A reduced form ARDL approach to counterfactual policy analysis

Assessing the effect on euro area GDP growth of non-standard measures introduced by the ECB

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Preface

My supervisor for this thesis has been Ragnar Nymoen, Professor at the Department of Economics at the University of Oslo. I would like to extend to him my sincere thanks for all his help and guidance throughout this process.

In addition I would like to thank Ron Smith of the Department of Economics, Mathematics and Statistics at the University of London, Birkbeck, for replying (very quickly) to my e-mail inquiries regarding a paper he has written with M. Hashem Pesaran of Cambridge University. His answers were clarifying and essential in letting me replicate the results reported in their paper.

I am also grateful to Michele Lenza and Philippine Cour-Thimann at the ECB for helpful advice regarding literature on ECB non-standard measures.

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List of Abbreviations

BoE	Bank of England
CAP	Common Agricultural Policy
Commission	European Commission
Council	European Council
ECB	European Central Bank
ECS	Enhanced Credit Support
ECU	European Currency Unit
EDP	Excessive Deficit Procedure
EEC	European Economic Community
EMI	European Monetary Institute
EMS	European Monetary System
EMU	European Monetary Union
EONIA	Euro Overnight Index Average
ERM	Exchange Rate Mechanism
EU	European Union
EURIBOR	Euro Interbank Offered Rate
Fed	Federal Reserve System of the USA
ESCB	European System of Central Banks
FTOs	Fine-Tuning Operations
HICP	Harmonised Index of Consumer Prices
LTROs	Long Term Refinancing Operations
MROs	Main Refinancing Operations
NCB	National Central Bank
OMOs	Open Market Operations
SEA	Single European Act, treaty entered into force in 1986
SGP	Stability and Growth Pact
TEU	Treaty on European Union (Maastricht Treaty) – consolidated version
TFEU	Treaty on the Functioning of the European Union – consolidated version

Introduction

The aim of this thesis is to investigate the effect on GDP growth in the euro area from the non-standard measures introduced by the ECB in response to the financial crisis in late 2008, using a method for counterfactual policy analysis developed by Pesaran and Smith (2012).

The ECB introduced a set of non-standard measures in response to the financial crisis at the end of 2008. The question is whether they had an effect on the real economy, represented by the GDP growth rate, and if so, how large was it. This kind of "what if" question is difficult to answer because there is no observable control case in which no such measures were introduced. One is therefore reduced to making educated guesses about the level of certain variables in the absence of policy, and using established pre-crisis regime to estimate the effect on other variables. The general method is therefore called ex-ante counterfactual policy analysis.

A methodological contribution in this area has been presented by Pesaran and Smith in their paper "Counterfactual Analysis in Macroeconometrics: An Empirical Investigation into the Effects of Quantitative Easing". The method they developed is interesting because it does not require the specification of a structural model. For a complicated subject like monetary policy transmission such structural models can become quite large. I later refer to a few which consist of around 40 different variables. Instead of a fully specified structural model, Pesaran and Smith show that under certain assumptions, a reduced form model is enough to estimate the ex-ante counterfactual policy effect. Not only is a structural form not necessary for estimation, but neither is it needed for the specification of the reduced form. This set-up has the potential to allow quicker and easier analysis of policy, by bypassing the complicated structural models.

In the dynamic case which is interesting for this thesis, the structural form takes the shape of an ARDL model. The specific model used in the paper by Pesaran and Smith was used to analyse the effect of QE in the UK. It contained a GDP growth variable, the policy variable and a set of conditioning variables. I have set up my models in the same way, only using other variables and more lags.

After specifying the basic ARDL model and the coefficients have been estimated, one should test for structural breaks around the time of the policy change. As long as there are no structural breaks a forecast of the dependent variable a number of periods into the future can be undertaken. This forecast, conditional on realised policy variable values, is then compared to a forecast conditional on the counterfactual values of the policy variable. The difference between these two conditional forecasts will represent the effect of the policy compared to the counterfactual “no policy” scenario.

