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The Lessons from QE and Other 'Unconventional' Monetary Policies – Evidence from the Bank of England

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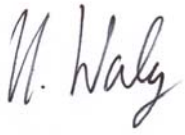

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The Lessons from QE and Other 'Unconventional' Monetary Policies – Evidence from the Bank of England

Victor Lyonnet[1] and Richard Werner[2]

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Abstract:
This paper investigates the effectiveness of the 'quantitative easing' policy, as implemented by the Bank of England in March 2009. Similar policies had been previously implemented in Japan, the U.S. and the Eurozone. The effectiveness is measured by the impact of Bank of England policies (including, but not limited to QE) on nominal GDP growth – the declared goal of the policy, according to the Bank of England. Unlike the majority of the literature on the topic, the general-to-specific econometric modeling methodology (a.k.a. the 'Hendry' or 'LSE' methodology) is employed for this purpose. The empirical analysis indicates that QE as defined and announced in March 2009 had no apparent effect on the UK economy. Meanwhile, it is found that a policy of 'quantitative easing' defined in the original sense of the term (Werner, 1994) is supported by empirical evidence: a stable relationship between a lending aggregate (disaggregated M4 lending, i.e. bank credit for GDP transactions) and nominal GDP is found. The findings imply that BoE policy should more directly target the growth of bank credit for GDP-transactions.

JEL Classification: E41, E52, E58

Keywords: Central Banking, General-to-specific Methodology, Monetary Policy, Nominal GDP Growth, Quantitative Easing

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1 Introduction

Central bank watching has for many years, if not decades, come to focus on interest rate policies and how actions of central banks might affect interest rates.[1] The preoccupation with interest rates has been so deeply ingrained that even quantitative monetary policies often get analysed in terms of their impact on interest rates. The first central bank to switch back towards a regime of monetary targeting was the Bank of Japan, which in 2001 announced a change in monetary policy, towards what it later referred to as 'quantitative easing' (QE). This policy has been analysed by economists, but the majority of empirical research on its effectiveness has focused on the impact it has had on interest rates (including the term structure of interest rates).

As Voutsinas and Werner (2010) pointed out, this created two problems. Firstly, it left researchers and policy-makers with little information about the effectiveness of such (or similar) policies on the macroeconomic variables that matter most to governments, central banks and the public at large, namely nominal GDP growth. Secondly, it did not contribute towards making the central bank more accountable for its policies, as accountability requires an assessment of how policy actions affect ultimate targets, not intermediate ones. as rendered central bank policy largely unaccountable, since accountability includes being accountable for the choice of tools and intermediate targets, in achieving a desired ultimate goal (usually nominal GDP).

Voutsinas and Werner (2010) suggested therefore to examine the effectiveness of monetary policy in a nested general model of the ultimate goal (nominal GDP growth). They employ the general-to-specific

[1] This despite the fact that there is relatively little empirical research that supports a consistent correlation or a particular direction of causation between interest rates and economic growth. Min Zhu (2011), for instance, has carefully studied the relationship between nominal interest rates and nominal GDP growth in four major economies (US, UK, Germany and Japan) and found the evidence not supportive of standard theoretical suppositions.

econometric modeling methodology (a.k.a. the 'Hendry' or 'LSE' method, following Hendry and Mizon, 1978), with the final target as the dependent variable, regressed on a large number of explanatory variables, potential and actual tools and intermediate targets that were or could have been deployed by the central bank. With this approach, the effectiveness of actual and potential tools or intermediate targets can be empirically evaluated, including the significance of announced policy changes.

The other innovation of their paper was the use of disaggregated credit as one of the explanatory variables, on the basis that credit for GDP transactions is more likely to be in a stable relationship with nominal GDP. This approach solves the problem of the 'velocity decline' that confounded earlier monetarist attempts at identifying stable empirical models of nominal GDP (see Werner, 1992, 1997).

As Voutsinas and Werner (2010) focused on the Japanese case, in this paper the same methodology is employed to assess the effectiveness of 'quantitative easing' in the UK. Their methodology appears especially relevant to the UK, because the Bank of England has stated explicitly that the ultimate target has been nominal GDP growth. In the words of Bank of England staff, the policy of quantitative easing was adopted

> "with the aim of … increasing nominal spending growth".[2]

> "…the effectiveness of the MPC's asset purchases [QE] will ultimately be judged by their impact on the wider macroeconomy.

Further, so far less empirical work has been conducted on the UK case, and none adopting this methodology. According to Bank of England staff

> "Our analysis suggests that the purchases have had a significant impact on financial markets and particularly gilt yields, but there is

[2] Joyce, Lasaosa, Stevens and Tong (2010), The financial market impact of quantitative easing, Bank of England working paper no. 393.

> clearly more to learn about the transmission of those effects to the wider economy."

It is the goal of this paper to contribute towards a better understanding of the transmission of monetary policy and the effect of particular tools and intermediate targets (actual and potential) "on the wider economy", as measured by nominal GDP.

The empirical analysis indicates that QE as defined and announced in March 2009 had no apparent effect on the UK economy. Meanwhile, it is found that a policy of 'quantitative easing' defined in the original sense of the term (Werner, 1994) is supported by empirical evidence: a stable relationship between a lending aggregate (disaggregated M4 lending, i.e. bank credit for GDP transactions) and nominal GDP is found. The findings imply that BoE policy should more directly target the growth of bank credit for GDP-transactions.

The paper is organized as follows: In section 2, the historical origin of the term 'quantitative easing' is briefly discussed, followed by a brief overview of recent international experience with QE. Section 4 surveys the literature on the effectiveness of QE (with the majority focusing on the Japanese policy). Section 5 implements a new test of the effectiveness of QE in the UK. Section 6 concludes.

2 Historical Origin of the Term 'Quantitative Easing'

Today, QE is often used synonymously with an expansion in the quantity of narrow money, figuratively referred to as 'printing money' by many commentators. The original Japanese expression for "quantitative easing" (量的金融緩和, *ryōteki kin'yū kanwa*) was used for the first time by a central bank in the Bank of Japan's publications. Indeed, in the Bank of Japan's announcement of 19 March 2001 – universally cited by commentators as the first time a policy called QE was implemented by a central bank – it is said that a high target of bank reserves held with the central bank would be set, which would (at least partly) be achieved by

purchasing more government bonds. Such a policy is identical traditional monetarist targeting of narrow money and can thus variously be called an expansion in bank reserves, high powered money, monetary base, base money, M0 or narrow money.

Since already at least half a dozen well-known expressions existed to describe the Bank of Japan's policy of March 2001 and following years, how did it happen that a new expression – yet another synonymous definition, namely 'quantitative easing' – came to be utilized by commentators and central banks?

Curiously, an analysis of the policy announcement actually made by the Bank of Japan on 19 March 2001 (Bank of Japan, 2001) shows that neither in the Japanese original statement or nor its English translation any use of the expression QE or any similar variant is made. It is only in a speech given on 9 December 2002 that the BoJ governor reckoned for the first time that the central bank was implementing QE. During the year 2001, only 11 speeches out of 29 given by the BoJ board members mention the term 'quantitative easing', and none of them claims that the policy was implemented at the Bank of Japan (in March 2001 or at any other date).

A turning point seems to have occurred when Governor Fukui (appointed in February 2003) stated in June 2003 that "The current framework [the BoJ is] adopting is called quantitative easing and was introduced on March 19, 2001". In his speech, Mr Fukui uses the expression QE 26 times, hitherto the highest use on record by a senior central banker. It is therefore not earlier than two years after its alleged start that QE was officially recognized as an important monetary policy concept.

To be sure, the Japanese central banks used the expression 'quantitative easing' often in its earlier publication – only and consistently in order to make the case that a policy by that name would not work and hence should not be introduced. Curiously, the Bank of Japan even argued right until one month before the alleged date of introduction of QE, namely until February 2001, that such a policy of "quantitative easing… is not effective" (Bank of Japan, 2001a). It produced such research, because critics of the Japanese

central bank had been using it, in order to argue that the central bank should abandon its emphasis on interest rates, and instead adopt a policy they called 'QE'.

The first time the expression QE was used prominently was in 1994, by the then economist of Jardine Fleming Securities (Asia) Ltd. in his client presentations and speeches in Tokyo. He used a macroeconomic model not reliant on frictionless markets and general equilibrium but assuming rationing and credit constraints, and incorporating a credit-creating banking sector. In his previous publications (Werner, 1991, 1992, 1994), Werner had already warned of the likely collapse of the Japanese banking system and a major economic slowdown. In the following years, Werner made recommendations about how the Japanese economy could be stimulated and the recession ended (e.g. Werner, 1995). Based on this model (published in Werner, 1997) Werner (1995) argued that neither price tools (interest rate reductions, even though they were still above 4% at the time), nor traditional bank reserves or money supply expansion would create an economic recovery.

Instead, the model indicated that the central bank should directly target and increase the quantity of credit creation by the overall banking system. Since however the Japanese-language translation of 'credit creation' can appear to be a somewhat obscure expression in modern-day Japan, Werner coined a new expression, 'quantitative easing', that would describe stimulatory monetary policy, but be differentiated from both interest rate policy and traditional monetary targeting as recommended by monetarist economists (see Werner, 1995).

