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Effects of Quantitative Easing on the USA Economy: A Test for Policy Effectiveness

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Abstract

The catastrophic disruption in the USA financial system in the wake of the financial crisis prompted the Federal Reserve to launch a Quantitative Easing (QE) programme in late 2008. In line with Pesaran and Smith (2014), I use a policy effectiveness test to assess whether this massive asset purchase programme was effective in stimulating the economic activity in the USA. Specifically, I employ an Autoregressive Distributed Lag Model (ARDL), in order to obtain a counterfactual for the USA real GDP growth rate. Using data from 1983Q1 to 2009Q4, the results show that the beneficial effects of QE appear to be weak and rather short-lived. The null hypothesis of policy ineffectiveness is not rejected, which suggests that QE did not have a meaningful impact on output growth.

Keywords: Counterfactual, Policy Effectiveness, Quantitative Easing, Zero Lower Bound

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1 Introduction

The 2008 financial turmoil prompted the Federal Reserve (Fed) to slash the federal funds rate to extreme low levels. Deprived of its conventional monetary policy tool, the Fed decided to embark on a series of unprecedented monetary policy actions, including forward guidance and massive asset purchases, in order to restore stability in financial markets and steer the economy. An extensive literature (Baumesteir and Benati (2010), Chung et al. (2011), among others) has tried to gauge the extent to which the first round of Quantitative Easing (QE1) unveiled in late 2008 promoted the recovery of the USA economy. The broad consensus is that the large stimulus package implemented by the Fed was successful in avoiding a depression in the USA.

Several other economies around the world have implemented nonstandard policy measures amid concerns that near zero interest rates, the so-called Zero Lower Bound (ZLB), would not be sufficient to spark recovery. In this study I pay particular attention to the different unconventional monetary policy actions taken by the Fed and the European Central Bank (ECB) in the wake of the crisis so as to establish possible links between the monetary policies of the two central banks.

The ultimate goal of this study is to further explore the role played by QE1 in the recovery of the USA economy by using a policy effectiveness test. In line with Pesaran and Smith (2014), I use two Autoregressive Distributed Lag Models (ARDL), one that covers the period before the announcement of the large scale asset purchases (1983Q1 – 2008Q4) and another that takes into account the full sample, from 1983Q1 to 2009Q4. A policy intervention is given by a change in at least one of the policy parameters. The null hypothesis of the policy effectiveness test is that the intervention is ineffective, that is, there is no change in the policy parameters. Moreover, I aim to capture possible indirect effects of the unconventional monetary policy actions implemented in Europe on the USA economic activity by including in the model the real output growth rate of the Euro Area.

The main conclusion of the study is that the beneficial effects of QE1 on output growth were rather short-lived. This result is corroborated by the policy effectiveness test, which indicates that the stimulus programme was ineffective in significantly boosting the economic activity. As a result, one can argue that the actual improvement in the real GDP growth rate in 2009 might have been due to other policies in place such as the American Recovery and Reinvestment Act.

The rest of the paper is organized as follows: Section 2 describes the unconventional monetary policy actions taken by the ECB and the Fed in the aftermath of the 2008 financial crisis, focusing however on the question of QE. Section 3 presents key findings in the literature on the effects of large scale asset purchases at the ZLB. Section 4 discusses the methodology that was used in the empirical analysis. The results are provided in Section 5. Finally, section 6 concludes.

2 Actions taken by the ECB and the Fed in the aftermath of the crisis

The unconventional measures taken by the ECB and the Fed in response to the 2008 financial turmoil were significantly different, though with a common goal of improving market functioning. However, it is not appropriate to make a comparison between those different responses without taking into account the mandate and the institutional set-up surrounding each central bank (Draghi, 2013). The primary mandate of the ECB is to maintain price stability over the medium-long term, whereas that of the Fed encompasses not only a price stability goal but also the promotion of maximum employment and moderate long term interest rates. Moreover, unlike the Fed, the Treaty on the Functioning of the European Union prohibits the ECB from purchasing government debt in the primary market. Despite being a controversial issue, secondary-market purchases of public debt by the ECB may be allowed as long as the main objectives of the monetary financing condition are fulfilled, namely safeguarding the primary aim of price stability and the independence of the central bank (ECB October Bulletin, 2012).

The intervention of central banks in the bond markets is always a topic of intense discussion as some economists believe that it might call into question the reputation, and ultimately, the independence of the institution. However, when an interest rate is at ZLB and the traditional monetary policy transmission mechanism is impaired, buying government bonds might be the only credible solution to avoid persistent deflationary pressures (Posen, 2010). Against this background, purchasing government bonds might even enhance the credibility of the central bank.

Lenza et al. (2010) state that the financial structure in which each central bank operates as well as the pre-crisis operational framework were two of the most important factors behind the different responses of the Fed and the ECB to the crisis. To the extent that banks play the predominant role in the provision of credit in Europe, the ECB implemented unconventional measures aimed at increasing the liquidity of the banking system, one of which was the increase in the maturity of the Eurosystem long-term operations. These measures, coupled with a decrease in the short-term interest rate, proved effective in ensuring the transmission of monetary policy, namely by significantly reducing the interest rate charged on the small-loans to non-financial corporations and households; by expanding the households´ volume of credit and easing banks´ credit standards (ECB October Bulletin, 2010). In the USA, the Fed launched a large-scale asset purchase programme – commonly referred to as Quantitative Easing (QE) - with the purpose of tackling the huge disruption in capital markets, on which non-financial corporations relied heavily to obtain credit. This decision was made based on the conviction that just decreasing the Fed funds rate would not be effective in restoring stability. The huge securitization in the American financial system has been referred to as one of the reasons for the recent weaker impacts of changes in the policy interest rate on the economy (Estrella (2002); Boivin et al., (2010)).

