact on banks’ lending decisions. This is especially true since central bank reserves cannot in total be reduced by banks ‘lending the money’ – banks create new credit when they lend, for which they do not need reserves, and the reserves at the central bank cannot in aggregate be reduced by banks via any action of their own (Ryan-Collins et al. 2012). Thus, in aggregate, banks must hold these large reserve balances, and they currently receive 0.5 per cent interest on them.

Actual impact of QE

There are both attribution and counterfactual issues when empirically examining the impact of QE. Attribution issues arise when it is not possible to isolate the impact of one among many different causal factors. A number of other interventions occurred at the same time as QE: a historically unparalleled drop in interest rates, a massive increase in government spending and reduction in taxation as automatic stabilizers commenced and huge injections of government money to support the liquidity and capital requirements of UK banks. In addition, other countries – the USA, Japan, and the Eurozone in particular – were also undertaking QE-type policies meaning there were likely to be spill-over effects, especially given the internationalised nature of the UK economy.

The counterfactual problem is that we can never know what would have happened if we had not carried out QE, so we can never truly know its impact (Werner, 2005, cites fiscal policy and interest rate policy supporters who use this argument to explain that their policy suggestions did work, although the economy failed to recover). We can only observe how the economy has changed. QE was initiated during extraordinary economic times – with output and bank lending and confidence in stock-markets collapsing in a fashion not seen since the Great Depression. Finally, whilst analysis of changes in financial markets (asset prices, risk spreads) is fairly amenable to direct observation, this is less true for the broader macroeconomic impact where significant time lags may be present (Martin and Milas, 2012).

It may be for the latter reason that the vast majority of empirical studies of QE, both in the UK and internationally, have concentrated on the impact of QE on changes in financial markets. Such studies have been criticised for missing the point; since the ultimate objective of QE was to boost nominal GDP and inflation, measuring such intermediate variables appears not very useful (Lyonnet and Werner 2012; Goodhart and Ashworth 2012). Nevertheless, a huge number of such studies have been conducted, mainly by central banks themselves. 'Meta-reviews' of these studies point towards two main conclusions: 1) that the earlier QE interventions (in 2008-09) prevented a more dramatic fall in output and deflation and had a significant impact in pushing down medium and long term interest rates[8] and 2) the policy runs in to diminishing returns, a dynamic that may be explained by the fact that market anticipation of central bank actions weakens their impact (or makes their impact more difficult to detect empirically) (Bowdler and Radia 2012; Martin and Milas 2012; Joyce et al 2012; Goodhart and Ashworth 2012).

3. Methodological approach

Our empirical quantitative research attempts to overcome the attribution and counterfactual problems described above in two ways. First, following Lyonnet and Werner (2012), we examine a wide range of different central bank tools and instruments, including QE-related variables such as the total assets of the central bank and the ratio of long term central bank assets to total assets, directly on *nominal GDP growth*, a widely accepted final target variable for monetary policy.[9] These are laid out in Table 1, along with their hypothesised effects,

[8] A recent study by the Bank of England suggest that QE contributed around 1.5 per cent to GDP growth at its peak and boosted annual inflation by around 1.25 per cent. See Joyce et al (2012).

[9] The literature on central bank performance identifies a range of goals related to macroeconomic stability, including price- and exchange rate-stability and maximizing output (Hasan and Master 2008: 6 in Lyonnet and Werner 2012: 99). The remit of the Bank of England is as follows: In relation to monetary policy, the objectives of the Bank of England shall be—(a) to maintain price stability, and (b) subject to that, to support the economic policy of Her Majesty's Government. This latter has been most recently defined as: *"to achieve strong, sustainable and balanced growth that is more evenly shared across the country and between industries."*. Letter

which relate to the channels described in section 2 above. Secondly, we use a longer quarterly time series, from the first quarter of 1990 and up to the last quarter of 2012, a total of 92 observations. This compares with Lyonnet and Werner's (2012) smaller sample, from Q2, 1995 to Q4, 2010 (63 observations). We regressed four 'lags' of each variable and also included lags of the dependent variable (nominal GDP growth) to take in to account typical macroeconomic dynamics. This provides us with a total of 34 different independent variables. We include two dummy variables: the first in 2000, quarter 2, to capture a structural break (see Appendix for explanation) and the second to adjust for the effect of the financial crisis, which runs from 2008 quarter 2 to 2009, quarter 2.

The general-to-specific methodology (also known as the Hendry, LSE or gets methodology) involves estimating a broad model with as many variables and lags as possible in order to ensure no important variables are excluded and that the resulting regression residuals are pure white noise. It is useful in a context where there remains considerable uncertainty about the transmission mechanism of QE to nominal GDP since it allows various different monetary policy tools, intermediary instruments and versions of 'quantitative easing' (as shown in table 1) to be equally represented in the first general model (Lyonnet and Werner 2012: 99; Campos, Ericsson and Hendry 2005). An example would be the equation below in which the dependent variable has an autoregressive component (Y_{t-k}) and it is a function of two independent variables:

$$Y = \alpha_0 + \sum_{l,k=1}^{t-1} \beta_l Y_{t-k} + \sum_{m,k=0}^{t-1} \gamma_m X_{t-k} + \sum_{n,k=0}^{t-1} \delta_n Z_{t-k} + \varepsilon_t$$

Our 'general-to-specific' methodology involves sequentially reducing the least significant of the independent variables in the general model down until we are left with a parsimonious specific model.

Figure 1: Central Bank monetary policy instruments used to estimate general model

Variable	**Variable name** (Quarterly Year-on-Year change except for Bank rate and QualEasing)	**Hypothesised effect**
Bank Rate (the bank of England interest rate charged to banks for holding reserves)	Bankrate	Standard monetary policy impact – reduce interest rate leads to increased growth

from the Chancellor to the Governor laying out the Monetary Policy Remit, 20 March 2013, p. 4. Retrieved from https://www.gov.uk/government/publications/monetary-policy-remit-2013 [accessed 20 May 2013]. Nominal GDP growth can be seen to combine price stability and output.

Quantity of reserves in the banking system	Reserves	More reserves in the banking system reduces liquidity and funding costs and leads to more bank lending and increased growth
Bank of England total assets	BoETA	'Portfolio rebalancing effect' – as the bank takes more safe assets on to its balance sheet and pushes up prices, it should stimulate investors to switch to corporate assets (bonds or equities), leading to increased business investment
Qualitative easing – the ratio of long-term assets (government bonds) to Total Assets held on the Bank of England's balance sheet	QualEasing	'Portfolio re-balancing effect' – by pushing down medium and long term interest rates on government bonds, investors should again be incentivized to buy corporate assets.
Broad money - the broadest deposit aggregate	M4	Increase in broad money will have portfolio re-balancing effects as investors switch out of deposits and in to higher yielding corporate assets.
Bank credit to the real economy (excluding the effects of securitization), following Werner (1992, 1997, 2005) and Lyonnet and Werner (2012)	M4LREx	Credit creation by banks for GDP transactions should directly create growth

4. Data description

We used Bank of England (BoE) data to construct our time series with the exception of nominal GDP which was sourced from the Office of National Statistics (ONS).[10] Codes are shown in the table below. All data is quarterly since this is the most frequent period available for the dependent variable, nominal GDP. Where data were only available in weekly or monthly form, we used the value at the end of every quarter. All data is non-seasonally-adjusted. A dummy to adjust for the financial crisis was employed from 2008, Quarter 2 to 2009, Quarter 2.