During his Nov. 19, 2010 speech at the ECB, the Federal Reserve's governor Ben Bernanke stated that "quantitative easing typically refers to policies that seek to have effects by changing the quantity of bank reserves, a channel which seems relatively weak, at least in the U.S. context".[3] Why

[3] Ben Bernanke (2010), Rebalancing the Global Recovery, speech at the 6th ECB Central Banking Conference, Frankfurt, available at www.federalreserve.gov/newsevents/speech/bernanke20101119a.htm

the Bank of Japan much later chose to use this expression to refer to its traditional monetarist reserve or base money expansion (for which already a plethora of epithets existed) remains puzzling. The principle of revealed preference suggests that the Bank of Japan thought it worthwhile to introduce a new name to describe an old policy, which could not possibly be due to the substance of the policy, but instead must be due to its PR value. This therefore further highlights the need for a careful examination of the empirical evidence that a new policy was indeed introduced.

3 Overview of Recent Japanese and UK Experience with QE

The Japanese case

Japan's economy experienced significant asset price rises in the 1980s, followed by a major and protracted banking and financial crisis. The Bank of Japan responded to the weakening economy by reducing interest rates from about 8% in 1991 to 0.001% a decade later (the BoJ has maintained short-term interest rates at close to zero since 1999), and by expanding bank reserves (commercial banks were provided with excess liquidity to promote private lending and reduce the risk of a liquidity shortage).

Ugai (2006) summarises the policy announced in March 2001 (and later referred to as QE) as consisting of three components: (i) shifting the BOJ's main operating target from the uncollateralized overnight call rate to the current account balances at the Bank (CABs), and supplying ample liquidity in an amount substantially in excess of the required reserves; (ii) being committed to maintain the policy until the CPI registers stably zero percent or an increase year-on-year; and (iii) increasing the purchase of long-term Japanese Government Bonds if deemed necessary to facilitate meeting the targeted CABs. Under the QE policy, the uncollateralized overnight call rate, formerly the main operating target, declined to zero percent.

Over 4 year period starting in March 2001, the commercial banks' current account balance did indeed increase from ¥5 trillion yen to ¥35 trillion (approximately US$300 billion). As well, the BoJ tripled the quantity of long-term Japan government bonds it could purchase on a monthly basis.

In spite of these measures, Japan's central bank has been obviously unsuccessful in achieving price stability or stable economic growth: Japan holds the world record for deflation in the era of regular GDP statistics and Japan's post-crisis economic underperformance has lasted for the better part of two decades.

The UK case

As part of its response to the global banking crisis and a sharp downturn in domestic economic prospects, the Bank of England's Monetary Policy Committee (MPC) cut Bank Rate from 5% at the start of October 2008 to 0.5% on 5 March 2009. But given the likelihood of undershooting the 2% CPI inflation target in the medium term, the Committee also decided it needed to ease monetary conditions further through a programme of asset purchases financed by the issuance of central bank reserves (BoE, 2010). This programme was termed 'quantitative easing', in reference to Bank of Japan's policies earlier in the decade, referred to by this name.

Although quantitative easing is said by the BoE to have been firstly implemented in March 2009, some measures had been undertaken before that time. First, the Special Liquidity Scheme was introduced in April 2008. From that point onwards, banks and building societies were allowed to swap some of their illiquid assets (notably ABS) for liquid UK Treasury bills for a period of up to three years. As these trades are stock lending transactions they are off balance sheet. The drawdown period for the scheme closed on 30 January 2009. Furthermore, in January 2009, under a remit from the Chancellor of the Exchequer, the Bank established a subsidiary company, the Bank of England Asset Purchase Facility Fund (BEAPPF). Its initial objective was to improve the liquidity of the corporate credit market by making purchases of high-quality private sector assets.

In March 2009, the remit from the Chancellor of the Exchequer was extended to allow the MPC to use the Asset Purchase Facility to make purchases of assets (now including gilt-edged securities) in pursuit of its monetary policy aims. The MPC decided at its regular March 2009 meeting that the Bank would buy £75 billion of assets financed through the creation of central bank reserves, via the Asset Purchase Facility. Subsequently, the

Committee decided at its meeting in May 2009 to make a further £50 billion of asset purchases that would bring total purchases to £125 billion. Again, at its meeting in August, the MPC decided to finance a further £50 billion of asset purchases so that total purchases would rise to £175 billion. And at its meeting in November, the MPC voted to increase total asset purchases to £200 billion (£25 billion purchases more). The total amount of such asset purchases represents 14% of UK nominal GDP. Most of the assets purchased have been UK government securities (gilts), but high-quality private sector assets were also purchased. At its meeting in February 2010, the Committee voted to maintain the stock of asset purchases at £200 billion but the Committee will continue to monitor the appropriate scale of the asset purchase programme and reserves the right to further implement asset purchases depending on the economic outlook. Given UK's economic prospects the option of further purchasing assets is still contemplated (e.g. by MPC member Adam Posen, who called in December 2010 for a £50 billion expansion of the Bank's quantitative easing programme, whilst his colleague Andrew Sentance has called for an increase in interest rates).

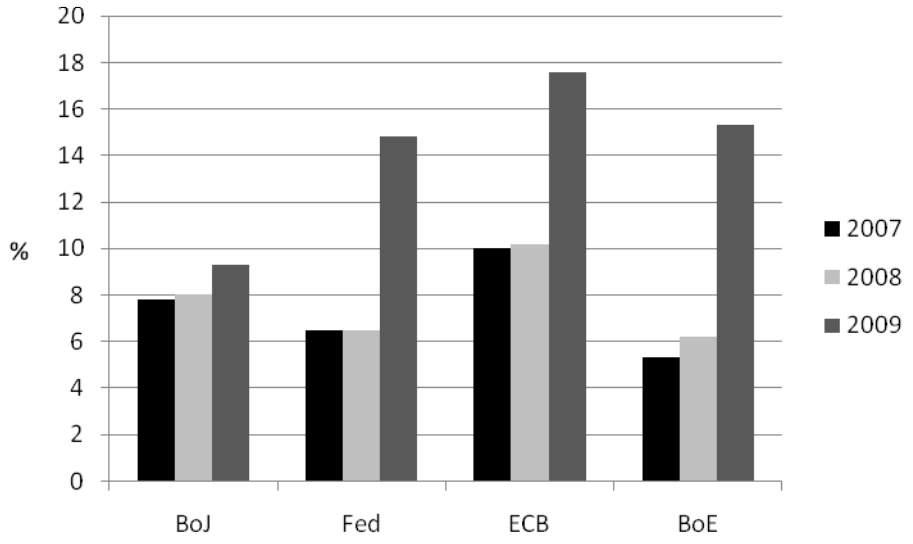
Additionally to the asset purchase programme, the Bank of England increased the average maturity of its outstanding operations. The range of collateral eligible for its longer-term repo operations was widened. This is, in contrast to the policy of QE, sometimes referred to as 'qualitative easing'.

Apart from the asset swap scheme, most of the measures taken by the Bank of England as a response to the financial crisis were instruments or procedures that already existed in the operational framework of the Bank (Lenza, Pill, and Reichlin, 2010). This suggests the possibilitythat the expression QE was chosen, just like in the Japanese case, for its potential euphemistic PR effect. The following tautological explanation from the Bank of England website would indicate a reluctance to clearly assert that its QE policy of asset purchases amounted to new money creation: "the sharp increase in reserves balances since March 2009 reflects the fact that asset purchases under the MPC's policy of Quantitative Easing have been financed by increasing reserves balances".[4]

[4] http://www.bankofengland.co.uk/mfsd/iadb/notesiadb/Central_bank_bs.htm

The scale of the Bank of England's QE policy, when measured in terms of balance sheet expansion, can be seen from Figure 1. It is similar to the Fed's and ECB's balance sheet expansion (although neither central bank formally announced the introduction of a policy called 'QE'), and significantly exceeds the Bank of Japan's. Given that some defenders of Bank of Japan policies have argued that the Japanese QE was merely not large enough, it is also interesting to examine how the much larger UK version has fared.

Figure 1: Central banks balance sheets relative to GDP



Notes: The data shown refer to end-June. The measure of central bank balance sheet size is total assets on the central bank balance sheet.
Source: Lenza (2010), Bank of Japan; Federal Reserve European Central Bank; Bank of England

4 The Literature on the Effectiveness of QE

Much of the literature on the effectiveness of particular policy tools, including QE, has been produced by central bank employees (Voutsinas and Werner, 2010), and it mostly focuses on the Japanese implementation of QE. Joyce, Lasaosa,, Stevens, and Tong (2010); as well as Kobayashi and Spiegel (2006); Lenza, Pill, and Reichlin (2010); and Shiratsuka (2010) and Ugai (2005, 2006) have been writing about QE and its assessment as staff members from either the Bank of Japan, the European Central Bank or the

Federal Reserve.

Voutsinas and Werner (2010) argue that the performance of central bank policy can be measured either in terms of processes ('process-based performance', which they chose to christen 'input performance') or relevant final economic outcomes ('result performance', 'outcome performance' or, their preferred term, 'output performance').