Using this method, and data on the euro area, I estimate the effect on GDP growth of the non-standard measures introduced by the ECB. The main picture is that the results support the view that the measures have had an effect on GDP in the euro area. The first specification of the model, which is a direct application of Pesaran and Smith’s model gives quite low, and rapidly decreasing, effects, but expanding the model by including more lags produces larger effects. The results of a second set of models which are better adapted to the euro area data set, indicates a stronger effect of the measures. Depending on which policy variable is used in the estimation, the annualised effect on GDP growth in the third quarter after introduction ranges from -0,4 to 2,7 percentage points.

The thesis is structured as follows. Chapter 1 gives an introduction to the history of monetary integration in Europe and an overview of how the ECB and the Eurosystem operates. Chapter 2 presents a chronology of the ECB’s monetary policy from the introduction of the euro up to the financial crisis in late 2008. Section 2.2 lists the non-standard measures and explains why they were introduced. Chapter 3 is a description of the method I will use and a summary of the article by Pesaran and Smith on which it is based. Section 3.2 explains how I intend to test for the presence of structural breaks in the model coefficients. Chapter 4 gives a short presentation of prior research on the ECB non-standard measures. Chapter 5 contains the results from my replication of the estimations by Pesaran and Smith of the effect of QE in the UK. Chapter 6 presents my contribution, starting with a section explaining my choice of variables in light of differences between the UK and the euro area. I continue by elaborating on my choice of counterfactual values and conclude section 6.1 by presenting an evaluation on the relationship between the policy variable and the conditioning variables. In section 6.2 I estimate my first set of models and present the results in the same way as in the replication section. Section 6.3 proceeds in the same way on a different set of models. Chapter 7 contains the conclusion. In the appendices following the references I have attached a number of tables and graphs which did not fit in the thesis itself as well as a description of the data and my sources. The last appendix contains all the batch files from my PcGive estimations. Running them will produce exactly the same results as I have presented, with the exception of the graphs which must be constructed manually based on the results. For all the econometric work in my thesis I have used the program PcGive which runs on OxMetrics 6, and for all data manipulation I have used Excel 2010.

1 The ECB and the Euro – The role of the ECB in euro area monetary policy

This section gives a (relatively) short history of monetary integration in post Second World War Europe, followed by an overview of the workings of the ECB and the Eurosystem.

1.1 A short history of monetary integration in post-WW2 Europe

The concept of a pan-European economic policy dates back to the very beginning of the European integration process following the Second World War. The preambles to the Treaty establishing the European Economic Community (Council 2002) contained the following ambitions:

> […]
> DETERMINED to lay the foundations of an ever closer union among the peoples of Europe,
> RESOLVED to ensure the economic and social progress of their countries by common action to eliminate the barriers which divide Europe,
> […]
> RECOGNISING that the removal of existing obstacles calls for concerted action in order to guarantee steady expansion, balanced trade and fair competition,
> ANXIOUS to strengthen the unity of their economies and to ensure their harmonious development by reducing the differences existing between the various regions and the backwardness of the less favoured regions,
> DESIRING to contribute, by means of a common commercial policy, to the progressive abolition of restrictions on international trade,
> […] [Capitals in original] (Council 2002)

Although this preamble did not represent a concrete plan for a monetary union, it reminds us that the subsequent creation of a European Monetary Union (EMU) and European Central Bank (ECB) was based on an old aspiration. The fact that it took over 30 years to realise, and that the institutions still leave much to be desired, is down to a range of both economic and political factors.

From the inception of the European project to the breakdown of the Bretton Woods system in 1971 there were two aborted attempts at economic and monetary union. The second was in response to a series of exchange rate and balance of payment crises in 1969, and led to the so-called Werner report. Nothing substantial was done as the collapse of the Breton Woods system changed the political and economic environment (ECB 2008, 8). The EEC countries soon realised however, that floating exchange rates posed a serious problem to the community, especially the Common Agricultural Policy (CAP) with its intricate cross-border system of guaranteed prices and market interventions.

The first attempted remedy was the “Snake in the tunnel” launched in 1972. This was a system designed to manage the fluctuations in exchange rates between the member states and worked by creating an upper and lower bound for currencies’ fluctuations against the dollar. The oil crisis and various other economic and political imbalances led however to the virtual collapse of the system (Commission 2010a).