When it comes to the pre-crisis operational framework, the larger size of the Eurosystem balance sheet when compared with that of the Fed implied that the demand for extra liquidity was proportionally smaller in Europe (Lenza et al. (2010)). Furthermore, a very limited set of assets were eligible as collateral by the Fed prior to the crisis (mostly US treasury securities) whereas the ECB accepted a broad range of assets, from corporate bonds to asset-backed securities. The narrower set of the eligible collateral and the nefarious effects of the financial turmoil on the USA capital markets prompted the Fed to have a much stronger reaction (in terms of balance sheet) to the crisis than that of the ECB (Kohn, 2010).

In fact, the effects of the financial crisis on the economic activity were particularly acute in the USA. A surge in the unemployment rate, the collapse of the Housing and Asset-backed securities markets, and the tight restrictions on credit pushed down business and consumer confidence[1]. Fischer (2013) argues that the countries where there was a turmoil in the financial sector in the aftermath of the crisis were those that suffered a

[1] This analysis is based on the *Monetary Policy Report to the Congress, February 2009*

stronger economic downturn. The absence of an alarming bubble in the Housing market as well as the government support to banks watered down the effects of the catastrophe on the European Economy.

The persistent low levels of inflation across the Eurozone in 2014 pushed the Governing Council of the ECB into discussing the possibility of implementing a QE programme (Draghi, 2014). The general view was that a prolonged period of extreme low levels of inflation could trigger a dangerous process of de-anchoring of inflation expectations, which in turn, with the nominal interest rate at the ZLB, could lead to an increase in the real interest rate. The fear of lower inflation expectations mainly reflected the slowdown in the economic activity of the Euro Area as a whole as well as the sharp downturn in the oil market.

Quantitative Easing has been used by the major central banks in an environment of near zero interest rates and gloomy outlook for inflation and economic activity. However, the extent to which this massive injection of liquidity causes a rapid and sustainable improvement in the economy is a contentious question. One of the traditional channels through which QE affects the economic activity is the Portfolio Rebalancing Channel. Joyce et al (2012) argues that a purchase of long-term government bonds – which on its own tends to push the bonds yields down - tends to reduce the risk premium required by investors to allocate their money to other long-term assets[2], particularly corporate bonds and equities. A growing body of literature, such as D`Amico and King (2010), Gagnon et al. (2011) and Krishnamurthy and Jorgenson (2011), has indeed identified a negative effect of QE on long term government bonds yields[3] (see section 3). Lower yields might

[2] This channel relies on the assumption that there is an imperfect substitutability of assets

[3] Schenkelberg, Watzka (2011) state that, despite the broad consensus about the negative effect of QE on government bonds yields, investors might require a higher yield in case they perceive that the stimulus package will be successful in boosting inflation in the future.

induce governments to issue more debt in an attempt to refinance their liabilities at lower interest rates, thereby countering the desired central bank´s change in the relative supply of securities. Thus, the way this channel affects the real economy might hinge on a potential coordination between the government´s debt-management policies and the central banks´ actions (Bernanke and Reinhart (2004). This aspect is of paramount importance when we compare the policies adopted by the ECB and the Fed. While in the USA the fiscal implications of QE are possible to be dealt between the Treasury and the central bank[4], in Europe this coordination is virtually impossible to occur as there is no European Treasury, but rather 18 different governments, each of which with its own legislation.

3 Empirical evidence of the effects of QE at the ZLB

3.1 Inflation and Output growth

A growing literature has tried to assess the effects of asset purchase programmes on the real economy when the short-term interest rate is constrained by the ZLB. Though a consensus has not been reached yet, there is large evidence that unconventional monetary policy was successful in avoiding a repeat of the Great Depression in the USA (e.g Baumeister and Benati (2010), Chung et al. (2011) and Chen et al. (2012)). Using a Bayesian VAR Sign Restrictions approach, Baumeister and Benati (2010) find that in the absence of a compression in the yield spread the output growth in the USA would have reached a trough of almost minus 10 percent in early 2009 and inflation would

[4] Greenwood et al, (2014) provide data showing that the Fed´s attempts to reduce the supply of long-term bonds in capital markets in 2009 was partly offset by the Treasury´s decision to lengthen the average maturity of debt in order to alleviate fiscal risks associated with the rise in the government debt´s burden. The authors therefore call for new institutional arrangements aimed at promoting more cooperation between the two institutions.

have been negative. Chung et al. (2011) conclude that the combination of QE1 and QE2 boosted the real GDP growth in 3% and inflation in 1% when compared with the scenario where the Fed would not have intervened. Based on a dynamic stochastic general equilibrium model (DSGE), Chen et al. (2012) find that the second round of QE adopted by the Fed expanded output growth by less than one third and inflation barely changed relative to what would otherwise have happened in the absence of policy intervention. Moreover, they show that the commitment to hold the fed funds rate at the ZLB for an extended period of time tends to amplify the responses of inflation and economic activity to large scale asset purchases.