"Output performance" assessment of QE

Examples of empirical work on 'output performance' are Parking and Bade, (1980), Emerson et al. (1991), Cukierman et al. (1992), Alesina and Summers (1993), Hasan and Mester (2008), usually focusing on inflation performance. While this is in many ways the natural way to approach central bank performance measurement, it remains agnostic about the details of the monetary transmission mechanism and fails to engage in any debate concerning the suitability of particular monetary policy instruments, intermediary targets or approaches (i.e. by leaving 'input performance' up to the central bank). To a great extent, empirical analysis of the effects of monetary policy has treated the monetary transmission mechanism itself as a "black box" (Bernanke and Gertler, 1995). Udai (2006) also stresses that "the transmission channels cannot be specified, [although] analyses find that the QEP had the effects of dispelling the funding concerns of financial institutions". An "output-oriented" assessment of QE is made by Lasaosa, Stevens and Tong (2010): they study the impact of QE on financial markets, claiming that "the place where we might have expected to see the clearest direct impact of QE is in the reaction of financial markets. This in turn may provide the most timely and clearest read on the effectiveness of the policy and how it might be feeding through to the rest of the economy". Their paper finally comes to the conclusion that "on balance, […] the largest part of the impact of QE came through a portfolio rebalancing channel".

"Input performance" assessment of QE

The literature on the effectiveness of specific monetary policy instruments,

tools or intermediate targets under circumstances of extremely low interest rates is an example of empirical work on 'input performance'. The literature analysing the effectiveness of monetary policy under conditions of extremely low interest ('zero interest' or 'zero bound') and/or the specific monetary policy instrument called 'quantitative easing' (QE), has defined the 'effectiveness' of such monetary policy not in terms of a final economic outcome, such as nominal GDP growth. Instead, the criterion for performance measurement is process-based 'input performance'; namely, whether such policy had an impact on interest rates, another intermediate target. At the same time, the empirical research fails to present evidence that interest rates are a reliable proxy for any relevant output performance goal.

Some theoretical work asks whether a shift to the quantity of money as an operational tool could substitute for lacking manoeuvrability of interest rates (Ueda, 2005, Oda and Ueda, 2007, Blinder, 2000, Orphanides and Wieland, 1998). Most authors propose a theoretical general equilibrium model with rational expectations, including Krugman (1998), Fujiki, Okina and Shiratsuka (2001), Woodford (2003), Svensson (2003), Eggertsson and Woodford (2003) and Benhabib, Schmitt-Grohé and Uribe (2003). Bernanke, Reinhart and Sack (2004) also measure policy effectiveness by the success in lowering long-term interest rates (and find negative results in the case of Japan).

This literature tends to share the assumptions of complete and efficient financial markets, whereby no agents face any constraints on their ability to borrow against future income. Instead of featuring a mechanistic monetary transmission mechanism, the models rely on the role of (unobservable) expectations and their impact on interest rates, which are assumed to be the main component of monetary transmission.

The assumptions stated above broadly led researchers to define the 'effectiveness' of QE as its effectiveness on interest rates (whether only short-term rates, as for instance in Krugman, 1998, or "the entire expected future path of short-term real rates, or very long term real rates" in Eggertsson and Woodford, 2003). In such models, the only way to stimulate the economy is through a change in the general equilibrium level of interest.

In the words of Eggertsson and Woodford (2003): "'quantitative easing' that implies no change in interest-rate policy should neither stimulate real activity nor halt deflation; and this is equally true regardless of the kind of assets purchased by the central bank". Udai (2005) reported that "the largest effect of QE found in form of its impact on expected future short-term interest rates". Fujiki et al. (2001), employees of the BoJ, denied the effectiveness of QE in February 2001 because of the zero interest rate lower bound, although QE was reported to have been introduced by their employer one month later. Notably, they define QE as an expansion in bank reserves and/or increased open market purchases. BoJ staff, Kimura et al. (2002) and Shirakawa (2002) chose the same definition of QE, which is identical to the policy adopted by the BoJ in March 2001. Measuring the effectiveness of this policy by the impact it had on interest rates, they conclude that one year after introduction, QE was not effective. It fits the findings of Ueda (2005), who argued that with a near zero nominal interest rate, "there are serious limitations to what a central bank can do to increase the rate of inflation significantly". Likewise, Kobayashi, Spiegel and Yamori (2006) find that "quantitative easing succeeded in reducing longer-term rates, and excess returns were larger among firms with weaker main banks". In their 2007 paper, Oda and Ueda (2007) share this optimistic view: they infer that the zero interest rate commitment has been effective in "lowering the expectations component of interest rates, especially with short- to medium-term maturities".

Focus on input performance has another drawback: Fujiki et al. (2001) conjectured that QE was ineffective, as long-term yields remained low ('indicating financial-market expectations that deflation will persist'). Blinder (2000), Kimura et al. (2002), Shirakawa (2002) and Ueda (2005) came to the same type of conclusion. This is of interest, since it indicates that the definition of 'effectiveness' of a policy tool, when framed in terms of input performance, may vary greatly, depending on the central bank's interpretation: By contrast, Oda and Ueda (2007), Orphanides and Wieland (1998), Kobayashi, Spiegel and Yamori (2006) and the Bank of England staff members have argued that low bond yields are a reflection of successful QE, as the bond purchase operations are said to be the reason for lower long-term interest rates (see, for instance, Miles, 2009).

We conclude that, surprisingly, the literature on quantitative easing and unorthodox monetary policy (including the literature on 'zero interest rate policy' or monetary policy at the 'lower interest rate bound') has largely confined itself to an analysis of the impact of such policies on another intermediate target, namely interest rates (including the term structure), while neglecting the influence on the variable that matters most to policy makers, businesses and households, especially in times of low inflation: nominal GDP

Gaps in the literature and contribution of this paper

Most of the literature on monetary policy and quantitative easing share some common weaknesses:

a) Assumptions: The literature often makes result-critical though unrealistic assumptions, such as assuming no friction or financial constraints. Many models do not feature banks, and if they do, they are not distinguished from non-bank financial intermediaries. There is considerable empirical evidence that banks are 'special' (e.g. Fama, 1985, Ashcraft, 2005), yet the literature on QE fails to incorporate banks in models that afford them special features not offered by non-bank financial intermediaries. The reliance on expectations as the sole transmission mechanism also raises a number of analytical problems.[5] It precludes the possibility of a direct, more mechanical transmission of monetary policy, as is frequently called for (e.g. Bernanke et al., 2004, Miles, 2009, Werner,

[5] This strand of literature suffers from and at times concedes the time inconsistency problem identified by Kydland and Prescott (1977), which renders monetary policy ineffective.

1997).[6] There is a gap in the literature on QE concerning less idealised and more realistic models of the economy that include financial friction and constraints, imperfect information and a plausible model of why banks are 'special'.

b) The role of interest rates: The majority of the literature focuses on the impact of QE on interest rates, but does not feature empirical tests of the actual relationship of monetary policy instruments in general, and interest rates in particular, with final policy targets (such as nominal GDP). Were nominal interest rates not in the assumed negative and causal relationship with nominal GDP growth, the measurement of the effectiveness of QE by quantification of their impact on interest rates, as most analysts performed, would be invalid.

c) Assumed structural breaks: The literature often assumes but rarely tests for a structural break in the era of near-zero interest rates. The admission of a structural break suggests that the models employed are not sufficiently robust to allow for diverse circumstances. In the case of the Bank of England, the structural break is supposed to have taken place, when the Monetary Policy Committee cut Bank Rate to 0.5%, namely on 5 March 2009. Should more robust models without structural break be found, they would be preferable.

5 An Empirical Evaluation of the Effectiveness of QE

[6] Bernanke et al. (2004) have pointed out that the assumptions of frictionless financial markets and complete separation of monetary and fiscal policies which characterise this literature "to be sure, are rather strong. If these assumptions do not hold, we may have some basis for believing that quantitative easing will be effective. " (p. 18). While remaining "agnostic about the precise mechanisms by which quantitative easing may have its effect" Bernanke et al. point to "the undeniable fact that, historically, money growth and inflation have tended to be strongly associated. It follows, according to this argument, that money creation will raise prices independent of its effects on the term structure" (p. 18).

By employing a different empirical methodology that does not require untested assumptions about the functioning of the economy or the operation of intermediary tools, the authors aim to address some of the gaps in the literature. The paper combines the measurement of output performance with input performance, by relating performance measurement to a final target variable. Adopting the same approach as Voutsinas and Werner (2010), the authors examine the performance of actual and potential monetary policy instruments and intermediary targets in explaining a final policy target variable, and conducting a 'horse race' test between them.

The empirical data are from the Bank of England, which introduced and carried out 'quantitative easing' from March 2009 onwards. No ending date has been officially stated yet. Based on the results, meaningful conclusions can be made concerning the actual performance of central bank's policies, as well as for other countries that have adopted similar policies.

The authors propose to test the different tools at the disposal of the central bank and try to infer from this the "best practice" macroeconomic and monetary policies. None of the effects of conventional and un-conventional monetary policy is taken for granted, and all key tools and instruments of the BoE are under examination.