In 1979 the European Monetary System (EMS) was introduced along with the European Currency Unit (ECU), a weighted average of a basket of European currencies. The EMS set a band of ±2.25%[1] around the ECU, within which the currencies of the participating countries could fluctuate. If a currency approached 75% of the allowed fluctuation margin, domestic authorities had to take action, and as the 100% bound was approached, the central bank would step in to prevent a breach. The system was undoubtedly an improvement on the snake, but still left much to be desired. The prohibition of unilateral exchange rate adjustments improved the predictability and cohesion of the system, but the need for cross-border political consensus on economic policy created new problems. The politicisation of exchange rate policy was nothing new, but the political stigma of exchange rate adjustment brought with it some economic consequences. The result was that the entire burden of adjusting exchange rates was placed on the countries facing devaluation. The loss of competitiveness from revaluing coupled with a central bank's ability to indefinitely keep a currency low led to this situation.

Despite its shortcomings, the ESM was relatively successful in reducing exchange rate volatility between the participating countries, and the experience gained by the community's central bankers in coordinating monetary policy set the stage for the European Monetary Union (EMU) a decade and a half later.

Against the backdrop of the Single European Act (SEA), enacted in 1986, and its aim of completing the single market by 1992, it was agreed that the full potential of a single market could not be achieved with multiple currencies and the transaction costs thereby incurred (Commission 2010b). The European Council (hereafter just the Council) therefore asked the European Commission (hereafter just the Commission) president Jaques Delors[2] to draw up a plan for a monetary union. The report, submitted a year later set out a three stage program towards EMU which was adopted, and the details enshrined in the Maastricht treaty in 1991.

Stage two of the program obliged member states to satisfy a set of convergence criteria and to harmonize their rules governing central banks and monetary policy in

[1] Except for the pound, lira, peseta and escudo which were allowed to fluctuate by ±6%

[2] The committee consisted of Delors and the heads of the EC central banks

preparation for the irrevocable fixing of exchange rates, to attempt to align more closely the business cycles of the different economies. If the common monetary policy was introduced at a time with diverging cycles it would create problems for the ECB. In such a case with one country experiencing a situation of increasing activity whilst another was facing recession it would be almost impossible for the central bank to do the right thing for both of them.

The criteria were designed to ensure the stability and sustainability of a country's economic policies, by setting thresholds for different economic indicators in relation to those of the best performing members. It was stipulated that inflation should be no more than 1,5% above the average of the three best performing members, government deficit as % of GDP should not exceed 3%, and the debt to GDP ratio should not be more that 60%. In addition, as participants of the EMS, the countries should not have experienced any severe tensions, and could not have devaluated in the past two years. Lastly, interest on long-term government bonds should not exceed, by more than 2%, the average of the three members with the lowest yielding bonds (Commission 2012).

In addition to the convergence criteria, stage two required the establishment of the European Monetary Institute (EMI) as a forerunner of the ECB. Its task was to facilitate a smooth transition to a supranational central bank system by preparing the regulatory, organisational and logistical framework.

In recognition of the fact that a monetary union must have, at least some, coordination of fiscal policy for it to be viable, the Amsterdam European Council in 1997 decided on the fiscal framework of EMU. The fiscal limits defined in the convergence criteria were to be continued in the form of the Stability and Growth Pact (SGP) which also provided for the introduction of the Excessive Deficit Procedure (EDP). This procedure provided for corrective action to be taken by the Council in case of any breach. The framework was however significantly weakened in 2005 (ECB 2011b, 36) after the conditions had been breached by France and Germany.

Stage three of EMU commenced on 31 December 1998 with the fixing of exchange rates and the ECB's takeover of monetary policy.

1.2 The ECB and the Eurosystem – Institutional design, tasks, tools and implementation

As the centre-piece of a new supranational monetary union, the ECB differs in some ways from other central banks. To give the reader some insight this section presents the main features of the ECB.

1.2.1 Institutional design

The ECB is the decision-making body of the Eurosystem which consists of the National Central Banks (NCBs) of the member states having adopted the euro. In addition, the European System of Central Banks (ESCB) also includes the NCBs of the remaining EU member states.