For nominal GDP, Bank of England reserves, total assets, money and credit aggregates (M4 and M4 lending to the real economy) and 'Qualitative Easing' we had to construct new time series. Calculations are shown in the table below. In order to de-trend the data and to adjust for seasonality, we use quarterly year-on-year growth rates for all data except interest rates obtain by using the following equation[11]:

[10] All data can be downloaded from the Bank of England Interactive Database: http://www.bankofengland.co.uk/boeapps/iadb/newintermed.asp

[11] YoY means year-on-year growth rate and *x* is a generic variable.

$$YoYx = \frac{(x_t - x_{t-4})}{x_{t-4}}$$

Figure 2: Data sources

Variable	**Variable name (Quarterly Year-on-Year growth rate)**	**Series name (Bank of England unless specified)**	**Code (Bank of England interactive database code unless stated)**
Nominal GDP	YoYGDP	Office of National Statistics (ONS): Total gross final expenditure (aligned - P.3+P.5+P.6 : CP NSA) – (minus) Statistical Discrepancy Gross Domestic Product : CP NSA	ONS codes: ABMD RVFD
Bank rate (the bank of England interest rate charged to banks for holding reserves)	Bankrate	Quarterly average of official Bank Rate	IUQABEDR
Quantity of reserves in the banking system	Reserves	Prior to May 2006: Monthly average amount outstanding of total sterling M0 total (in sterling millions) not seasonally adjusted (discontinued April 2006) – (minus) Monthly average amount outstanding of total sterling notes and coin in circulation, excluding backing assets for commercial banknote issue in Scotland and Northern Ireland total (in sterling millions) May 2006 onwards: Weekly amounts outstanding of BoE Banking department sterling reserve balance liabilities)	LPMAVAD LPMAVAA RPWBL38
Bank of England Total assets	BoETA	Prior to March 2006: (Banking department) securities issued by central government + sterling and foreign currency securities + premises equipment and other + notes and coins holdings + (Issue department) securities issued by central government + other securities; Post March 2006: Total assets of issuing department + total assets of banking department	RPQAEFJ, RPQAEFK, RPQAEFLRPQ AEFM, RPQAEFC, RPQAEFD RPWBL37, RPWBL56
Qualitative easing – the ratio of long-term assets (government bonds) to Total Assets held on the Bank of England's balance sheet	QualEasing	Prior to March 2006: Banking dept securities issued by Central govt + Issue dept securities issued by central govt)/(divided by) BoE Total Assets; Post March 2006: (Bonds and other securities acquired via market transactions (in sterling millions) + bonds acquired via OMOs + assets in the APF + Corporate bonds/ (divided by) BoE Total	RPQAEFJ, RPQAEFC RPWBL53 RPWBL35 YWWB9T9 YWWB8X9

		Aassets	
Broad money	M4	Quarterly amounts outstanding of monetary financial institutions' sterling M4 liabilities to: other financial corporations + private non-financial corporations + household sector (in sterling millions)	LPQVVHX, LPQVVID, LPQVVIJ
Bank credit to the real economy (excluding the effects of securitization)	M4LREx	As above, removing 'other financial corporations'	LPQB9Y2, LPQB8DF, LPQB8DG

5. Empirical results

We describe here our final and preferred estimation (model C). To trace our analysis, further estimations (models A and B) are provided in the Appendix.

The general model, including the 2000 structural break dummy ('dummy') and the Crisis dummy (Crisis_D), is shown below in Figure 1. The basis for including the structural break dummy is included in model B in the Appendix. The Durbin-Watson test shows there is no autocorrelation and the errors are normally distributed.

Figure 3: General Model C - OLS, using observations 1990:1-2012:4 (T = 92)
Dependent variable: YoYGDP

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0249344	0.00908891	2.7434	0.00819	***
YoYRES	-7.61975e-05	3.02671e-05	-2.5175	0.01476	**
YoYRES_1	-6.62188e-05	2.93291e-05	-2.2578	0.02795	**
YoYRES_2	9.19783e-06	2.93496e-05	0.3134	0.75517	
YoYRES_3	-4.21146e-06	3.02712e-05	-0.1391	0.88986	
YoYRES_4	3.76472e-05	3.0299e-05	1.2425	0.21932	
YoYBoETA	-0.00105094	0.00431688	-0.2434	0.80856	
YoYBoETA_1	-0.00926949	0.00520039	-1.7825	0.08019	*
YoYBoETA_2	0.0141851	0.00553259	2.5639	0.01311	**
YoYBoETA_3	-0.00646392	0.00556768	-1.1610	0.25067	
YoYBoETA_4	-0.003486	0.00492422	-0.7079	0.48198	
YoYNEFQE	-0.00103618	0.00136695	-0.7580	0.45167	
YoYNEFQE_1	-0.000896671	0.00136307	-0.6578	0.51339	
YoYNEFQE_2	0.00331343	0.0013231	2.5043	0.01526	**
YoYNEFQE_3	-0.00110933	0.00124534	-0.8908	0.37693	
YoYNEFQE_4	0.000422252	0.00107365	0.3933	0.69563	
YoYM4	0.102053	0.0795711	1.2825	0.20503	
YoYM4_1	-0.0313196	0.111396	-0.2812	0.77965	
YoYM4 _2	-0.0304176	0.109518	-0.2777	0.78225	
YoYM4_ 3	0.0596739	0.111845	0.5335	0.59581	
YoYM4_ 4	0.0299127	0.0719486	0.4158	0.67921	
YoYM4LRE	0.00402401	0.120824	0.0333	0.97355	
YoYM4LREx_1	0.124451	0.1678	0.7417	0.46145	
YoYM4LREx_2	0.103917	0.15824	0.6567	0.51411	