5.1 Methodology

We regress a generally accepted final target variable for monetary policy on a list of potential and actual central bank tools, instruments and intermediate targets (including different interpretations of what could be meant with 'quantitative easing'). Officially, the Bank of England aims not only at a particular inflation target, but also at a "… healthy and successful economy"[7], and considers its QE policy, as cited at the outset, a means to boost "nominal spending" and "the wider economy". This is in line with the aims of governments, businesses and the general public: their main interest is nominal GDP growth, as wages, revenues and profits are in nominal terms. Thus a significant number of macroeconomists from various

[7] http://www.bankofengland.co.uk/financialstability/financialsystem/index.htm

persuasions agree (unusually in this profession) that a nominal GDP growth target more readily reflects the objectives of governments and economic agents (Tobin, 1980, Bean, 1983, Meade, 1984, Gordon, 1985, Hall, 1985, Taylor, 1985, McCallum, 1997, 1999, Frankel, 1995).

The literature on central bank performance has identified price stability, maximum economic growth, and stable currencies as the three key outputs of monetary policy.[8] Prices and output can be examined in one combined target variable, nominal GDP, without the need of separating the two.

In order to establish empirically, based on historical relationships, which policy tools and instruments are more likely to be useful in influencing nominal GDP growth, the general-to-specific model selection methodology (the 'London School of Economics methodology', also known as the 'Hendry method') is adopted. The general-to-specific methodology tends to produce robust and stable models (see e.g. Bauwens and Sucarrat, 2005).[9] It allows all competing monetary policy tools, intermediary instruments and differing interpretations of 'quantitative easing' to be equally represented in the first general model, whose features and statistical characteristics can also be tested (see Campos, Ericsson and Hendry, 2005).

After the formulation of the general model, an objective sequential procedure of downward reduction to the parsimonious form is adopted, which amounts to a horse-race between the contenders. It also enables us to

[8] Hasan and Mester (2008, p. 6) state: "…while the tasks assigned to particular central banks have changed over the years, their key focus remains macroeconomic stability, including stable prices (low inflation), stable exchange rates (in some countries), and fostering of maximum sustainable growth (which may or may not be explicitly listed as a goal of the central bank in enabling legislation). See, e.g., Tuladhar (2005), Siebert (2003), Lybek (2002), McNamara (2002), and Healey (2001), Amtenbrink (1999), Maier (2007), and Caprio and Vittas (1995)." Not everyone shares the focus on maximum growth. Cecchetti and Krause (2002) define central bank performance as a weighted average of output and inflation variability.

[8] "The GETS models are relatively consistent in that they tend to be more accurate than the benchmark models on most horizons and according to both our forecast accuracy measures." . Bauwens and Sucarrat, 2005.

assess the relative performance of the competing policy models.[10] This empirical benchmark can then be compared with particular actions taken by central banks in order to assess their likely relevance or effectiveness. The findings are likely to aid the design of effective monetary policy in general, and measure the effectiveness of 'quantitative easing' in particular.

In theory, QE can be implemented by combining the two elements of the central bank balance sheet, namely size and composition (Bernanke and Reinhart, 2004). The size means extending the balance sheet, while keeping its composition unchanged (narrowly defined quantitative easing). The composition corresponds to changing the composition of the balance sheet, while keeping its size unchanged by replacing conventional assets with unconventional assets (narrowly defined credit easing).

In a financial and economic crisis, both the asset and liability sides of the central bank balance sheet play an important role in countering the adverse effects stemming from the financial system. The asset side works as a substitute for private financial intermediation, for example, through the outright purchase of credit products. The liability side, especially expanded excess reserves, functions as a buffer for funding liquidity risk in the money markets.

The following potential central bank policy instruments or intermediary targets have been cited in the literature:

(a) Price tool: interest rates. The **Bank Rate**, the United Kingdom's policy rate, will be the relevant variable.
(b) Quantity tool I: traditionally, monetarist theory emphasised 'high powered money' (aka monetary base), which consists of two components: notes and coins in circulation and banks' reserves held in their accounts with the central bank. The relevant variable is thus **bank reserves**.
(c) Quantity tool II: it has been argued by the literature that the central

[10] Theoretical discussions about the usefulness of a particular tool may turn out to be futile if this tool is not significant as an explanatory variable of the target variables.

bank's balance sheet may be considered a tool of quantitative monetary policy (e.g. Bernanke et al., 2004). Specifically, the role of purchases of long-term assets, mainly government bonds, by the central bank is emphasised. This policy tool can most simply be quantified by considering the growth of **central bank total assets**, in addition to the:

(d) 'Quality tool': the role of the composition of the central bank's balance sheet. Willem Buiter has proposed a terminology to distinguish *quantitative easing*, or an expansion of a central bank's balance sheet, from what he terms *qualitative easing*. He says "*qualitative easing* is a shift in the composition of the assets of the central bank towards less liquid and riskier assets, holding constant the size of the balance sheet". While a more complex analysis of the impact of various aspects of the composition of the central bank balance sheet on the target variables may be of interest in the future, here the basic **ratio of long-term central bank assets to total assets** is tested. These are defined to include both government bonds and direct loans to legal entities.

(e) Intermediate target I: the money supply. Monetary aggregate M4 will be taken into account, as it provides an accurate estimation for monetary holdings in the economy as a whole.

(f) Intermediate target II: bank credit. There is a substantial body of literature, including the so-called 'credit view' that considers bank lending important and 'special' (see e.g. Bernanke and Gertler, 1995). A further innovation in this paper is the use of a more refined credit aggregate, namely **bank credit to the real economy** (excluding the sectors closely associated with non-GDP, financial transactions) which has been shown to be superior theoretically and empirically in accounting for nominal GDP (Werner, 1997, 2005).

The *personae dramatis* of the econometric analysis can thus be summarised in Table 1, including their abbreviations in the econometric model. The sources and construction of the variables defined above can be found in annex 1.

Table 1: Variables in the Empirical Model

Policy instrument or intermediary target	**Relevant variable in the UK**	**Abbreviation in econometric model**
Interest rates	Bank Rate	Bankrate
Bank reserves	Reserves	YoYRes
Asset purchases	BoE B/S	YoYBoETA
'Qualitative easing'/balance sheet composition	Ratio of long-term assets of central bank B/S	QualEasing
Money supply	M4 (holdings of the entire economy)	M4
Bank credit to the 'real economy' (M4 lending)	M4 lending to all sectors except the financial one (non-financial corporations, individuals, unincorporated businesses and non-profit institutions serving households[11])	M4LRE

5.2. Empirical Findings

The general model

After stationarity tests have confirmed that all variables (except interest rates) are I(2) processes, year-on-year growth rates are calculated (except for interest rates) and the general model with nominal GDP as dependent variable is formulated. As discussed, the independent variables are the Bankrate (Bankrate), the bank reserves at the central bank (Res), the proportion of long-term assets on the central bank's balance sheet (QualEasing), BoE total assets (BoETA), the traditional money supply measure M4 and the measure of broad credit used for GDP transactions (M4LRE). The general model is shown below in Table 2 (Eq 1). Tests of the error normality properties of the model found no problems.

Table 2: The General Model

[11] See annex for further explanation.

EQ(1) Modelling YoYnGDP by OLS

The estimation sample is: 1995 (2) to 2010 (4)

	Coefficient	Std Error	t-value	t-prob	Part.R^2
YoYnGDP_1	0.298944	0.1695	1.76	0.089	0.1000
YoYnGDP_2	0.224352	0.2097	1.07	0.294	0.0393
YoYnGDP_3	0.140846	0.2132	0.661	0.514	0.0153
YoYnGDP_4	-0.352793	0.1693	-2.08	0.046	0.1342
Constant	0.000882557	0.01616	0.0546	0.957	0.0001
M4LRE	0.173137	0.09527	1.82	0.080	0.1055
M4LRE_1	0.169488	0.1398	1.21	0.235	0.0499
M4LRE_2	0.163549	0.1194	1.37	0.182	0.0628
M4LRE_3	-0.146529	0.1580	-0.928	0.362	0.0298
M4LRE_4	-0.144046	0.1716	-0.839	0.408	0.0245
BankRate	0.00823152	0.006833	1.20	0.238	0.0493
BankRate _1	-0.00532145	0.01021	-0.521	0.606	0.0096
BankRate _2	0.000264448	0.009891	0.0267	0.979	0.0000
BankRate _3	-0.00205284	0.009510	-0.216	0.831	0.0017
BankRate _4	0.00374993	0.005484	0.684	0.500	0.0164
YoYBoETA	-0.00157570	0.007663	-0.206	0.839	0.0015
YoYBoETA_1	-0.00342880	0.008335	-0.411	0.684	0.0060
YoYBoETA_2	-0.000928474	0.008945	-0.104	0.918	0.0004
YoYBoETA_3	0.00891243	0.009727	0.916	0.367	0.0291
YoYBoETA_4	-0.0259946	0.008612	-3.02	0.005	0.2455
YoYRes	-2.08736e-005	3.403e-005	-0.613	0.545	0.0133
YoYRes_1	-1.40251e-005	3.436e-005	-0.408	0.686	0.0059
YoYRes_2	1.06650e-005	3.380e-005	0.316	0.755	0.0035
YoYRes_3	-9.35783e-006	3.362e-005	-0.278	0.783	0.0028
YoYRes_4	-2.42223e-005	3.272e-005	-0.740	0.465	0.0192
QualEasing	0.00351896	0.008783	0.401	0.692	0.0057
QualEasing_1	-0.00983846	0.009851	-0.999	0.326	0.0344
QualEasing_2	-0.00108053	0.008151	-0.133	0.895	0.0006
QualEasing_3	0.00288414	0.008277	0.348	0.730	0.0043
QualEasing_4	-0.00890442	0.007149	-1.25	0.223	0.0525
M4	-0.0110177	0.08743	-0.126	0.901	0.0006
M4_1	0.0525224	0.1264	0.415	0.681	0.0061
M4_2	-0.180663	0.1332	-1.36	0.186	0.0617
M4_3	0.214646	0.1416	1.52	0.141	0.0759
M4_4	-0.105140	0.1076	-0.977	0.337	0.0330

sigma	0.00901254	RSS	0.0022743234
R^2	0.940333	F(34,28) =	12.98 [0.000]**
log-likelihood	232.827	DW	2.33
no.of observations	63	no. of parameters	35
mean(YoYnGDP)	0.047609	var(YoYnGDP)	0.000605035