Organisation

Because of it supranational nature, the organisational structure of the Eurosystem incorporates multiple levels. The *European Council*, through the treaty, created and set the objectives and defined the instruments of the Eurosystem, but has no power over day-to-day operations. Decisions on monetary policy are taken by the ECB which the treaty designated as the decision-making body of the Eurosystem.

The ECB has two main decision-making organs: the Governing Council which is responsible for deciding on policy, and the Executive Board which is responsible for overseeing the implementation. In addition there is the General Council which encompasses the entire ESCB. The operations themselves however, are mostly carried out at the NCB level.

The Governing Council comprises the governors of the euro area NCBs and the six members of the Executive Board. The Governing Council is the main decision-making body of the ECB, and in line with article 12(1) of its statutes, it is responsible for adopting the guidelines and making the decisions required for the ECB to perform its duties as stipulated in the treaties. Its main duty therein is to "[…] formulate the monetary policy of the Union […]" (Council 2008), which entails setting intermediate objectives, decisions related to key interest rates, reserve requirements, and establishing the guidelines to be followed by the Executive Board and the NCBs (Council 2008).

The Executive Board is composed of six appointed members and is responsible for the day-to-day operations of the ECB. Because of the real-time nature of monetary policy the Executive Board plays an important role on the implementation side. The treaty therefore gives the Board exclusive competence to implement monetary policy. Acting on the guidelines adopted by the Governing Council, the Board provides instructions to the NCBs. It also carries out certain tasks delegated to it by the Governing Council, including publishing various reports, managing the ECB’s foreign reserve holdings and the day-to-day running of the ECB itself.

The final body is the *General Council*. It consists of the president and vice-president of the Executive Board and the governors of all the EU NCBs. Its main role is in monitoring of ERM II (Exchange Rate Mechanism) and providing advice on preparations for joining the euro. The ECB president must also inform the General Council of decisions made by the Governing Council, thereby ensuring that the NCBs of non-euro member states are kept up to date.

It is the *NCBs* are the work-horses of the Eurosystem. The division of labour whereby the NCBs implement most of the policies decided by the ECB is referred to as the principle of decentralisation (statutes art. 12(1)). The reasons for keeping the decentralised system of NCBs, as opposed to centralising everything with the ECB, were both political and economic. In the first instance it would have been politically unfeasible to consolidate the NCBs. Also there was considerable know-how within the NCBs and as they would continue to perform some non-Eurosystem tasks, it would have been a complicated procedure of moving and splitting up. A third point in favour of keeping the NCBs was the geographical distances and language and cultural differences within the new single currency area, coupled with the desirability for credit institutions to be close to a provider of central banking services (Scheller 2004).

Independence

The ECB was in the treaty given status as an institution of the European Union. This legal independence was a confirmation by the member states of their commitment to the single currency. By enshrining the central bank’s independence in the treaty they gave the Eurosystem the means to conduct a credible monetary policy, and committed themselves to respecting it.

It is widely acknowledged that a central bank which is independent from the meddling by policy makers will pursue a more credible monetary policy. The simple explanation for this is related to the phenomenon known as ‘time inconsistency of policy’: as time passes incentives may change leading to abandonment of a policy. At some point in time policy makers may define a prudent monetary policy which they commit to following. Then as an election approaches the incentive would be to use monetary policy to temporarily boost popularity, even if it would hurt the economy in the long run. This combination of uncertainty and short sighted policy is detrimental to the economy. Bad policy is by itself not good for the economy, and in addition by creating uncertainty it decreases the incentive to invest which in turn reduces growth, increasing unemployment and reducing the overall welfare for the economy.

Fiscal policy

The ECB has only a very limited role to play in the fiscal policy of the euro-area countries. The ECB (ECB 2008, 11) points out that it is unheard of in history for a monetary union not also to be accompanied by political, and hence fiscal, union, but it gives a range of arguments for why it might not be all bad to centralise monetary policy, while leaving fiscal policy up to the individual member states. It argues that since fiscal policy has to take account of national characteristics and institutional settings it can be more effectively conducted at the nation state level. It goes on to emphasise however, that uncoordinated fiscal policy in an interconnected world will most likely lead to less effectiveness in coping with common economic shocks, and the danger that spillovers will not be taken account of.