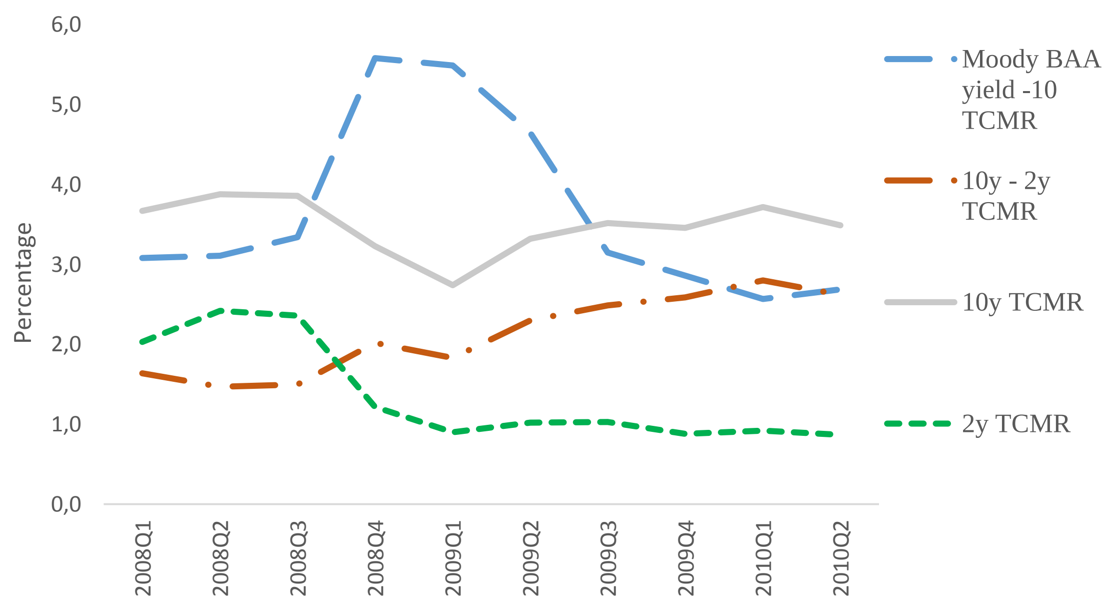
Pesaran and Smith (2014) provide a test for policy effectiveness using reduced form policy equations. As an illustrative test, they attempt to gauge the effectiveness of the QE programme unveiled in March 2009 in the UK. Using an ARDL (1,1) model, they conclude that a permanent 100 basis points reduction in the UK government spread has an immediate positive impact on the real output growth rate, though it tends to be temporary. Nevertheless, after applying a policy effectiveness test, they verify that the null hypothesis is not rejected, which suggests that the Bank of England´s stimulus plan was ineffective.

3.2 Bond markets

The Federal Reserve´s decision to embark on a massive purchase of medium-long term assets came in two steps. In late November 2008, the Fed announced that it would purchase agency mortgage-backed securities (MBS) and agency debt of up to 600 billion in order to avoid the collapse of these markets. The Fed decided to further expand its balance sheet by announcing in March 2009 that it would purchase long-term treasury securities.

Figure 1 portrays the response of the bond markets to the Fed´s announcement. In line with the aforementioned literature, the figure shows that it might have had an immediate impact on the long and short term Treasury constant maturity rates (TCMR), 10 year and 2 year respectively. One of the ultimate goals of the programme was to lower the long term yields as the short term interest rates were already constrained by the ZLB (Kohn, (2010)). In fact, the stronger response of the 10 year interest rate led to a decline in the spread between the 10 and 2 year yields in the first quarter of 2009. Gagnon et al. (2010) conclude indeed that the QE announcement depressed long term yields mainly by lowering the term premium rather than by signalling a possible commitment to keep interest rates low for an extended period of time.

Figure 1: Evolution of the bond markets in the aftermath of the crisis



Source : Federal Reserve Bank of ST.Louis (US)

The short-lived decrease in the 10-year Treasury yield suggests that QE1 did not have a permanent effect. Gagnon et al. (2010) states that several factors might have been behind the slight increase in the long term Treasury yields in 2009, the most important of which were the improvement in the economic outlook and a strong reversal of the flight-quality flows that had taken place after the break out of the crisis in 2008.

The notorious decline in the spread between the Moody Seasoned BAA corporate bond yield and 10 year TCMR sheds light on the effects of the expansionary monetary policy programme on the private borrowing costs. A decrease in the default and prepayment risk premium are considered to be the main channels through which it negatively affected BAA corporate bonds and mortgage backed-securities yields (Krishnamurthy and Jorgensen, (2011)).

4 Methodology

In this section I briefly describe the model proposed by Pesaran and Smith[5] (2014) that I used in order to test for the effectiveness of QE1 in the USA.