AR 1-4 test: F(4,24) = 2.0656 [0.1170]

ARCH 1-4 test:	F(4,20) =	0.42292 [0.7902]
Normality test:	Chi^2(2) =	2.5366 [0.2813]
Not enough observations for hetero test		
RESET test:	F(1,27) =	0.20241 [0.6564]

The parsimonious model

Following the 'gets' methodology, this general model is reduced to its parsimonious form by sequentially dropping the most insignificant coefficient and then re-estimating the new model after each single variable omission, until all coefficients are significant at the 5% level. Additionally, the downward reduction is checked for validity using F-tests and linear restriction tests (the progress report in PcGive). As a cut-off for the validity of the reduction progress, the 1% level was chosen. The result is the following parsimonious form (Table 3):

Table 3: The Parsimonious Model A

EQ(2) Modelling YoYnGDP by OLS

The estimation sample is: 1995 (2) to 2010 (4)

	Coefficient	Std Error	t-value	t-prob	Part.R^2
YoYnGDP_1	0.386947	0.08096	4.78	0.000	0.2934
YoYnGDP_4	-0.352793	0.07887	-4.47	0.000	0.2665
Constant	-0.0130521	0.004467	-2.92	0.005	0.1343
M4LRE	0.180465	0.05314	3.40	0.001	0.1733
M4LRE_1	0.214432	0.06737	3.18	0.002	0.1556
Bankrate	0.00706230	0.001161	6.08	0.000	0.4021
YoYBoETA_4	-0.0143186	0.002760	-5.19	0.000	0.3286
QualEasing_1	-0.00903374	0.003037	-2.97	0.004	0.1386

sigma	0.00811532	RSS	0.00362220987
R^2	0.904972	F(7,55) =	74.83 [0.000]**
log-likelihood	218.167	DW	2.02
no.of observations	63	no. of parameters	8
mean(YoYnGDP)	0.047609	var(YoYnGDP)	0.000605035

AR 1-4 test:	F(4,51) =	0.65049 [0.6292]
ARCH 1-4 test:	F(4,47) =	0.44625 [0.7745]
Normality test:	Chi^2(2) =	0.34775 [0.8404]
hetero test:	F(14,40) =	0.63192 [0.8222]
hetero-X test:	F(35,19) =	0.70570 [0.8185]
RESET test:	F(1,54) =	2.1717 [0.1464]

Solved static long run equation for YoYnGDP

	Coefficient	Std Error	t-value	t-prob
Constant	-0.0135164	0.004930	-2.74	0.008
M4LRE	0.408945	0.06910	5.92	0.000
CallRate	0.00731355	0.0006461	11.3	0.000
YoYBoETA	-0.0148280	0.002612	-5.68	0.000
QualEasing	-0.00935512	0.003057	-3.06	0.003

Long-run sigma = 0.00840402

ECM = YoYnGDP + 0.0135164 - 0.408945*M4LRE - 0.00731355*CallRate + 0.014828*YoYBoETA + 0.00935512*QualEasing;

WALD test: Chi^2(4) = 304.295 [0.0000] **

Analysis of lag structure, coefficients:

	Lag 0	Lag 1	Lag 2	Lag 3	Lag 4	Sum	SE(Sum)
YoYnGDP	-1	0.387	0	0	-0.353	-0.966	0.111
Constant	-0.0131	0	0	0	0	-0.0131	0.00447
M4LRE	0.18	0.214	0	0	0	0.395	0.0575
CallRate	0.00706	0	0	0	0	0.00706	0.00116
YoYBoETA	0	0	0	0	-0.0143	-0.0143	0.00276
QualEasing	0	-0.00903	0	0	0	-0.00903	0.00304

Tests on the significance of each variable

Variable	F-test	Value [Prob]	Unit-root t-test
YoYnGDP	F(2,55) =	20.535 [0.0000]**	-8.7328**
Constant	F(1,55) =	8.5358 [0.0050]**	
M4LRE	F(2,55) =	24.972 [0.0000]**	6.8683
CallRate	F(1,55) =	36.984 [0.0000]**	6.0815
YoYBoETA	F(1,55) =	26.919 [0.0000]**	-5.1884
QualEasing	F(1,55) =	8.8468 [0.0044]**	-2.9744

Tests on the significance of each lag

Lag 1 F(3,55) = 32.002 [0.0000]**

Lag 4 F(2,55) = 18.738 [0.0000]**

Tests on the significance of all lags up to 4

Lag 1 - 4 F(5,55) = 29.945 [0.0000]**

Lag 2 - 4 F(2,55) = 18.738 [0.0000]**

Lag 3 - 4 F(2,55) = 18.738 [0.0000]**

Lag 4 - 4 F(2,55) = 18.738 [0.0000]**

As can be seen, parsimonious model A has no noticeable problems and

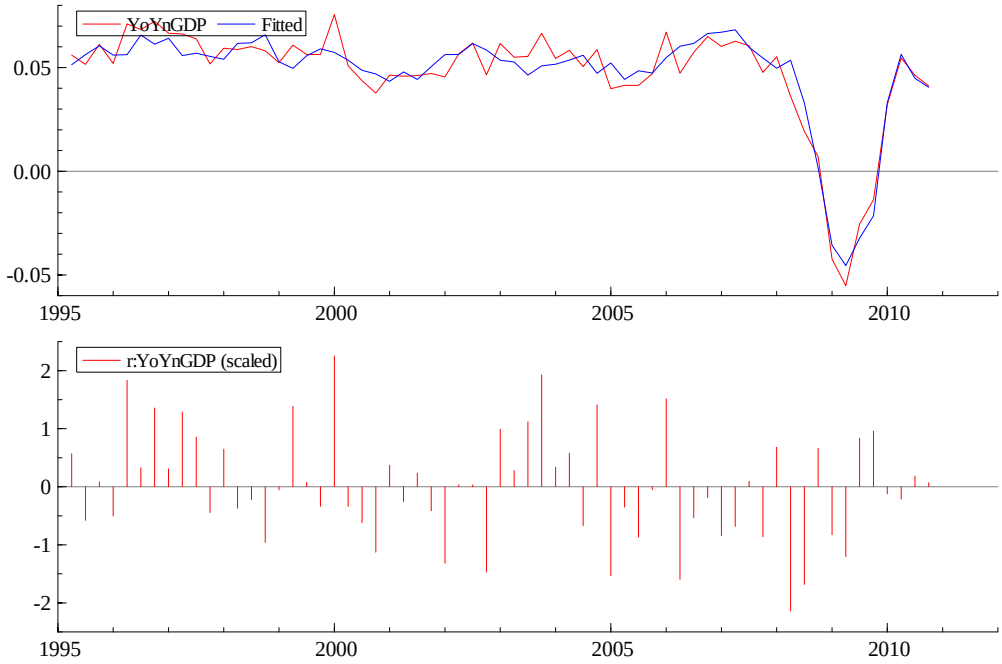
appears to be a valid empirical model of nominal GDP growth. No significant variables were dropped at this point. Three issues arise:

a) Bankrate has a positive sign.
b) Bank of England total assets have a negative sign. This may be due to data issues. The authors learned from conversations with the BoE staff that the time series for the assets of the BoE *prior* to 2006, comprising "advances and other accounts" (AEFK) relates to the BoE's participation in the TARGET system which began with the introduction of the Euro in January 1999[12]. Therefore the apparent role of BoE total assets may be overstated.
c) The coefficient of qualitative easing is found to be negatively correlated with nominal GDP.

The charts of the actual and fitted curves for nominal GDP growth are shown in Figure 1.