The provisions in the treaty for such coordination are not very substantial and come in the form of the earlier mentioned Stability and Growth Pact.

1.2.2 Tasks and objectives

Price stability

The treaty stipulates very clearly what the main objective of the ESCB is. Article 127(1):
"The primary objective of the European System of Central Banks[3] (hereinafter referred to as 'the ESCB') shall be to maintain price stability."(Council 2008)

But what does this mean in practice? The Governing Council of the ECB decided in 1998, with a further clarification in 2003 that

> […] price stability shall be defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%. Price stability is to be maintained over the medium term [aiming] to keep HICP inflation below, but close to, 2% (ECB 2008).

Inflation targeting has become more and more common in the past decades, with most central banks following this practice. Setting a target for the desired level of price increase aims to create a stable and predictable environment conductive to business. When the economy is in a situation where there is no anchoring of the inflation expectations it is hard for economic actors to predict what inflation will be in the future, i.e. there is uncertainty. Uncertainty over the future level of inflation will force the imposition of inflation risk-premia

[3] Since this part of the treaty only applies to the countries having adopted the euro, ESCB must until such a time be read as the Eurosystem.

which will increase the cost of borrowing, hence the cost of investment, and lower the growth potential of the economy as a whole. Price-setting by firms, and in the next round wage setting, would also be affected by the uncertainty, feeding the spiral of inflation uncertainty.

Aiming for inflation “below, but close to 2%” avoids a number of negative effects of high levels of inflation. The general efficiency of resource allocation in the economy is affected by higher levels of inflation. Because goods hold their value better than money assets in a high inflation environment, many firms and investors will decide to stockpile goods instead of investing. The signalling effect of prices is also clouded by the constant increase in their nominal value, making it difficult for actors to discern to which extent a good is becoming scarcer and to which extent the increase is due to inflation. The weak members of society, like those living off a fixed pension, government benefits or on a low wage, are especially vulnerable to high levels of inflation as it tends to eat up a disproportionately large amount of their income.

The central bank has only one instrument, the policy rate, and may hence only target one objective. Even if it was desirable to do more than target inflation, say unemployment, it would not be possible.

The amount of money also has no long term effect on the real economy, only changing the nominal price of goods, the Philips curve in the long run is vertical.

Zero inflation is however not a good policy option because it is too close to deflation. Deflation dis-incentivises people to spend and invest thereby reducing the growth potential of the economy. Leaving some room between the inflation target and deflation decreases the probability of slipping into deflation. In addition this also ensures that the central bank has sufficient room to manoeuvre, avoiding as far as possible the zero lower-bound from becoming binding. This is especially important in a new monetary union where there are inflation differentials between the constituent countries. Even if the average inflation is positive it might be that some countries are facing deflation (Scheller 2004, 82).

Other tasks

The ECB is obliged by the treaty, if possible without compromising the aim of price stability, to support the general economic policies of the Union and generally act in accordance with the principles of an open market economy with free competition, favouring an efficient allocation of resources. The ECB deems its pursuit of price stability to be its main contribution to supporting the general economic policies of the Union (Scheller 2004).

In addition to the mentioned primary tasks, the ECB performs a number of more technical tasks related to its role as central bank for the Eurosystem (art. 127 of the TFEU).

These include:

- holding and managing the euro area member states' official foreign reserves and conducting foreign exchange operations
- promoting the smooth operation of payment systems
- control over the issuance of money

The ECB's role in conducting foreign reserve operations is an important extension of its task of conducting monetary policy. Through the price of imports, the exchange rate may have a significant effect on the stability and level of prices, and the exchange rate in itself may influence domestic liquidity.

Considerations of liquidity also figure in the two last items on the list. The ECB as supplier of liquidity needs to control the medium, money, and make sure the transmission channels, payment systems, are up to the job.

In addition the ECB is tasked with collecting statistical information (jointly with Eurostat) and providing advice to relevant Community and national bodies regarding legislation which comes within its domain of expertise.

1.2.3 Tools and implementation

The objective of keeping prices stable, and increasing at a rate of below, but close to 2% a year, requires information. Together with Eurostat, the ESCB has been tasked by the treaty to collect statistical information about all aspects of the economy. This information is used in a number of models of varying degree of aggregation and complexity to give a picture of the euro-area economy.