Pesaran and Smith (2014) propose a macroeconometric rational expectations model and they show that the reduced form is given by:

$$q_t = \Phi\,(\theta) q_{t-1} + \psi_x(\theta) x_t + \psi_w\,(\theta) w_t + \varepsilon_t \qquad (1)$$

where q_t is a vector that contains the endogenous variables, y_t (the target variable) and z_t; x_t is the policy exogenous variable and w_t is a non-policy exogenous variable that is assumed to be invariant to changes in x_t. θ is made up of a set of policy parameters, θ_p, and a set of structural parameters, θ_s, that are assumed to be invariant to changes in the former. A policy intervention is given by a change in at least one of the policy parameters. The null hypothesis of the test is that the policy intervention is ineffective,

[5] In this paper I only briefly expose the case of the dynamic model. Pesaran and Smith (2014) describe a model without dynamics as well.

that is, there is no evidence of change in θ_p after the intervention. ε_t accounts for disturbances in the model. The policy intervention is assumed to occur at the end of time t = T_0 and as a result it is possible to have two different samples: one that covers the pre-intervention period t = $M, M+1, \ldots, T_0$ and another that is related to the post-intervention period t = $T_0+1, T_0+2, \ldots, T_0+H$. Thus, while the sample size of the former is $T = T_0 - M + 1$, the latter is equal to H.

The impact of the policy intervention on the target variable, y_t, is given by the difference between the realised outcomes, y_{T_0+h}, and the counterfactual outcomes, $y^0_{T_0+h}$, during the post-intervention period,

$$d_{T_0+h} = y_{T_0+h} - y^0_{T_0+h}, \ h = 1,2,3,\ldots,H \qquad (2)$$

These estimated policy effects do not however accurately reflect the actual policy impacts as the former will be subject to the post intervention random errors, ε_{y,T_0+h}.

Pesaran and Smith (2014) state that using a fully specified rational expectations structural model might not give robust estimates of the counterfactual values once we are uncertain about the specification of the complete model. As a result, they believe that more accurate estimates of the counterfactual outcomes can be obtained by using reduced form policy equations. After excluding the lagged values of z_t, they obtain an ARDL model ($p_{y,}$ p_x, p_w) for pre and post-intervention samples :

$$y_t = \sum_{i=1}^{p_y} \lambda_i(\theta^0) y_{t-i} + \sum_{j=0}^{p_x} \pi_{yx,i}(\theta^0) x_{t-i} + \sum_{k=0}^{p_w} \pi'_{yw,i}(\theta^0) w_{t-i} + \upsilon_{yt,} \quad t = M, M+1, M+2, \ldots, T_0 \qquad (3)$$

$$y_t = \sum_{i=1}^{p_y} \lambda_i(\theta^1) y_{t-i} + \sum_{j=0}^{p_x} \pi_{yx,i}(\theta^1) x_{t-i} + \sum_{k=0}^{p_w} \pi'_{\acute{y}w,i}(\theta^1) w_{t-i} + \upsilon_{yt,} \quad t = T_0+1, T_0+2, \ldots, T_0+H \qquad (4)$$

The reason for excluding the variable z_t is that they aim to attribute to x_t the possible effects that the former might have on the target variable. In other words, they replace the variable z_t with its determinants, which are given by x_t.

In line with Pesaran and Smith (2014), I set the following lag orders p_y= p_x=1 and p_w= 0, and rewrite the ARDL specification for the pre-intervention sample as

$$\mathbf{y}_{(0)} = \lambda^0 \mathbf{y}_{-1,(0)} + \boldsymbol{S}_{(0)}\pi^0_{ys} + \boldsymbol{\nu}_{(0)} \tag{5}$$

where $\mathbf{y}_{(0)} = (y_M, y_{M+1,} \dots, y_{T_0})$, $\mathbf{y}_{-1,(0)} = (y_{M-1}, y_{M,} \dots, y_{T_0-1})'$, $\boldsymbol{S}_{(0)} = (\boldsymbol{X}_{(0)}, \boldsymbol{W}_{(0)})$ in which $\boldsymbol{X}_{(0)} = (\boldsymbol{x}_{(0),}\boldsymbol{x}_{-1,(0)})$, $\boldsymbol{x}_{(0)} = (x_M, x_{M+1,} \dots, x_{T_0})'$ $\boldsymbol{x}_{-1,(0)} = (x_{M-1}, x_{M,} \dots, x_{T_0-1})'$, and $\pi^0_{ys} = (\pi^0_{yx0}, \pi^0_{yx1}, \pi^{0'}_{yw})'$. Finally, $\boldsymbol{\nu}_{(0)} = \left(\upsilon_{y,M}, \upsilon_{y,M+1}, \dots, \upsilon_{y,T_0}\right)$. $\boldsymbol{X}_{(0)}$ and $\boldsymbol{W}_{(0)}$ are the $T \times k_x$ and $T \times k_w$ matrix of observations on the policy variables and the policy invariant variables over the pre-intervention sample, respectively.

Using $\boldsymbol{X}^0_{(1)}$, which is a matrix that includes the counterfactual outcomes of the policy variables and their respective lagged values over the period after the intervention, and after applying forward iterations of the dynamic equations from $t = T_0$, Pesaran and Smith (2014) obtain the following expression for the counterfactual outcome:

$$\hat{\mathbf{y}}^0_{(1)} = \widehat{\boldsymbol{\Lambda}}^0_H \left[\boldsymbol{e}_1 \hat{\lambda}^0 y_{T_0} + \boldsymbol{X}^0_{(1)}\hat{\pi}^0_{yx} + \boldsymbol{W}_{(1)}\hat{\pi}^0_{yw'}\right]$$

$$= \widehat{\boldsymbol{\Lambda}}^0_H \left[\boldsymbol{e}_1 \hat{\lambda}^0 y_{T_0} + \boldsymbol{S}^0_{(1)}\hat{\pi}^0_{ys}\right] \tag{6}$$

where $\widehat{\boldsymbol{\Lambda}}^0_H$ is the $H \times H$ lower triangular matrix