YoYM4LREx_3	-0.0496884	0.159658	-0.3112	0.75681	
YoYM4LREx _4	-0.0811745	0.121528	-0.6679	0.50696	
Crisis_D	-0.0420206	0.00659758	-6.3691	<0.00001	***
dummy	-0.0110376	0.00491631	-2.2451	0.02880	**
Bankrate	0.00330934	0.00281588	1.1752	0.24496	
Bankrate_1	-0.00754664	0.00445187	-1.6952	0.09570	*
Bankrate_2	0.00228548	0.00469228	0.4871	0.62814	
Bankrate_3	-0.00335639	0.00472247	-0.7107	0.48026	
Bankrate_4	0.00395858	0.0028291	1.3992	0.16736	
YoYGDP_1	0.288447	0.098532	2.9274	0.00496	***
YoYGDP_2	0.265904	0.114733	2.3176	0.02422	**
YoYGDP_3	0.232589	0.122017	1.9062	0.06186	*
YoYGDP_4	-0.30932	0.11198	-2.7623	0.00779	***

Mean dependent var	0.047987		S.D. dependent var	0.023799
Sum squared resid	0.003656		S.E. of regression	0.008154
R-squared	0.929060		Adjusted R-squared	0.882626
F(36, 55)	20.00828		P-value(F)	6.56e-21
Log-likelihood	335.5782		Akaike criterion	-597.1563
Schwarz criterion	-503.8501		Hannan-Quinn	-559.4971
rho	-0.025489		Durbin's h	-0.712306

To identify the specific, or restricted, model, the regression is then progressively simplified by removing the least significant explanatory variables based on information from t-statistics (‘t-ratio’) and p-values. We used the Gretl software package to conduct this ‘sequential elimination’ – see below. For each sequential elimination, the validity of the result is checked by using F-tests and linear restriction tests. As a cut-off for the validity of the reduction progress, the 1% level was chosen..

Sequential elimination using two-sided alpha = 0.01

Dropping YoYM4LREx_LPQB (p-value 0.974)
Dropping YoYRES_3 (p-value 0.885)
Dropping YoYBoETA (p-value 0.803)
Dropping YoYM4_LPQVV_1 (p-value 0.796)
Dropping YoYRES_2 (p-value 0.753)
Dropping YoYM4LREx_LPQB_3 (p-value 0.705)
Dropping YoYM4_LPQVV_4 (p-value 0.672)
Dropping YoYNEFQE_4 (p-value 0.692)
Dropping Bankrate_2 (p-value 0.545)
Dropping YoYM4LREx_LPQB_2 (p-value 0.515)
Dropping Bankrate_3 (p-value 0.533)
Dropping YoYNEFQE_1 (p-value 0.396)
Dropping YoYBoETA_4 (p-value 0.402)
Dropping YoYM4LREx_LPQB_4 (p-value 0.339)
Dropping YoYNEFQE_3 (p-value 0.266)
Dropping Bankrate (p-value 0.146)

Dropping YoYNEFQE (p-value 0.158)
Dropping YoYRES_4 (p-value 0.061)
Dropping Bankrate_4 (p-value 0.057)
Dropping YoYM4_LPQVV (p-value 0.095)
Dropping YoYM4_LPQVV_2 (p-value 0.205)
Dropping YoYBoETA_3 (p-value 0.079)
Dropping YoYBoETA_2 (p-value 0.093)
Dropping YoYBoETA_1 (p-value 0.246)
Dropping YoYM4_LPQVV_3 (p-value 0.069)
Dropping YoYRES_1 (p-value 0.076)
Dropping YoYRES (p-value 0.036)
Dropping Bankrate_1 (p-value 0.020)
Dropping YoYNEFQE_2 (p-value 0.024)
Dropping YoYGDP_3 (p-value 0.083)

Test on Model 1:

Null hypothesis: the regression parameters are zero for the variables:

YoYRES, YoYRES_1, YoYRES_2, YoYRES_3, YoYRES_4, YoYBoETA, YoYBoETA_1, YoYBoETA_2, YoYBoETA_3, YoYBoETA_4, Bankrate, Bankrate_1, Bankrate_2, Bankrate_3, Bankrate_4, YoYNEFQE, YoYNEFQE_1, YoYNEFQE_2, YoYNEFQE_3, YoYNEFQE_4, YoYM4_LPQVV, YoYM4_LPQVV_1, YoYM4_LPQVV_2, YoYM4_LPQVV_3, YoYM4_LPQVV_4, YoYM4LREx_LPQB, YoYM4LREx_LPQB_2, YoYM4LREx_LPQB_3, YoYM4LREx_LPQB_4, YoYGDP_3

Test statistic: F(30, 55) = 1.84726, p-value 0.0240913
Omitting variables improved 2 of 3 model selection statistics.

This leaves us with parsimonious model C below.

Figure 4 - Parsimonious model C - OLS, using observations 1990:1-2012:4 (T = 92)
Dependent variable: YoYGDP

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0291163	0.00363823	8.0029	<0.00001	***
Crisis_D_short	-0.0337562	0.00514234	-6.5644	<0.00001	***
YoYM4LREx_1	0.122704	0.0256994	4.7746	<0.00001	***
dummy	-0.00848437	0.00233445	-3.6344	0.00048	***
YoYGDP_1	0.41572	0.0840194	4.9479	<0.00001	***
YoYGDP_2	0.328568	0.088118	3.7287	0.00035	***
YoYGDP_4	-0.379147	0.0685698	-5.5294	<0.00001	***

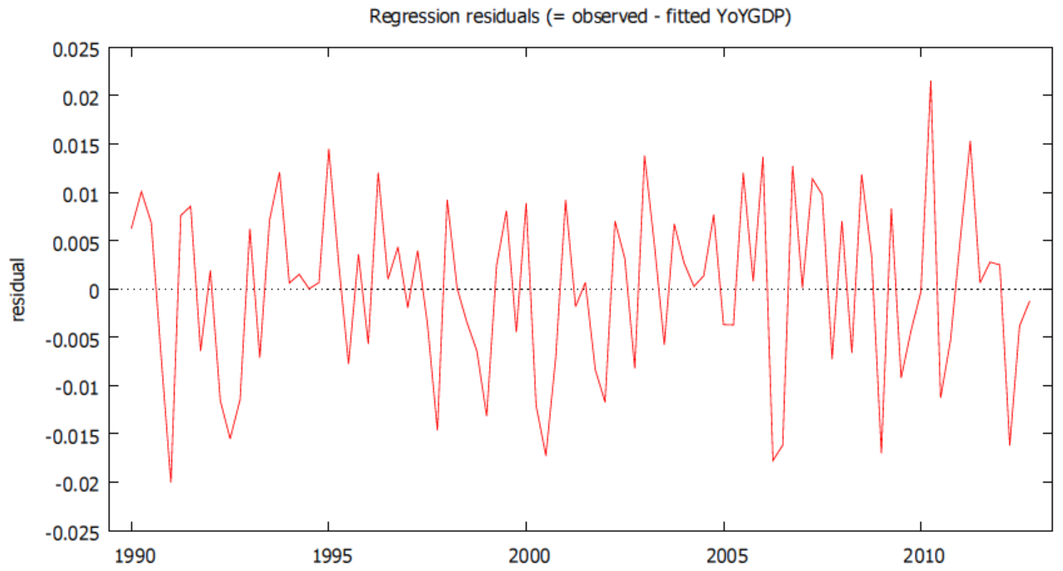
Mean dependent var	0.047987		S.D. dependent var	0.023799
Sum squared resid	0.007341		S.E. of regression	0.009293
R-squared	0.857580		Adjusted R-squared	0.847527
F(6, 85)	85.30455		P-value(F)	7.63e-34
Log-likelihood	303.5190		Akaike criterion	-593.0380
Schwarz criterion	-575.3855		Hannan-Quinn	-585.9133