Figure 1 – Actual and fitted nominal GDP (model A), Error terms

[12] footnote on the series in question (AEFK): "*The large increases in Reserves and other accounts, and Advances and other accounts from January 1999 arise from the Bank of England's role in TARGET, as a result of which other European central banks may hold substantial credit balances or overdrafts with the Bank.*" Also, the subsequent fall in December 2000 is almost certainly related to the below extract from the Bank's 2001 annual report: "*The size of Banking Department's balance sheet has, for the past two years, been largely determined by the bilateral positions between central banks in the TARGET system. As explained in previous years these balances reflected the net flows between the individual countries through the central banks and fluctuated with such payments. Although the net position was what mattered for most operational purposes, the individual balances were with different legal entities and had therefore to be shown gross under UK accounting rules. A netting arrangement was implemented from 30 November 2000, under which the bilateral balances that arise intra-day between the central banks are netted into a single position with the European Central Bank.*"



Given these empirical issues with Bank of England assets and maturity composition of the balance sheet (qualitative easing), parsimonious model A was further reduced, by dropping QualEasing, as well as the first lag of M4 lending to the real economy (M4LRE) from the equation. This leads to parsimonious model B (see table 4).

Table 4: Parsimonious Model B

EQ(3) Modelling YoYnGDP by OLS

The estimation sample is: 1995 (2) to 2010 (4)

	Coefficient	Std Error	t-value	t-prob	Part.R^2
YoYnGDP_1	0.565444	0.07106	7.96	0.000	0.5263
YoYnGDP_4	-0.362486	0.08513	-4.26	0.000	0.2413
Constant	-0.00693162	0.004596	-1.51	0.137	0.0384
M4LRE	0.271940	0.04902	5.55	0.000	0.3506
BankRate	0.00588350	0.001257	4.68	0.000	0.2778
YoYBoETA_4	-0.00998374	0.002834	-3.52	0.001	0.1788

sigma	0.00909157	RSS	0.00471143312
R^2	0.876396	F(5,57) =	80.83 [0.000]**

log-likelihood	209.885	DW	2.37
no.of observations	63	no. of parameters	6
mean(YoYnGDP)	0.047609	var(YoYnGDP)	0.000605035

AR 1-4 test:	F(4,53) =	1.4870 [0.2193]
ARCH 1-4 test:	F(4,49) =	0.73266 [0.5741]
Normality test:	Chi^2(2) =	1.2823 [0.5267]
hetero test:	F(10,46) =	0.99101 [0.4648]
hetero-X test:	F(20,36) =	0.93742 [0.5494]
RESET test:	F(1,56) =	2.0787 [0.1549]

Solved static long run equation for YoYnGDP

	Coefficient	Std Error	t-value	t-prob
Constant	-0.00869668	0.006139	-1.42	0.162
M4LRE	0.341186	0.08070	4.23	0.000
CallRate	0.00738167	0.0008602	8.58	0.000
YoYBoETA	-0.0125260	0.003385	-3.70	0.000
QualEasing	-0.00935512	0.003057	-3.06	0.003

Long-run sigma = 0.0114066

ECM = YoYnGDP + 0.00869668 - 0.341186*M4LRE - 0.00738167*CallRate + 0.012526*YoYBoETA;

WALD test: Chi^2(3) = 158.023 [0.0000] **

Analysis of lag structure, coefficients:

	Lag 0	Lag 1	Lag 2	Lag 3	Lag 4	Sum	SE(Sum)
YoYnGDP	-1	0.565	0	0	-0.362	-0.797	0.115
Constant	-0.00693	0	0	0	0	0.272	0.049
M4LRE	0.18	0.214	0	0	0	0.395	0.0575
BankRate	0.00588	0	0	0	0	0.00588	0.00126
YoYBoETA	0	0	0	0	-0.00998	-0.00998	0.00283

Tests on the significance of each variable

Variable	F-test	Value [Prob]	Unit-root t-test
YoYnGDP	F(2,57) =	43.404 [0.0000]**	-6.9447**
Constant	F(1,57) =	2.2741 [0.1371]	
M4LRE	F(1,57) =	30.776 [0.0000]**	5.5476
CallRate	F(1,57) =	21.925 [0.0000]**	4.6824
YoYBoETA	F(1,57) =	12.407 [0.0008]**	3.5224

Tests on the significance of each lag

Lag 1 F(1,57) = 63.317 [0.0000]**

Lag 4 F(2,57) = 12.075 [0.0000]**

Tests on the significance of all lags up to 4

Lag 1 - 4 F(3,57) = 35.373 [0.0000]**

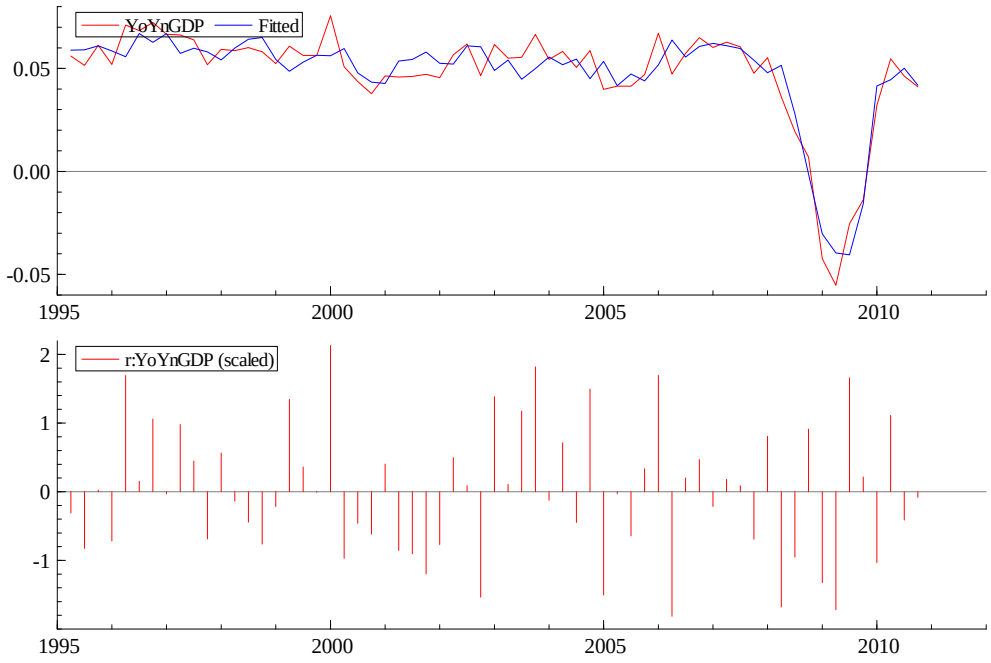
Lag 2 - 4 F(2,57) = 12.075 [0.0000]**

Lag 3 - 4 F(2,57) = 12.075 [0.0000]**

Lag 4 - 4 F(2,57) = 12.075 [0.0000]**

Parsimonious model B has no noticeable problems either. The charts of the actual and fitted curves for nominal GDP growth are shown in Figure 2. This model seems valid as an empirical model of nominal GDP growth, although some stars come up in the tests of model reduction (PCGive's "progress test"). These stars are the result of the omission of significant variables in this model (QualEasing_1 and M4LRE_1).

Figure 2 – Acutal and fitted nominal GDP (model B), Error terms



Granger-causality tests show that there is evidence for unidirectional 'causality' from lending variable M4LRE to nominal GDP, and not in the other direction (Table 5).

Table 5: Granger 'causality' test: Autoregressive Distributed Lag Model

Test on the significance of independent variable	nGDP dependent M4LRE independent	nGDP independent M4LRE dependent
Dynamic Analysis:	F(4,54) = 7.7773 [0.0001]**	F(4,54) = 2.3729 [0.0636]

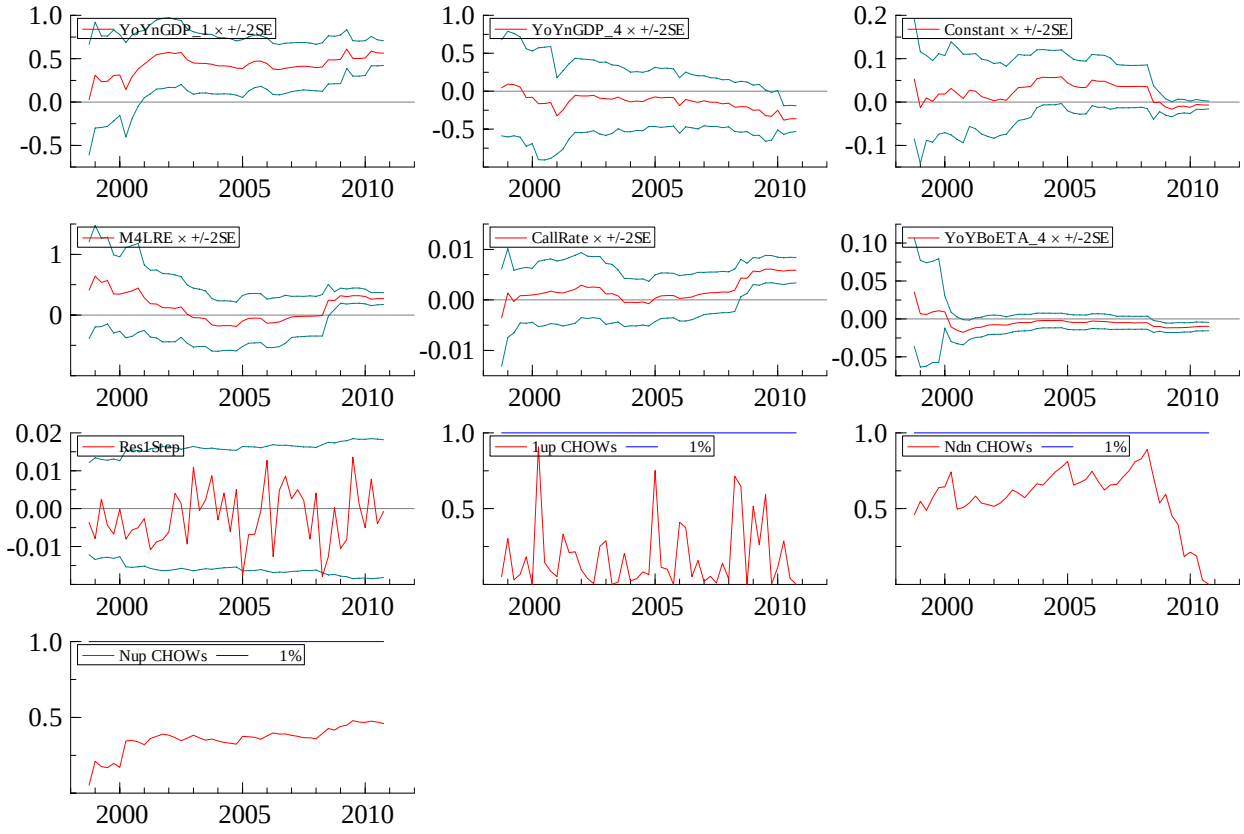
Finally, structural break tests are conducted, to examine whether there were any breaks in the relationship between nominal GDP and monetary variables.