$$\widehat{\boldsymbol{\Lambda}}^0_H = \begin{bmatrix} 1 & 0 & 0 & \cdots & 0 & 0 \\ \hat{\lambda}^0 & 1 & 0 & \cdots & 0 & 0 \\ \left(\hat{\lambda}^0\right)^2 & \hat{\lambda}^0 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ \left(\hat{\lambda}^0\right)^{H-2} & \left(\hat{\lambda}^0\right)^{H-3} & \left(\hat{\lambda}^0\right)^{H-4} & \cdots & 1 & 0 \\ \left(\hat{\lambda}^0\right)^{H-1} & \left(\hat{\lambda}^0\right)^{H-2} & \left(\hat{\lambda}^0\right)^{H-3} & \cdots & \hat{\lambda}^0 & 1 \end{bmatrix}$$

$\boldsymbol{e}_1$ = (1,0,…,0)′, $\hat{\pi}_{ys}^0 = (\hat{\pi}_{yx}^{0\prime}, \hat{\pi}_{yw}^{0\prime})'$ and $\hat{\lambda}^0$ are least squares estimates of the parameters in the dynamic policy impulse equation covering the pre-intervention sample (3), $\lambda^0, \pi_{ys}^0 = (\pi_{yx}^{0\prime}, \pi_{yw}^{0\prime})'$. $\boldsymbol{W}_{(1)}$ is the $H \times k_w$ matrix of observations on the policy invariant variables over the post-intervention period.

Applying the same forward recursive approach as before, they derive an expression for the realised outcomes:

$$\mathbf{y}_{(1)} = \boldsymbol{\Lambda}_H^1\left[\boldsymbol{e}_1\lambda^1 y_{T_0} + \boldsymbol{X}_{(1)}\pi_{yx}^1 + \boldsymbol{W}_{(1)}\pi_{yw}^1 + \boldsymbol{\nu}_{(1)}\right]$$

$$= \boldsymbol{\Lambda}_H^1\left[\boldsymbol{e}_1\lambda^1 y_{T_0} + \boldsymbol{S}_{(1)}\pi_{ys}^1 + \boldsymbol{\nu}_{(1)}\right]. \tag{7}$$

Based on the equations (6) and (7) the measured policy effects are therefore given by

$$\hat{\boldsymbol{d}}_{(1)} = \boldsymbol{\Lambda}_H^1\left[\boldsymbol{e}_1\lambda^1 y_{T_0} + \boldsymbol{S}_{(1)}\pi_{ys}^1\right] - \hat{\boldsymbol{\Lambda}}_H^0\left[\boldsymbol{e}_1\hat{\lambda}^0 y_{T_0} + \boldsymbol{S}_{(1)}^0\hat{\pi}_{ys}^0\right] + \boldsymbol{\Lambda}_H^1\boldsymbol{\nu}_{(1)}, \tag{8}$$

This expression can be decomposed into three main parts: the systematic effect of the policy - changes in the policy parameters due to the policy intervention – that is given by $\mu_{(1)}$, the random components owing to the post-intervention errors, $\boldsymbol{\nu}_{(1),}$ and finally the uncertainty regarding the estimation of the parameters λ^0 and π_{ys} that is reflected in $\xi_{(1)}$. Thus, the above equation can be written as

$$\hat{\boldsymbol{d}}_{(1)} = \mu_{(1)} - \xi_{(1)} + \boldsymbol{\Lambda}_H^1\boldsymbol{\nu}_{(1)}, \tag{9}$$

where

$$\mu_{(1)} = y_{T_0}\left(\boldsymbol{\Lambda}_H^1\lambda^1 - \boldsymbol{\Lambda}_H^0\lambda^0\right)\boldsymbol{e}_1 + \left[\boldsymbol{\Lambda}_H^1\boldsymbol{S}_{(1)}\pi_{ys}^1 - \boldsymbol{\Lambda}_H^0 S_{(1)}^0\pi_{ys}^0\right], \tag{10}$$

$$\xi_{(1)} = \hat{\boldsymbol{\Lambda}}_H^0\left[\boldsymbol{e}_1\hat{\lambda}^0 y_{T_0} + \boldsymbol{S}_{(1)}\hat{\pi}_{ys}^0\right] - \boldsymbol{\Lambda}_H^0\left[\boldsymbol{e}_1\lambda^0 y_{T_0} + \boldsymbol{S}_{(1)}\pi_{ys}^0\right] \tag{11}$$

$\boldsymbol{\Lambda}_H^1\boldsymbol{\nu}_{(1)}$ accounts for a vector of random disturbances over the post-intervention period. As mentioned above, the null hypothesis of the test for policy effectiveness implies that there is an absence of change in the policy parameters after the intervention has taken place, which means that the term $\mu_{(1)}$ has to be equal to zero. Moreover, Pesaran and Smith (2014) state that in the dynamic case it is also necessary to assume that under H_0 the reaction of the target variable to its lagged value is the same in the pre and post-intervention period, that is $\lambda^1 = \lambda^0$, as well as υ_{yt} is serially uncorrelated with a constant variance, given by σ_{υ}^2.