rho	-0.053420	Durbin's h	-0.852154

6. Test diagnostics on Model C

In order to evaluate our model and ensure Gauss-Markov conditions are satisfied we carried out various diagnostic tests, listed below:

i) Heteroskedasticity

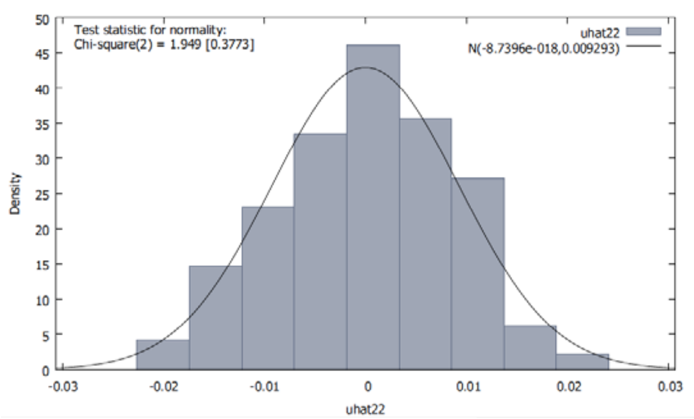


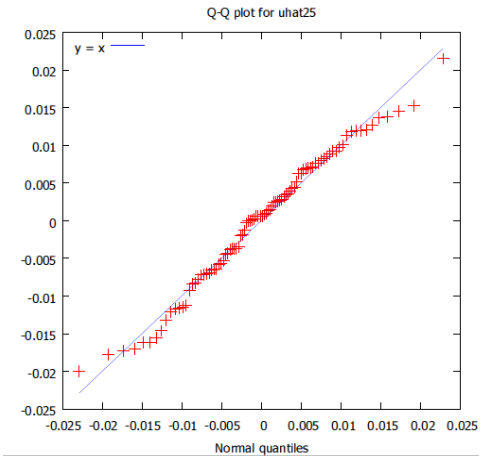
a) Breusch-Pagan test for heteroskedasticity
Test statistic: LM = 2.465131
with p-value = P(Chi-square(6) > 2.465131) = 0.872350

b) White's test for heteroskedasticity
Test statistic: TR^2 = 8.078438,
with p-value = P(Chi-square(10) > 8.078438) = 0.621175
c) Breusch-Pagan test for heteroskedasticity
Dependent variable: scaled uhat^2 (Koenker robust variant)
Test statistic: LM = 3.457228,
with p-value = P(Chi-square(6) > 3.457228) = 0.749651

d) Test for ARCH of order 4
Null hypothesis: no ARCH effect is present
Test statistic: LM = 2.13602
with p-value = P(Chi-square(4) > 2.13602) = 0.710758

ii) Normality





a) Normality test
Frequency distribution for uhat22, obs 61-152
number of bins = 9, mean = -8.73961e-018, sd = 0.00929304

interval	midpt	frequency	rel.	cum.
< -0.017436	-0.020033	2	2.17%	2.17%
-0.017436 - -0.012241	-0.014839	7	7.61%	9.78% **
-0.012241 - -0.0070472	-0.0096443	11	11.96%	21.74% ****
-0.0070472 - -0.0018529	-0.0044500	16	17.39%	39.13% ******
-0.0018529 - 0.0033414	0.00074427	22	23.91%	63.04% ********
0.0033414 - 0.0085357	0.0059386	17	18.48%	81.52% ******
0.0085357 - 0.013730	0.011133	13	14.13%	95.65% *****
0.013730 - 0.018924	0.016327	3	3.26%	98.91% *
>= 0.018924	0.021521	1	1.09%	100.00%

Test for null hypothesis of normal distribution:
Chi-square(2) = 1.949 with p-value 0.37734

3) Autocorrelation

Breusch-Godfrey test for autocorrelation up to order 4
OLS, using observations 1990:1-2012:4 (T = 92)
Dependent variable: uhat

Unadjusted R-squared = 0.098926

Test statistic: LMF = 2.223176,
with p-value = P(F(4,81) > 2.22318) = 0.0737

Alternative statistic: TR^2 = 9.101171,
with p-value = P(Chi-square(4) > 9.10117) = 0.0586

Ljung-Box Q' = 5.3421,
with p-value = P(Chi-square(4) > 5.3421) = 0.254

4) Collinearity, specification and stability

a) Collinearity
Variance Inflation Factors

Minimum possible value = 1.0
Values > 10.0 may indicate a collinearity problem

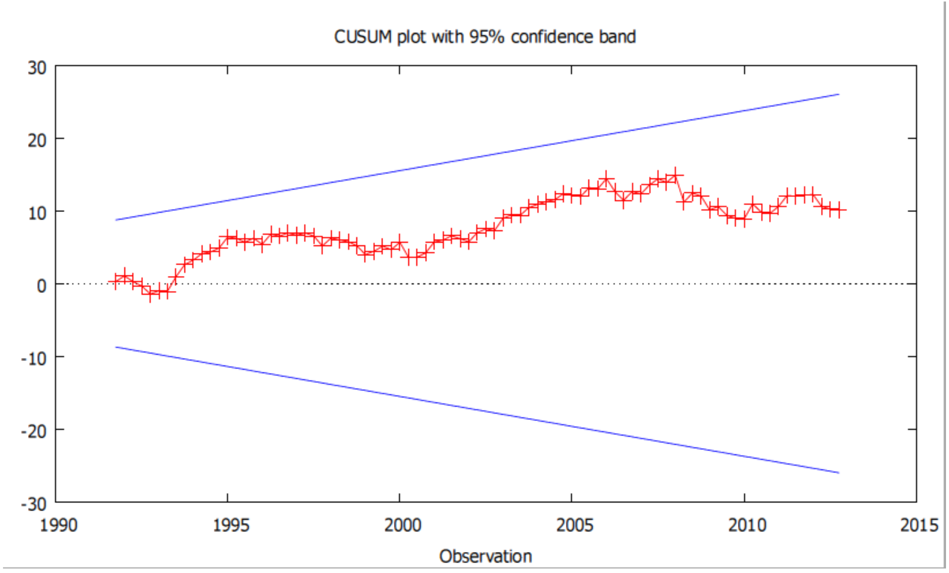
Crisis_D_short 1.448
YoYM4LREx_LPQB_1 2.094
dummy 1.43
YoYGDP_1 4.333
YoYGDP_2 4.911
YoYGDP_4 3.129