The two pillar framework – economic and monetary analysis

The ECB utilises this information through a two pillar framework of economic and monetary analysis. This set-up, according to the ECB (Scheller 2004, 83), makes sure that no information is missed in the overall analysis of threats to price stability. The ECB (Ibid, 84) points out that economic analysis is best suited to analysis of the short to medium term, because inflation is ultimately a monetary phenomenon. This long-term neutrality of money implies that economic analysis is unsuited for detecting long-run effects, hence the monetary pillar.

The economic analysis utilises information on economic and financial indicators to assess the threat to price stability in the short to medium term while the monetary analysis utilises information on the growth of money assets to assess the medium to long term threats.

Benchmark growth is set at 4,5% for the M3 money aggregate, but the ECB is careful to point out that there is no mechanical reaction to this benchmark. In this sense the monetary pillar is more of a compliment to the economic pillar than an independent tool of evaluation. This is partially confirmed by the ECB referring to it as a method of cross checking. The reason why there is no mechanical reaction to the M3 is that it also exhibits short term fluctuations. It is the trend growth of M3 which seems to lead inflation (ECB 2008, 38).

Implementing policy by managing liquidity

The ECB possesses three main tools, derived from its monopoly of the supply of the monetary base, by which to affect the short-term interest rate in the money market: open market operations (OMOs), standing facilities and minimum reserve requirements. Open market operations are the active tools of the ECB in steering money market rates, while the standing facilities are used to a much lesser degree. The minimum reserve requirements play an important passive role in the system.

Open Market Operations

There are four kinds of open market operations: Main Refinancing Operations (MROs), Long Term Refinancing Operations (LTROs), Fine-Tuning Operations (FTOs) and structural operations.

The *MROs* are the main tool used for steering the money market rates and are carried out every week with maturities of a week. In principle, all credit institutions in the euro area are eligible to take part. In normal times, i.e. before the financial crisis, the auctions took place at variable rates, to discourage over-bidding, with the ECB determining ex ante the amount of liquidity to be auctioned and the minimum rate at which bids were accepted. During the time of financial turmoil the process was changed so that liquidity was provided to satisfy demand at a fixed rate.

LTROs are also executed on a regular basis, monthly with a three month maturity. The liquidity provided is less than that provided through the MROs, but serves the important purpose of providing more continuity to the short term money market. With this instrument the ECB ensures that all the liquidity in the market isn’t rolled over every week, at the same time.

FTOs provide the ECB with the means to smooth the effects of unexpected liquidity situations in the market. They are usually executed through quick tenders of an hour with a limited amount of counterparties.

Structural operations are hardly ever used, but provide the ECB with the possibility to alter the structural liquidity situation of the market.

The Standing Facility

The standing facility consists of the marginal lending facility and the deposit facility, both over-night facilities open to credit institutions at their discretion. It serves mainly to absorb liquidity in exceptional circumstances as the interest rates obtained in the market are generally more lucrative.

The *marginal lending facility* and the *deposit facility* act as, respectively, a ceiling and floor on the over-night rate. Generally ±1 percentage point around the main refinancing rate on the MRO. In normal times the standing facilities are mostly used towards the end of the reserve maintenance period because of the incentives created by the averaging procedure (ECB 2011b, 109).

Minimum Reserve Requirements

The minimum reserve requirements play two important roles. The primary role is to stabilise the money market rates by the averaging provision, but by also creating a structural liquidity shortage on the part of the credit institutions required to hold minimum reserves with the ESCB, it guarantees that the banking system needs central bank credit, thereby making it easier for the ECB to steer money market rates.

All credit institutions in the euro-area are required to keep a minimum reserve on accounts with the ESCB. So as not to interfere with incentives, the ECB remunerates institutions for their reserves at the average rate on the MRO through the maintenance period. The required reserve amount is calculated on the basis of the value of liabilities on an institution's balance sheet. The institutions are however not required to keep the said amount with the ESCB every day, but on average over the maintenance period. The maintenance period is one month and runs from the day after the Governing Council's policy meeting to the next.