Pesaran and Smith (2014) use a policy mean effect statistic,

$$\overline{\hat{d}_H} = H^{-1} \mathcal{T}'_H \,\hat{\boldsymbol{d}}_{(1)}, \tag{12}$$

in order to obtain a policy effectiveness test statistic. $\mathcal{T}'_H$ is a vector of ones of length H. In their view, this strategy has the advantage of minimizing the importance of the aforementioned post-intervention random errors. Thus, they obtained the following test statistic

$$\mathcal{T}_{d,H}^{a} = \frac{\sqrt{H}\overline{\hat{d}_H}}{\hat{\sigma}_{0\upsilon}\left(\frac{\mathcal{T}'_H \hat{\boldsymbol{\Lambda}}_H^0 \hat{\boldsymbol{\Lambda}}_H^{0\prime} \mathcal{T}_H}{H}\right)^{1/2}} \rightarrow_d N(0,1), \tag{13}$$

where,

$$\frac{\mathcal{T}'_H \hat{\boldsymbol{\Lambda}}_H^0 \hat{\boldsymbol{\Lambda}}_H^{0\prime} \mathcal{T}_H}{H} = \frac{1}{\left(1-\hat{\lambda}^0\right)^2}\left[1 - \frac{2}{H}\left(\frac{\left(\hat{\lambda}^0\right)^{H+1} - \hat{\lambda}^0}{1-\hat{\lambda}^0}\right) + \frac{1}{H}\left(\frac{\left(\hat{\lambda}^0\right)^{2H+2} - \left(\hat{\lambda}^0\right)^2}{\left[1-\left(\hat{\lambda}^0\right)^2\right]}\right)\right] \tag{14}$$

This test statistic is only valid as long as T is reasonably large relative to H and $\boldsymbol{\nu}_{(1)}$ follows a normal distribution.

5. Empirical Analysis

5.1Data

I use an ARDL model to estimate the effects of QE1 on the USA real output growth rate, y_t. The full sample period (quarterly frequency) is from 1983Q1 to 2009Q4. The growth rate is measured by the quarterly change in the logarithm of real GDP. Thus, I extracted the quarterly seasonally adjusted series for real GDP from the St.Louis Fed´s database. Following Pesaran and Smith (2014) I use the Euro Area real GDP growth rate as a conditioning variable (w_t) so as to capture possible indirect effects of the Euro Area unconventional monetary policy actions on the USA output growth. This variable is extracted from the Global VAR data set and includes eight countries, namely Austria, Belgium, Finland, France, Germany, Italy, Netherlands, and Spain. The correlation between the USA and Euro Area real output growth over the pre-intervention period (1983Q1-2008Q4) is 0.37, lower than that observed over the full sample period, 0.47 (Figure A1 in the appendix). This large gap therefore suggests that the correlation between the two growth rates intensified in the wake of the crisis.

As far as the policy variable is concerned, x_t, I use the quarterly seasonally unadjusted spread between the 10 year and 2 Treasury Constant Maturity rate available in the St.Louis Fed´s database. A few remarks are however needed to be made regarding this choice. Firstly, the fact that the USA is one of the largest, if not the largest economy in the world, could indicate that a change in the USA government bonds spread would have a meaningful impact on the Euro Area output growth. Given the overwhelming importance of the banking system in the dynamics of the European Economy (section 2), it is unreasonable to assume that such change would have sizeable effects on the latter. Such view is corroborated by the correlation between the spread and the Euro

Area output growth, -0.47 and -0.46 over the pre-intervention period and full sample, respectively. Secondly, the strong dependence of the USA economy on capital markets prompted the use of a variable that could somehow reflect the reaction of these markets to the large scale asset purchase programme. Gagnon et al. (2010) concluded that the 10-year term premium decreased between 38 and 82 basis points as a result of the Fed´s \$1.725 trillion asset purchases. Thus, for illustrative purposes, I regard the counterfactual as the effect on the USA real GDP growth rate of there not having been a 60 basis points reduction - the average of Gagnon et al. (2010) ´s estimates[6] - in the 10-year government bond yield spread for the whole 2009.

5.2 Results

As the Schwarz criterion indicated one lag, the ARDL model that I consider is given by:

$$y_t = \lambda y_{t-1} + \pi_{yx0} x_t + \pi_{yx1} x_{t-1} + \pi_{yw} w_t + \upsilon_{yt} \qquad (14)$$

I consider two samples, one that covers the pre-intervention period (1983Q1 to 2008Q4) and other that ends estimation in 2009Q4. Pesaran and Timmermann (2005) prove that when our goal is to minimize out-of-sample mean squared forecast error, it may be advantageous to include data before the intervention period to estimate forecasting models on data samples that are subject to structural breaks. They state that this preposition is only valid as long as some conditions are verified, including the fact that the error variances should rise at the point of the structural break and the number of observations in the post-intervention period, $H,$ must be sufficiently low. To the extent

[6] Baumeister and Benati (2010) also consider the average of Gagnon et al.´s (2010) time-series estimates

that the error variances increased in late 2008 and H is equal to 4 - fulfilling in turn the two conditions -, I followed the strategy proposed by Pesaran and Timmermann (2005).

For both sample periods, the equation above passes tests for serial correlation, heteroskedasticity and normality, but it fails tests for functional form (at 1% level), that is, there is evidence that the model is badly specified. The restriction that the long run cumulative effect is equal to zero - $\pi_{yx0} + \pi_{yx1}$ =0 – is not rejected (at 5% level) either taking into account the pre-intervention sample or the full sample. The fact that the long run effect is equal to zero is in line with standard macroeconomic theory that establishes a temporary link between the rate of monetary growth and real output growth. Thus, this restriction requires the use of the variation of spread, Δx_t, as a regressor in my model.