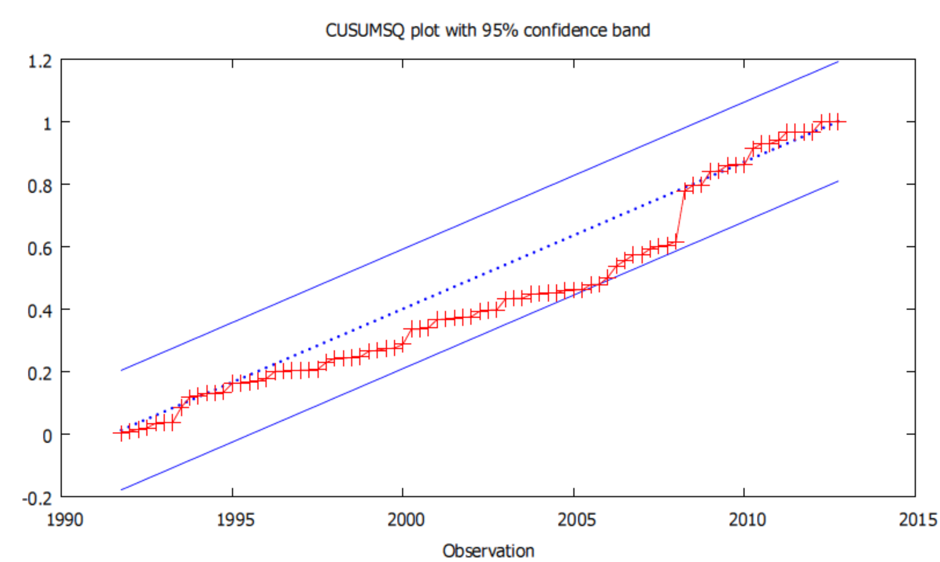
b) Specification

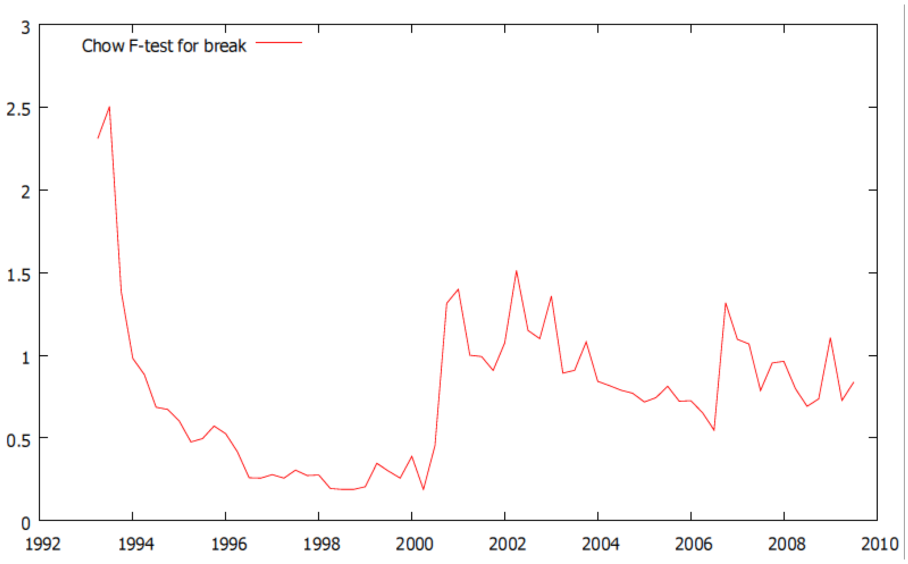
RESET test for specification (squares and cubes)
Test statistic: F = 0.633564,
with p-value = P(F(2,83) > 0.633564) = 0.533

RESET test for specification (squares only)
Test statistic: F = 0.551409,
with p-value = P(F(1,84) > 0.551409) = 0.46

RESET test for specification (cubes only)
Test statistic: F = 0.058659,
with p-value = P(F(1,84) > 0.0586586) = 0.809


CUSUM plot with 95% confidence band
30
20
10
0
-10
-20
-30
1990
1995
2000
2005
2010
2015
Observation


CUSUMSQ plot with 95% confidence band
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
1990
1995
2000
2005
2010
2015
Observation


Chow F-test for break
3
2.5
2
1.5
1
0.5
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

d) Chow test for structural break
Augmented regression for Chow test
OLS, using observations 1990:1-2012:4 (T = 92)
Dependent variable: YoYGDP

	coefficient	std. error	t-ratio	p-value	
const	0.0282363	0.00839201	3.365	0.0012	***
Crisis_D_short	-0.0345067	0.00543551	-6.348	1.18e-08	***
YoYM4LREx_LPQB_1	0.136386	0.0730834	1.866	0.0656	*
dummy	-0.00702060	0.00890893	-0.7880	0.4330	
YoYGDP_1	0.523891	0.174284	3.006	0.0035	***
YoYGDP_2	0.209974	0.190875	1.100	0.2746	
YoYGDP_4	-0.368863	0.151761	-2.431	0.0173	**
sd_YoYM4LREx_L~_1	-0.0150839	0.0784252	-0.1923	0.8480	
sd_YoYGDP_1	-0.146788	0.200357	-0.7326	0.4659	
sd_YoYGDP_2	0.156933	0.217052	0.7230	0.4718	
sd_YoYGDP_4	-0.0204926	0.171391	-0.1196	0.9051	

Mean dependent var	0.047987	S.D. dependent var	0.023799
Sum squared resid	0.007273	S.E. of regression	0.009476
R-squared	0.858895	Adjusted R-squared	0.841474
F(10, 81)	49.30401	P-value(F)	2.83e-30
Log-likelihood	303.9456	Akaike criterion	-585.8912
Schwarz criterion	-558.1515	Hannan-Quinn	-574.6952
rho	-0.066985	Durbin-Watson	2.130624