First, the recursive graphical tests are shown in Figure 2. We tested for structural breaks in March 2009 – the official date of implementation of QE - but also in quarter 2 of 2006, when the series for BoE assets began to be calculated differently (new methods were applied due to reforms to the Bank of England's money market operations on 18 May 2006[13] and the data collection changed).

As can be seen, there is no indication that a structural break occurred either in March 2009, when 'quantitative easing' was said to have been adopted, or in 2006, when the new money market reforms were introduced.

[13] See http://www.bankofengland.co.uk/statistics/ms/articles/artjun06.pdf

Figure 2: Recursive Structural Break Tests



A more precise test of whether the relationship between nominal GDP and its explanatory variables changed in the period of 2009 Q1 - when the BoE is said to have implemented QE – or in 2006 Q2 – when new money market reforms and data collection methods were first implemented by the BoE - can be conducted by the inclusion of a dummy variable. We introduced the dummies in the general model and in the two parsimonious forms. In the downward reduction process, the dummy for QE drops out at an early stage. The dummies are found to be insignificant (tables 6 and 7). Models A and B with dummies did not show any problem. The F-tests for exclusion of the dummies indicated that they can be dropped. The final forms, identical with the above, did not have any statistical problems (see Tables 3 and 4 for the former case).

Table 6: Dummy Variable for QE and 2006 in parsimonious model A

EQ(4) Modelling YoYnGDP by OLS

The estimation sample is: 1995 (2) to 2010 (4)

	Coefficient	Std Error	t-value	t-prob	Part.R^2
YoYnGDP_1	0.366317	0.07738	4.73	0.000	0.2972
YoYnGDP_4	-0.412926	0.1054	-3.92	0.000	0.2247
Constant	-0.00225855	0.01199	-0.188	0.851	0.0007
M4LRE	0.144192	0.05284	2.73	0.009	0.1232
M4LRE_1	0.216470	0.07707	2.81	0.007	0.1296
BankRate	0.00661335	0.001257	5.26	0.000	0.3431
YoYBoETA_4	-0.0136886	0.002982	-4.59	0.000	0.2845
QualEasing_1	-0.0114332	0.003011	-3.80	0.000	0.2139
Dummy2006	-0.00783052	0.002803	-2.79	0.007	0.1283
DummyQE	-0.00207126	0.009874	-0.210	0.835	0.0008

sigma	0.00770752	RSS	0.00314851483
R^2	0.917399	F(9,53) =	65.4 [0.000]**
log-likelihood	222.582	DW	2.14
no.of observations	63	no. of parameters	10
mean(YoYnGDP)	0.047609	var(YoYnGDP)	0.000605035

AR 1-4 test:	F(4,49) =	0.18071 [0.9473]
ARCH 1-4 test:	F(4,45) =	0.54453 [0.7039]
Normality test:	Chi^2(2) =	0.57279 [0.7510]
hetero test:	F(16,36) =	0.63637 [0.8327]
Not enough observations for hetero-X test		
RESET test:	F(1,52) =	2.0217 [0.1610]

Table 7: Dummy Variable for QE and 2006 in parsimonious model B

EQ(5) Modelling YoYnGDP by OLS

The estimation sample is: 1995 (2) to 2010 (4)

	Coefficient	Std Error	t-value	t-prob	Part.R^2
YoYnGDP_1	0.518409	0.07389	7.02	0.000	0.4723
YoYnGDP_4	-0.482462	0.1028	-4.69	0.000	0.2858
Constant	0.0139026	0.01090	1.28	0.208	0.0287
M4LRE	0.207169	0.05659	3.66	0.001	0.1959
BankRate	0.00476614	0.001330	3.58	0.001	0.1892
YoYBoETA_4	-0.00762119	0.002974	-2.56	0.013	0.1067
Dummy2006	-0.00447062	0.003081	-1.45	0.152	0.0369

DummyQE	-0.0156552	0.009415	-1.66	0.102	0.0479

sigma	0.00885368	RSS	0.00431132206
R^2	0.886893	F(7,55) =	61.61 [0.000]**
log-likelihood	212.681	DW	2.18
no.of observations	63	no. of parameters	8
mean(YoYnGDP)	0.047609	var(YoYnGDP)	0.000605035

AR 1-4 test:	F(4,51) =	0.59422 [0.6684]
ARCH 1-4 test:	F(4,47) =	1.1006 [0.3674]
Normality test:	Chi^2(2) =	0.57279 [0.7510]
hetero test:	F(12,42) =	0.95912 [0.5010]
hetero-X test:	F(32,22) =	1.0740 [0.4381]
RESET test:	F(1,54) =	1.1215 [0.2943]

Based on the various tests above, we conclude that no statistical evidence of a significant change in the relationship between potential monetary policy tools or intermediary targets and nominal GDP could be found when quantitative easing was officially implemented in March 2009. The announcement of changes in the operating procedure by the BoE seems not to have disturbed the explanatory variables of nominal GDP.

Unlike parsimonious model B, parsimonious model A finds a structural break in 2006(Q2). One could therefore argue that the strategy of the BoE has changed at the point at which the money market reforms of May 2006 were introduced, although no difference is found in May 2006, either in parsimonious model B (table 7) or in the recursive structural break tests (figure 2).

The results suggest that the research strategy of measuring the effectiveness of QE by the perceived impact on nominal interest rates or the term structure – as has been dominant in the literature – may not be fruitful. The findings also differ from much of the literature in that there appears to be a stable relationship between nominal GDP growth and a broad money lending aggregate, confirming earlier findings (Werner, 1997, Voutsinas and Werner, 2010).

4. Concluding remarks

In summary, the authors have come to several findings:

(a) The quantity equation relationship: M4 lending growth, adjusted to include only credit for transactions that contribute to GDP, is found to be in a stable long-term relationship with nominal GDP growth (see annex 1). With this, the long-standing velocity decline problem is overcome (the lack of such disaggregation had previously been identified as the reason for the apparent 'velocity decline', Werner, 1997, 2005).

(b) The 'new consensus' of monetary policy implementation had been to focus mainly on nominal short-term interest rates for central banks (see e.g. Woodford, 2003, Curdia and Woodford, 2010, Lenza et al, 2010), at least until the 2008 crisis. However, interest rates are found to be positively correlated with GDP in our model. Mainstream monetary theories are not validated by our analysis. This raises the prospect of a revival of a more traditional, quantity-based approach (monetarism modified by the use of disaggregated credit counterparts).

(c) The BoE's announcement of March 2009 claimed that a break with past policy was made and a massive amount of assets was newly purchased. However, there is no evidence that monetary policy changed in a meaningful way at that specific point in time. Total assets do not appear to be in a positive relationship with the economy throughout the 1995 to 2010 observation period.

(d) 'Unorthodox monetary policy tools': There seems no need to make recourse to 'unorthodox' monetary policy, or at least name them in a new way: bank reserves must historically be considered an orthodox method (Bernanke et al., 2004). Targeting them together with a broad monetary aggregate (also an orthodox idea, albeit refined here by the use of a disaggregated credit counterpart) appears to be a promising avenue for research and policy applications.

(e) The 'qualitative easing' strategy of changing a central bank's balance sheet composition (by increasing long-term holdings of assets) does not seem to have a significant impact on the economy, as this particular indicator dropped out from the model.

(f) Total central bank asset growth was not found to be helpful as far as the recovery of the economy is concerned. It is not found to play a

positive role on GDP, and probably no role at all (if any, it is actually a negative one). It is thus unlikely to be attractive as a main monetary policy instrument.