Table 1 provides the estimates for the full and the pre-intervention samples, after considering the aforementioned restriction

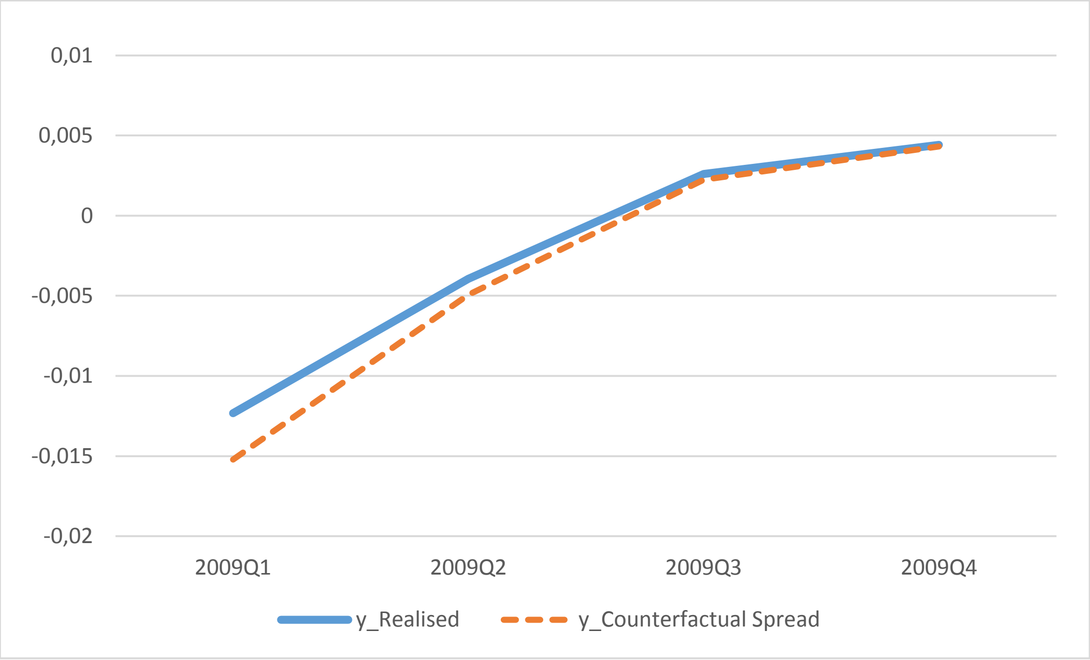
Table 1: ARDL estimates (t ratios in parentheses)

	1983Q1-2008Q4	1983Q1 – 2009Q4
C	0.003352	0.003424
	(3.21)	(4.17)
y_{t-1}	0.344443	0.335524
	(3.43)	(3.77)
Δx_t	-0.483813	-0.459398
	(-2.24)	(-2.23)
w_t	0.336402	0.346500
	(3.05)	(3.55)
$\bar{R}^2$	0.278286	0.356998
$\hat{\sigma}_v$	0.005438	0.005365

The full-sample model suggests that a unit change in the variation of 10 year spread would have a rather small impact effect, -0.46%. We can equally observe that a unit change in the Euro Area output growth tends to increase the USA real GDP growth rate by roughly 0.35%.

Figure 2 examines the effects of a 60 basis points reduction in the spread on the predicted real output growth. In other words, the predictions for the counterfactual outcomes take into account the spread that would have occurred had the FED not engaged in a massive purchase of assets, which in this case would be 60 basis points higher. Both predictions – realized and counterfactual outcomes – are obtained from the model estimated on the pre-intervention data. Overall, a 60 basis points reduction in the spread has a positive temporary impact on the USA real output growth (the fall in output growth in the first quarter of 2009 takes less serious proportions), disappearing altogether within one year.

Figure 2: USA output growth forecast using realised and counterfactual spreads



As $H = 4$, (2009Q1-2009Q4), $\overline{\hat{d}_H}$ = 0.001091 (12), and from table 1 $\hat{\lambda}^0$= 0.344 and $\hat{\sigma}_v$=0.005438, the value of the policy effectiveness statistic (13),

$$\mathcal{T}^a_{d,H} = \frac{\sqrt{H}\overline{\widehat{d_H}}}{\hat{\sigma}_{0v}\left(\frac{\mathcal{T}'_H \widehat{\mathbf{\Lambda}}^0_H \widehat{\mathbf{\Lambda}}^{0\prime}_H \mathcal{T}_H}{H}\right)^{1/2}}$$

is 0.2378

Thus, we cannot reject the hypothesis that QE1 was not effective in promoting the recovery of the USA economy. Once under the null hypothesis of this test further policy changes are assumed to be ineffective ($\lambda^1 = \lambda^0$), these results might reflect the well-known Keynesian's impotence of monetary policy during a crisis period. Specifically, at the same time that the Fed launched a massive asset purchase programme, the Congress approved a fiscal stimulus package – American Recovery and Reinvestment Act (ARRA) of 2009 - with the intention of creating jobs and providing help to those most hit by the crisis. Thus, if after imposing the restriction that other policies were not effective we still draw the conclusion that QE1 did not significantly affect economic growth, then these results suggest that the actual boost in the USA real GDP growth rate from 2009Q1 to 2009Q4 (Figure A1 in the appendix) might have been mainly due to other policies, such as the ARRA. In fact, Feyer and Sacerdote (2011) conclude that low-income families incredibly benefited from the fiscal stimulus plan, with Keynesian multipliers of over 2. Auerbach and Gorodnichenko (2010) discover that the size of the fiscal multipliers tends to be substantially higher in recessions than in expansions. According to the Keynesian's monetary impotence, pumping the economy with more money might not have immediate expansionary effects as a collapse of expectations and confidence, as it was seen after the eruption of the 2008 crisis, can deter individuals from investing.