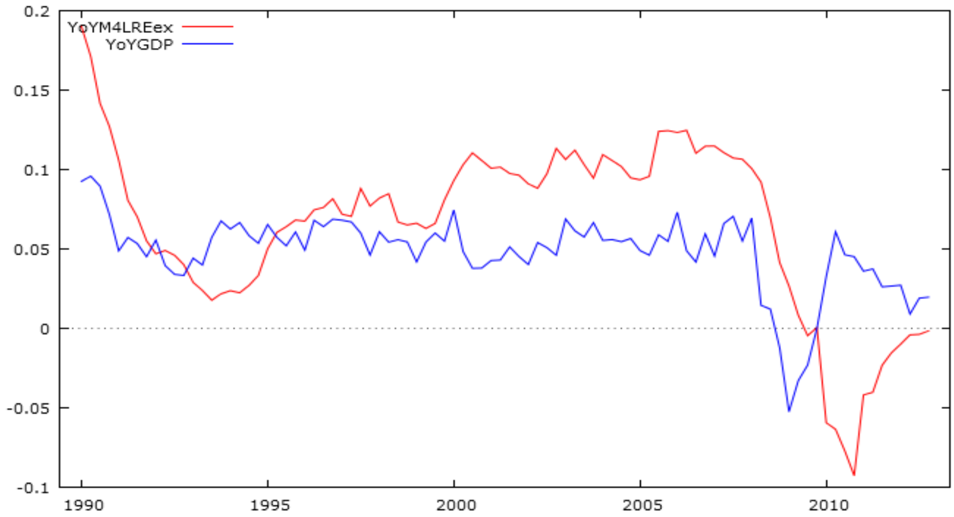
Chow test for structural break at observation 2000:2
F(4, 81) = 0.188664 with p-value 0.943

7. Interpretation of results

Our results suggest changes in *bank credit creation to the real economy* (with a one-year time lag – M4LREx_1) are the most important predictor of GDP growth, taking into account the relative changes in all the other variables discussed. Changes in interest rates and increases to ‘broad money’ (increased deposits in the hands of investors and banks) do not appear to have had any significant effect on nominal GDP growth even in non-recessionary periods (e.g. 1993 to 2008) – both variables drop out of the specific model. Likewise the proposed ‘portfolio re-balancing’ instruments, ‘QualitativeEasing’ and changes to total Bank of England assets. The lags of GDP (e.g. YoYGDP_2) remain in the parsimonious model, but this is quite a standard result for quarterly time series data.

As shown in Figure 16, the results support the Quantity Theory of Credit (Werner 1992, 1997, 2005) which postulates that nominal GDP growth is a function of credit creation for GDP transactions. It is found that the relationship between credit creation for the real economy and nominal GDP is close for the whole 12-year period under analysis, with the exception of the crisis period itself where credit creation appears to lag GDP growth. We believe this may be due to various systemic distortions, as well as the impact of automatic stabilisers[12] coming into effect as the recession emerged and also the international effects described earlier, in particular the action of the Federal Reserve. The UK banking system, meanwhile, took much longer to recover for reasons already described in detail.

Figure 6. Bank lending to the real economy versus growth rate of nominal GDP. ***1990, Q1 to 2012, Q1***



8. Conclusions

Our results support earlier studies by Voutsinas and Werner (2010) and Lyonnet and Werner (2012) that disaggregated bank credit creation for the real economy is the most important predictor of nominal GDP growth when taking in to account a wide-range of alternative monetary policy instruments and variables. Since QE as practised in the UK effectively bypasses the banking system, relying instead on capital markets to buy corporate assets, this may be one explanation for why QE has not enabled a more rapid recovery from the financial crisis of 2007-2008.

Perhaps in recognition that QE was too indirect a policy, the Bank of England introduced the Funding for Lending (FLS) scheme in 2012 in the hope of more directly influencing bank credit creation towards the real economy. FLS subsidizes the funding cost for banks which create loans for households and small businesses and appears to have adopted the definition of 'credit for the real economy' proposed in Lyonnet and Werner (2012), which was

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[12] Automatic stabilisers describe changes in taxation and government spending (fiscal policy) that occur to smooth out the effects of fluctuations in GDP growth. Because many taxes, such as income tax, corporate tax and VAT are based upon output and/or are progressive, a recession has the effect of proportionately reducing the proportion of such taxes taken out of the economy. In addition, government spending automatically increases during a recession due to increased welfare and unemployment benefits, creating economic multiplier effects. The combined effect is an increase the government deficit to counter falls in private output. The opposite process applies during booms. See Sullivan and Sheffrin (2003).

originally presented to the Bank of England in 2011. Initial results show the scheme would appear to have stimulated more credit creation for the real economy but the majority of this has gone to households for mortgages rather than to SMEs. Mortgage lending may just increase house prices. If this happens, it is possible that there may be some wealth effect in the short term, encouraging more consumption, but in the long-term the higher monthly mortgage repayments suffered by new entrants to the housing market paying inflated house prices might reduce consumer demand.

Only lending to businesses can be more reliably viewed as resulting in an increase in GDP transactions, without the negative effects of asset inflation or consumer price inflation. It is for this reason perhaps that the Bank of England chose in March 2013 to alter the terms of FLS to more specifically incentivize lending to SMEs over mortgage financing.[13]

An interesting further research topic would be to be to attempt to model the proportion of mortgage lending that flows through to the real economy in contrast to simply inflating asset prices. It would also be interesting to see if the results in this paper could be replicated in other countries which have undertaken simply large scale asset purchase programs.

[13]News Release - Bank of England and HM Treasury announce extension to the Funding for Lending Scheme. Retrieved from http://www.bankofengland.co.uk/publications/Pages/news/2013/061.aspx

Technical Appendix

Model A: Observations from 1980:1-2012

The sample that we take into account for this regression is from 1990 to 2012 but we initially collected data from 1980. Despite the fact that the coefficients are similar to the previous one (Figure A.1), we restricted the sample because the Gauss-Markov condition are violated. In particular the errors are not normally distributed and there is evidence of heteroskedasticity. There were a number of structural breaks in the 1980s in Britain due to unusually high inflation and for this reason we restricted the sample.

Figure A1: Parsimonious model of Ordinary Least Squared general-to-specific model of QE variables regressed on to Quarterly Year-on-Year GDP growth, 1980 Q1: 2012:Q4 (132 observations)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Const	0.00953472	0.00261078	3.6521	0.00038	***
YoYBoETA_2	0.0107738	0.00385805	2.7926	0.00607	***
YoYBoETA_4	-0.0115364	0.00400406	-2.8812	0.00468	***
YoYNEFQE_2	0.00304718	0.000795065	3.8326	0.00020	***
YoYM4LREex_1	0.103171	0.0205367	5.0237	<0.00001	***
dummy	-0.0369636	0.00611303	-6.0467	<0.00001	***
YoYGDP_1	0.463211	0.0754441	6.1398	<0.00001	***
YoYGDP_2	0.438207	0.0803962	5.4506	<0.00001	***
YoYGDP_4	-0.218422	0.0545321	-4.0054	0.00011	***