(g) As credit for GDP transactions if found to have so much importance in affecting economic growth, all methods that may influence this particular variable need to be considered. Suggestions are made in Werner (1995, 2005), and include the substitution of bond issuance with government borrowing from banks. This would boost credit creation which, ironically, was the original meaning of the term 'quantitative easing'. Another, more controversial method would be the re-introduction of a regime of credit controls ('window guidance').

(h) Finally, the most recent collapse in credit for the real economy suggests that policies need to be adopted to expand it.

- Annex 1 – Data Sources and Issues

No complete time series of the reserves of banks with the Bank of England or for Bank of England's total assets are provided on the central bank's website. Several time series suffer from a break or discountinuity, even termination, in June 2006. BoE staff members stated that this discontinuity is due to the introduction of new calculation methods as a result of the implementation on 18 May 2006 of new money market reforms[14]. Data after 2006 only are complete (see further explanations below).

Note: Data that was not quarterly originally: it was transformed by the authors (by keeping only the amounts outstanding at the end of every quarter, from 1995 to 2010).

- **Nominal GDP** (GDP): Data bases of most institutions (Bank of England, European Central Bank, IMF, World Bank, OECD etc.) fail to provide simple time series of GDP in its nominal format, which is neither seasonally adjusted nor real (inflation adjusted). The time series of GDP these institutions provide do not allow for strong conclusions. Indeed, calculations made to adjust various perturbations are rather opaque, which renders it quite confusing and makes it difficult to draw economic and policy conclusions. Therefore the authors picked a series of nominal GDP data provided by the Office for National Statistics and available from its *Economic and Labour Market Review monthly issue*.

- **Bank Rate** (Bankrate) : The quarterly average of the official Bank Rate was provided by the Bank of England (time series IUQABEDR)

- **Bank of Engand Reserves** (BoEReserves): Because of the money market reforms introduced in June 2006, time series of the Bank of

[14] See http://www.bankofengland.co.uk/statistics/ms/articles/artjun06.pdf

England balance sheet are discontinued in June 2006[15]. Therefore the authors had to combine different data to build a continued series (the BoE's balance sheet being quite different from *prior* 2006 to *post* 2006). Before June 2006, the authors used the initial definition of M0 to calculate out the BoE reserves: As M0 equals reserves plus notes and coins in circulation outside the bank of England, the authors calculated the time series for reserves as the difference between M0 *prior* 2006 (time series LPMAVAD) and Notes and Coins outside the BoE (time series LPMAVAA). After June 2006, the data on BoE reserves of the new balance sheet was kept unchanged (Table B1.1.1, time series BL38). The obtained time series for BoE reserves from 1985 to 2010 is not available online but it can be provided by the authors on demand.

	prior June 2006	*post* June 2006
Author's time series for BoE reserves (**Res**)	LPMAVAD - LPMAVAA (= M0 - Notes and Coins outside the BoE)	BL38 (= BoE Reserves)

- **Bank of England Total Assets** (BoETotAssets): Just like in the above case of the BoE reserves, and because of the money market reforms implemented in June 2006, no continued data of the BoE total assets is available in the BoE database. Therefore the authors had to build up their own data once again. *Prior* June 2006, the authors calculated the BoE total assets by adding up the values of all the assets owned by the central bank, namely: Banking Department's securities - including Treasury bills - issued by Central Government (RPQAEFJ); Banking Department's advances and other accounts (RPQAEFK); Banking Department's premises equipment and other securities (RPQAEFL); Banking Department's holdings of notes and coin (RPQAEFM); Issue Department's securities issued by Central

[15] See http://www.bankofengland.co.uk/statistics/ms/articles/artjun06.pdf: Reserve balances replaced operational deposits in 2006 and these are much larger then operational deposits, as banks and building societies were able to hold voluntary interest-bearing reserves with the BoE from 2006 onwards. Unfortunately therefore the BoE does not have reserve balance data prior to 2006.

Government (RPQAEFC) and Issue Department's other securities (RPQAEFD). *Post* 2006, the authors kept unchanged the time series of total assets of the Issue Department (BL37) plus total assets of the Banking Department (BL56) that can be found on the BoE balance sheet (table B1.1.1)

	prior June 2006	*post* June 2006
Author's time series for BoE total assets (**BoETA**)	RPQAEFJ + RPQAEFK + RPQAEFL + RPQAEFM + RPQAEFC + RPQAEFD (= securities 1 + advances and other + premises equipment and other + notes and coins + securities 2 + other securities)	BL37 + BL56 (= total assets of the Issue Department + total assets of the Banking Department)

- **Qualitative easing** (QualEasing): According to Buiter, the composition of the central bank's balance sheet may be a relevant instrument for monetary policy. We have chosen to focus on the ratio of long-term central bank assets to total assets. Once again, an adjustment was needed in the data, and a time series for qualitative easing had to be constructed by the authors. Before June 2006, we took the ratio of the long term assets of the Issue and Banking Departments (which is the sum of the value of the Issue department's long term assets, RPQAEFC, plus the banking Department's long term assets, RPQAEFJ) over total assets (obtained with the method explained above). After June 2006, this ratio was calculated by dividing the value of the long term assets of the Issue and Banking Departments that can be found on the BoE balance sheet. It is the sum of the value of the Issue department's long term assets, BL35, plus the banking Department's long term assets, BL53, over BoE's total assets (see above). In this manner, the authors obtain a continued time series of qualitative easing from 1988 to 2010, representing the ratio of the BoE long term assets over its total assets. This series will be made available on demand.

	prior June 2006	*post* June 2006
Author's time series for Qualitative Easing (**QualEasing**)	(RPQAEFC + RPQAEFJ) / BoETA (= (Issue Dpt's long term assets + Banking Dpt's long term assets) / total assets of the BoE)	(BL35 + BL53) / BoETA (= Issue Dpt's long term assets + Banking Dpt's long term assets) / total assets of the BoE)

- **Monetary aggregate M4**: As admitted by BoE staff members during conversations with the authors, B6NM is not an accurate time series for M4 excluding other financial corporations, although it is its name. The BoE members were not able to explain why, as "prior to 1996 data were collected differently and unfortunately we (the BoE, *author's note*) are unable to breakdown clearly its contributions".

  In order to introduce the M4 monetary aggregate into the regression, the authors had to build their own time series of M4 from the BoE database. As explained above, the authors had to build their own M4 aggregate for the real economy instead of using the time series called "M4 excluding other financial corporations" (B6NM) provided by the Bank of England. In order to add to the time series of "M4 holdings of other financial corporations" (LPQAVHA) and get a general M4 aggregate for the whole economy, the authors built a time series different from B6NM in order to account for M4 holdings of the real economy. This latter is a sum of M4 holdings of private non-financial corporations **(**LPQAVHB) and M4 holdings of the household sector (LPQVSCL).

  The time series for M4 was in the end a sum of M4 holdings of other financial corporations (LPQAVHA), of private non-financial corporations (LPQAVHB) and of the household sector (LPQVSCL). It is made available by the authors on demand.

	prior June 2006	*post* June 2006
Author's time series for monetary aggregate M4 (**M4**)	LPQAVHA + LPQAVHB + LPQVSCL (= M4 holdings of other financial corporations + private non-financial corporations + household sector)	

Note: From 1982 to 1989, our own addition of individual sectors is substantially larger than the total provided by the Bank of England (by more than £100bn). The Bank of England could not provide a satisfactory explanation[16].

- **M4 lending aggregate to the real economy** (M4LRE): The authors have been looking for an accurate lending aggregate that would theoretically and empirically account for nominal GDP (Werner, 1997, 2005). M4 lending to the real economy is a sum of M4 lending to all sectors excluding the financial one. Instead of using the time series called "M4 lending excluding other financial corporations" (B6NL) provided by the Bank of England, the authors had to build their own M4 lending aggregate for the real economy. Indeed, from personal conversations with the BoE staff again, it seems that the central bank cannot explain why B6NL is not a reliable time series, although it admits it is not. We had the exact same problem as with B6NM (see above for the M4 monetary aggregate). Whereas B6NL should have been a good proxy for bank credit to the real economy; we had to build our own lending to the real economy time series (M4LRE). We added up lending to private non-financial corporations (LPQAVHF); lending to the household sector (secured lending to individuals, LPQAVHG, and unsecured lending to individuals, LPQVVXS) and lending to unincorporated businesses and non-profit making institutions (LPQAVHI). This data is made available on demand.

[16] An abstract from an email sent by a BoE employee: « Prior to 1996 data were collected differently and unfortunately we are unable to break down clearly it's contributions therefore I can't give you an exact reason as to why the data don't add up in the back data. The quality of data improved in 1990 (the summing becomes much more accurate) and then again in 1996 when we started collecting the data under the current methodology. The reason the monthly data sum up exactly is because they only begin in 1996 when our improved methodology began." It is clear that no light is shed on the reason why B6NM is not an accurate data of "M4 excluding other financial corporations" although it is presented as such on the BoE website, and no improvement of the data is scheduled in the near future.

	prior June 2006	*post* June 2006
Author's time series for M4 lending to the real economy (**M4LRE**)	LPQAVHF + LPQAVHG + LPQVVXS + LPQAVHI (= lending to private non-financial corporations + lending to the household sector (secured + unsecured lending to individuals) + lending to unincorporated businesses and non-profit making institutions)	

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