5.4 Robustness Check

As a robustness check, I estimate the above regression (14) using however the lagged value of the Euro Area real GDP growth rate[7] as a conditioning variable, w_t. This change is due to the fact that it might be unreasonable to assume that the improvement in the USA output growth did not have a meaningful impact on the economic activity in Europe, thereby causing an endogeneity problem in my model. As before, I estimate two equations, one that covers the pre-intervention period and other that takes into account the full sample. Unlike the previous exercise, x_t accounts for the 10 year/2 year government spread[8].

Table 2: ARDL estimates (t ratios in parentheses)

	1983Q1-2008Q4	1983Q1 – 2009Q4
C	0.002988	0.003017
	(1.90)	(2.31)
y_{t-1}	0.371045	0.399260
	(3.56)	(4.17)
x_t	-0.506232	-0.418840
	(-2.23)	(-1.90)
x_{t-1}	0.571622	0.485452
	(-2.52)	(2.21)
w_{t-1}	0.243325	0.198726
	(1.71)	(1.70)

[7] Using an instrument for the conditioning variable is particularly hard in this context as one of the key assumptions of the model is that w_t has to be invariant to changes in the policy variable. For instance, it would not be valid to use the terms of trade as an instrument for the Euro Area output growth since a change in the government spread would certainly have an impact on the exchange rate which in turn would affect the Euro Area output growth.

[8] The use of the variation of spread was not possible in this exercise as the real GDP growth rate of the Euro Area was not statistically significant.

$\bar{R}^2$	0.226032	0.291892
$\hat{\sigma}_v$	0.005631	0.005630

The full-sample model suggests that a unit change in the 10 year government spread would not have a strong impact effect, -0.419%.

Figure A2 (in the appendix) portrays the impact of a 60 basis points reduction in the spread on the predicted real GDP growth rate. As before, the positive impact of the decline in the spread is rather short-lived.

Taking into account that $H = 4$, (2009Q1-2009Q4), $\overline{\hat{d}_H}$ = 0.000803 (12), and from table 2 $\hat{\lambda}^0$= 0.371 and $\hat{\sigma}_v$=0.005631, the value of the aforementioned policy effectiveness statistic (13) is 0.1606. Thus, we conclude again that QE1 did not significantly affect real GDP growth in the USA.

5.3 Caveats

The previous exercise suffers from one potential source of endogeneity, due to a simultaneity problem .The policy variable is likely to respond to changes in the target variable[9]. In fact, the sharp contraction in output growth in late 2008 (Figure A1 in the appendix) together with the turbulence in financial markets triggered a strong reaction from the Fed´s policy makers. Another critical limitation of this exercise is the low number of observations after the intervention period. However, as in 2010 a second

[9] As far the policy variable is concerned, Pesaran and Smith (2014) suggest expanding the ARDL model with a reasonable number of lagged values of the endogenous variable. This strategy however did not work out in my model as some of the variables were not statistically significant and it did not pass the test for functional form. Moreover, the estimates provided by Gagnon et al.(2010) would no longer be applicable in case I decided to use an instrument for the government spread.

round of asset purchases was adopted by the Fed, including observations after 2009 could seriously hamper the link that I was trying to establish between QE1 and the recovery of the USA economy.

6 Conclusion

The aim of this paper is to assess the extent to which the Fed´s first round of QE introduced in late 2008 was effective in stimulating the economic activity in the USA. Based on the methodology proposed by Pesaran and Smith (2014) I have estimated two ARDL models, one that ends estimation in 2008Q4 – before the announcement of the programme – and another that covers the full sample (1983Q1 – 2009Q4). I have used an ARDL (1,1) between the real output growth rate and the change in the spread between the 10 year and 2 year treasury constant maturity rate, augmented by the Euro Area real output growth. The fact that the real economy in the USA relies heavily on credit provided by capital markets triggered the use of the government bonds spread as a policy variable. The counterfactual simulations are obtained taking into account the average of the estimates of Gagnon et al. (2010) regarding the effects of QE1 on the 10 year government spread. Specifically, I have assumed that the spread between the long and short term interest rate would have been 60 basis points higher in the absence of the policy intervention, for the whole 2009.

The model show that QE1 had an immediate positive impact on output growth, not having however lasting effects. The policy effectiveness test supports this conclusion as the null hypothesis of ineffectiveness is not rejected. Given the existence of potential endogeneity problems in the original model, I have estimated two other equations using the lagged value of the Euro Area real GDP growth rate as a conditioning variable. This change does not appear to have had a significant impact on the results since the null hypothesis of ineffectiveness keeps being not rejected. This conclusion suggests that other policies might have played a stronger role in the recovery of the USA economy such as the large fiscal economic plan, ARRA, approved by the Congress in 2009. However, further research is needed to be done in order to accurately evaluate the role played by the different policies.

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