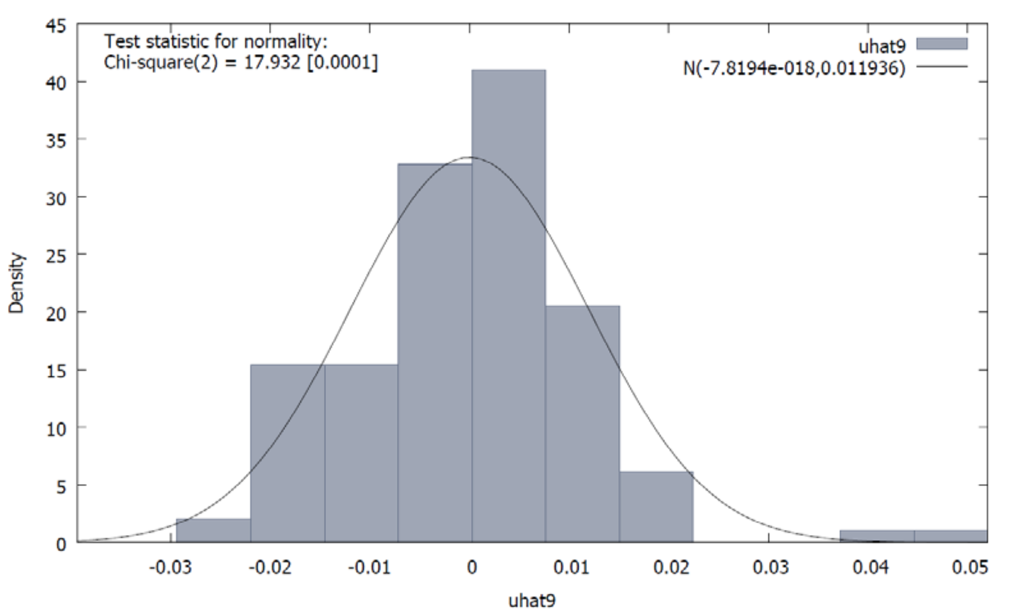
Mean dependent var	0.064641	S.D. dependent var	0.036686
Sum squared resid	0.017523	S.E. of regression	0.011936
R-squared	0.900611	Adjusted R-squared	0.894147
F(8, 123)	139.3204	P-value(F)	6.80e-58
Log-likelihood	401.8835	Akaike criterion	-785.7670
Schwarz criterion	-759.8218	Hannan-Quinn	-775.2241
Rho	-0.020196	Durbin's h	-0.458314

Breusch-Pagan test for heteroskedasticity
OLS, using observations 1980:1-2012:4 (T = 132)
Dependent variable: scaled uhat^2

	coefficient	std. error	t-ratio	p-value	
const	-0.0793279	0.429728	-0.1846	0.8538	
YoYBoETA_2	0.301090	0.635025	0.4741	0.6362	
YoYBoETA_4	-0.414958	0.659060	-0.6296	0.5301	
YoYNEFQE_2	-0.0680486	0.130866	-0.5200	0.6040	
YoYM4LREx_LPQB_1	-0.166313	3.38030	-0.04920	0.9608	
Crisis_D_short	1.60560	1.00619	1.596	0.1131	
YoYGDP_1	27.6400	12.4179	2.226	0.0278	**
YoYGDP_2	11.3055	13.2330	0.8543	0.3946	
YoYGDP_4	-21.9379	8.97585	-2.444	0.0159	**

Explained sum of squares = 101.04

Test statistic: LM = 50.520245,
with p-value = P(Chi-square(8) > 50.520245) = 0.000000



Model B: Observations from 1990:1-2012:4 without structural break

So we then tested the model from 1990:1-2012:4 and found that this avoided the normality and heteroskedacity problems identified in Model A above. The General and Specific Models are presented below.

General model B: 1990:1-2012:4 without 2000 structural break

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.00974754	0.00628568	1.5508	0.12659	
YoYRES	-8.5881e-05	3.10202e-05	-2.7686	0.00762	***
YoYRES_1	-7.09675e-05	3.02897e-05	-2.3430	0.02271	**
YoYRES_2	1.05363e-05	3.03837e-05	0.3468	0.73006	
YoYRES_3	-4.6415e-06	3.13436e-05	-0.1481	0.88281	
YoYRES_4	3.8788e-05	3.13686e-05	1.2365	0.22143	
YoYBoETA	-0.000510247	0.00446294	-0.1143	0.90939	
YoYBoETA_1	-0.00646442	0.00522702	-1.2367	0.22135	
YoYBoETA_2	0.0160313	0.00566507	2.8299	0.00645	***
YoYBoETA_3	-0.00759924	0.00574121	-1.3236	0.19100	
YoYBoETA_4	-0.00718111	0.00480553	-1.4943	0.14070	
YoYNEFQE	-0.000603262	0.00140125	-0.4305	0.66847	
YoYNEFQE_1	-0.000529566	0.00140119	-0.3779	0.70690	
YoYNEFQE_2	0.003633	0.00136205	2.6673	0.00998	***
YoYNEFQE_3	-0.00122851	0.00128832	-0.9536	0.34440	
YoYNEFQE_4	-9.40695e-06	0.00109374	-0.0086	0.99317	

YoYM4	0.148073	0.079611	1.8600	0.06815	*
YoYM4_1	-0.0307791	0.115345	-0.2668	0.79057	
YoYM4_2	-0.0365762	0.113364	-0.3226	0.74817	
YoYM4_3	0.0806316	0.115405	0.6987	0.48764	
YoYM4_4	-0.0134738	0.0717615	-0.1878	0.85174	
YoYM4LREex	0.0137589	0.125027	0.1100	0.91277	
YoYM4LREex_1	0.100307	0.17339	0.5785	0.56524	
YoYM4LREex_2	0.0687403	0.163044	0.4216	0.67493	
YoYM4LREex_3	-0.0274242	0.164999	-0.1662	0.86859	
YoYM4LREex_4	-0.154702	0.12118	-1.2766	0.20700	
Bankrate	0.00479425	0.00283413	1.6916	0.09628	*
Bankrate_1	-0.00841568	0.00459223	-1.8326	0.07218	*
Bankrate_2	0.00280826	0.00485262	0.5787	0.56511	
Bankrate_3	-0.00312503	0.00488871	-0.6392	0.52528	
Bankrate_4	0.00459671	0.00291456	1.5772	0.12039	
dummy	-0.0431866	0.00681025	-6.3414	<0.00001	***
YoYGDP_1	0.321651	0.100869	3.1888	0.00234	***
YoYGDP_2	0.316585	0.116478	2.7180	0.00873	***
YoYGDP_3	0.251664	0.126036	1.9968	0.05072	*
YoYGDP_4	-0.332525	0.115455	-2.8801	0.00562	***