The averaging provision ensures that the reserve requirement is not a binding constraint on banks. As long as they satisfy the requirement on average they are free to run a surplus or a deficit on any given day. If for example the money market rates on a certain day are expected to be higher than the average rate on the MRO over the period, a bank may run a reserve surplus by borrowing in the market and storing the funds with the ESCB. This possibility for intertemporal arbitrage serves to smooth out the short-term money market interest rates, relieving the ECB of having to intervene to often in the market (ECB 2011b, 101).

Figure 1: Overview over the Eurosystem's monetary policy operations

Monetary policy operations	Types of transactions Provision of liquidity	 Absorption of liquidity	Maturity	Frequency	Procedure
Open market operations					
Main refinancing operations	Reverse transactions	-	One week	Weekly	Standard tenders
Longer-term refinancing operations	Reverse transactions	-	Three months	Monthly	Standard tenders
Fine-tuning operations	Reverse transactions Foreign exchange swaps	Reverse transactions Collection of fixed-term deposits Foreign exchange swaps	Non-standardised	Non-regular	Quick tenders Bilateral procedures
	Outright purchases	Outright sales	-	Non-regular	Bilateral procedures
Structural operations	Reverse transactions	Issuance of debt certificates	Standardised/ non-standardised	Regular and non-regular	Standard tenders
	Outright purchases	Outright sales	-	Non-regular	Bilateral procedures
Standing facilities					
Marginal lending facility	Reverse transactions	-	Overnight	Access at the discretion of counterparties	
Deposit facility	-	Deposits	Overnight	Access at the discretion of counterparties	

Source: (Scheller 2004, 86)

2 A decade of monetary policy

To make the presentation of the past decade and a half easier, the ECB (2011b) has divided the period into six phases. Starting from the introduction of the monetary union, the phases correspond to periods in which the monetary policy had the same trend. Figure 2 taken from an ECB report (Ibid) illustrates this quite clearly.

Figure 2: Key ECB interest rates divided into six phases

Source: (ECB 2011b, 117)

2.1 Good times before the crisis

Phase 1 – the transition to monetary union, mid-1998 to mid-1999.

Thanks to the convergence policies under stage two of EMU the ECB took over monetary policy at a time with low and converging inflation. Policy rates were also low in the countries adopting the euro, the rate on the MRO stood at 3% with the rates on the marginal lending facility and the deposit facility creating a ceiling and floor at 4.5% and 2% respectively.

Lower oil prices and deregulation of the service sector led to less pressure on the HICP, and the global economic environment in the wake of the Asia financial crisis and turmoil in Russia led to a weakening of external demand. In light of this the ECB lowered the fixed rate on its MROs by 50 basis points to 2.5%.

Phase 2 – mid-1999 to end-2000

During this phase the minimum bid rate on the MROs was raised by 225 basis points, to 4.75%. The reason for this was concerns about second-round effects on wages and prices from lower import prices, and the accumulation of liquidity.

Phase 3 – early 2001 to mid-2003

Fluctuations in the financial markets and the attacks on the World Trade Centre led to uncertainty in the market and a downgrade of the threats to medium term price stability. The ECB reduced its policy rate by 275 basis points, so that by June 2003 it stood at 2%. This was in spite of a significant increase in the M3 indicator of money growth. The explanation given was that this growth was seen as a result of the uncertainties in the financial markets and the subsequent shift of investors' portfolios to money market assets as a place of security. In this sense the growth of money was an indicator of difficult, and not good, times.

Phase 4 – mid-2003 to end 2005

During this period growth was sluggish and only picked up towards the end of the period. The growth was driven by exports, but tempered by increases in energy and food prices. The monetary analysis indicated that the uncertainty in the market decreased, as seen from a gradual unwinding of the portfolio shift into monetary assets seen in the previous period. There was not deemed to be any significant medium-term threat to price stability, hence the rates remained unchanged at 2% throughout the period.

Phase 5 – end-2005 to mid-2008

The economic analysis was at the beginning of the period ambiguous about the expectation of growth, it was the monetary analysis which provided the first indications. This led the ECB to increase rates gradually, and when the economic analysis later confirmed this, rates were further increased, such that they by the end of the period had increased by 225 basis points to 4.25%.