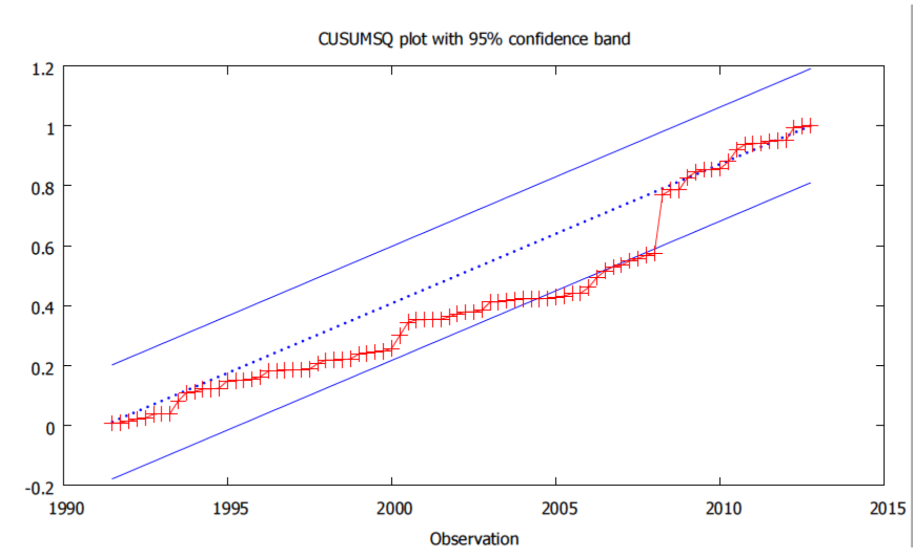
Mean dependent var	0.047987		S.D. dependent var	0.023799
Sum squared resid	0.003992		S.E. of regression	0.008443
R-squared	0.922558		Adjusted R-squared	0.874157
F(35, 56)	19.06067		P-value(F)	1.47e-20
Log-likelihood	331.5446		Akaike criterion	-591.0892
Schwarz criterion	-500.3048		Hannan-Quinn	-554.4478
rho	-0.054700		Durbin's h	-1.916675

Parsimonious model B

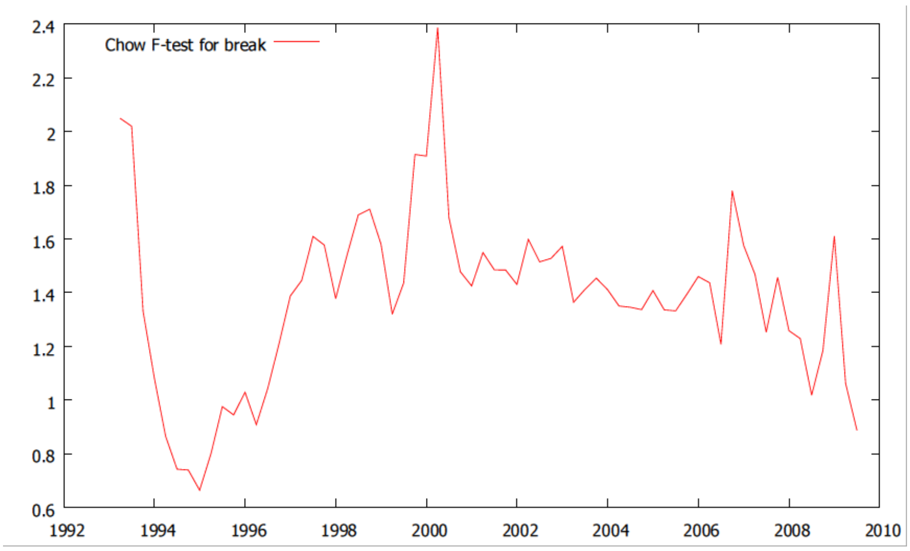
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0200038	0.00281726	7.1004	<0.00001	***
YoYM4LREex_1	0.0918259	0.025919	3.5428	0.00064	***
dummy	-0.0363168	0.00544343	-6.6717	<0.00001	***
YoYGDP_1	0.453059	0.0891117	5.0842	<0.00001	***
YoYGDP_2	0.335024	0.0941462	3.5585	0.00061	***
YoYGDP_4	-0.291836	0.0686314	-4.2522	0.00005	***

Mean dependent var	0.047987		S.D. dependent var	0.023799
Sum squared resid	0.008481		S.E. of regression	0.009931
R-squared	0.835448		Adjusted R-squared	0.825881
F(5, 86)	87.32633		P-value(F)	3.40e-32
Log-likelihood	296.8744		Akaike criterion	-581.7489
Schwarz criterion	-566.6182		Hannan-Quinn	-575.6420
rho	-0.003576		Durbin's h	-0.064769

We conducted diagnostic tests on this model. The Cusum Q test shows that potentially there is an additional structural break in 2000 (as well as the crisis in 2008).



In order to check this possibility we did a Quandt likelihood ratio test and a Chow test. Both tests confirm that there is a structural break.



Augmented regression for Chow test

OLS, using observations 1990:1-2012:4 (T = 92)
Dependent variable: YoYGDP
Omitted due to exact collinearity: sd_Crisis_D_short

	coefficient	std. error	t-ratio	p-value	
const	0.0282363	0.00839201	3.365	0.0012	***

YoYM4LREx_LPQB_1	0.136386	0.0730834	1.866	0.0656	*
Crisis_D_short	-0.0345067	0.00543551	-6.348	1.18e-08	***
YoYGDP_1	0.523891	0.174284	3.006	0.0035	***
YoYGDP_2	0.209974	0.190875	1.100	0.2746	
YoYGDP_4	-0.368863	0.151761	-2.431	0.0173	**
splitdum	-0.00702060	0.00890893	-0.7880	0.4330	
sd_YoYM4LREx_L~_1	-0.0150839	0.0784252	-0.1923	0.8480	
sd_YoYGDP_1	-0.146788	0.200357	-0.7326	0.4659	
sd_YoYGDP_2	0.156933	0.217052	0.7230	0.4718	
sd_YoYGDP_4	-0.0204926	0.171391	-0.1196	0.9051	

Mean dependent var	0.047987	S.D. dependent var	0.023799
Sum squared resid	0.007273	S.E. of regression	0.009476
R-squared	0.858895	Adjusted R-squared	0.841474
F(10, 81)	49.30401	P-value(F)	2.83e-30
Log-likelihood	303.9456	Akaike criterion	-585.8912
Schwarz criterion	-558.1515	Hannan-Quinn	-574.6952
rho	-0.066985	Durbin-Watson	2.130624

Chow test for structural break at observation 2000:2
F(5, 81) = 2.69187 with p-value 0.0266

Given the existence of the structural break in 2000, we thus introduced the dummy for 2000 described in section 5.

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