The growth came first from exports, as the global economy took off and substantial increases in the oil price and prices for food all contributed to pressure on the medium term inflation. It turned out that the inflation expectations remained at the 2% level even though the actual inflation rate peaked above 3% and at the end of this period stood at 4%. Wage increases remained modest, but in such an environment there was substantial risk of second-round effects.

At the first signs of financial turmoil in the autumn of 2007 the ECB introduced a set of non-standard measures. They included unlimited over-night liquidity through FTOs and currency swaps with other central banks, mainly the Federal Reserve system in the USA to provide currency liquidity to European banks.

2.2 Phase 6 - Financial crisis and the introduction of non-standard measures

Turn of events

After the collapse of Lehman Brothers in September 2008, what had been turmoil in the financial markets turned into a full-blown crisis, eventually leading to the worst recession since the Second World War. Both the fact that Lehman was allowed to collapse, and the fact that it was in such bad shape, sent shockwaves through the markets, and led to the virtual seizing up of the interbank market.

Because of the asymmetry of information in the highly interconnected financial markets, fears of what might be hiding on counterparts' balance sheets led to increasing uncertainty and loss of trust, which resulted in a refusal of banks to lend to each other (the bank lending channel).

Banks interact in the interbank market to satisfy short term liquidity needs stemming from fluctuations in day-to-day activity. Loss of access to this vital market, from the refusal to lend or prohibitively high risk premia, would mean that the banks would have to find other ways of satisfying their liquidity needs. The easiest way to do this would be to stop, or reduce lending to customers and to call in outstanding debts (the risk-taking channel).

The effect on the wider economy from such actions would be severely growth retarding. If firms lost access to credit they would have to shut or scale down their activities affecting employment and sales, starting a downward spiral which in turn would lead to reduced asset prices and a further squeeze on banks' balance sheets (balance sheet channel).

Rationale for introducing non-standard measures

Monetary policy works primarily though the short term money market interest rates (interest rate channel). A normal response to a downturn would therefore be to reduce the main policy rate to encourage spending and investment. The interest rate is however only the first step on the road in the transmission mechanism of monetary policy. By adjusting the policy rate the central bank affects the large institutional actors' access to credit, they in turn must adjust their rates in order to transmit this effect through to the public. In the euro area retail banks play a more important role in the provision of credit to the private sector than in the US where financial markets and institutions other than retail banks play the most important role (Cour-Thimann and Winkler 2012).

The terms in parenthesis in the previous section represent the channels through which financial intermediaries affect spending and investment. If these channels become blocked or unstable, changing the main policy rate will have a very limited effect on the economy (ECB 2011a, 56).

Seeing that only reducing interest rates would not provide an adequate response to the crisis, the ECB introduced a number of non-standard measures. The stated aim of which was to "maintain the transmission mechanism of monetary policy" by "(i) support[ing] funding conditions for banks, in order to enhance the provision of credit to the private sector, and (ii) keep[ing] contagion in financial markets contained" (ECB 2011a, 55).

These non-standard measures were introduced while the policy rate was still not constrained by the zero lower bound. Traditionally any unconventional policy was seen as a continuation of standard policy when the interest rate hit the zero lower bound. Because of the way in which the ECB remunerates reserves at the MRO rate (the BoE and the Fed have different systems) it is able to conduct so-called credit easing independently of interest rate setting. The ECB hence considered the non-standard measures complements and not replacements for standard monetary policy (ECB 2011a, 56).

Enhanced Credit Support

In a coordinated effort with other western central banks the ECB reduced its interest rates by 50 basis points on 8th October, then unilaterally by a further 325 points to 1% in the following seven months. In the same period, from October, the ECB introduced a number of non-standard measures under the label of Enhanced Credit Support (ECS). This consisted of five measures (ECB 2011b, 127):

Extension of the maturity of liquidity provision: The ECB provided refinancing operations with maturities of up to 12 months in order to reduce the uncertainty connected to banks' liquidity needs. Longer maturities were expected to shift the focus to the longer term and reduce the short term interest rate volatility. In addition, security of short term liquidity needs was expected to encourage banks to keep lending to businesses at low rates corresponding to the ones set by the ECB.

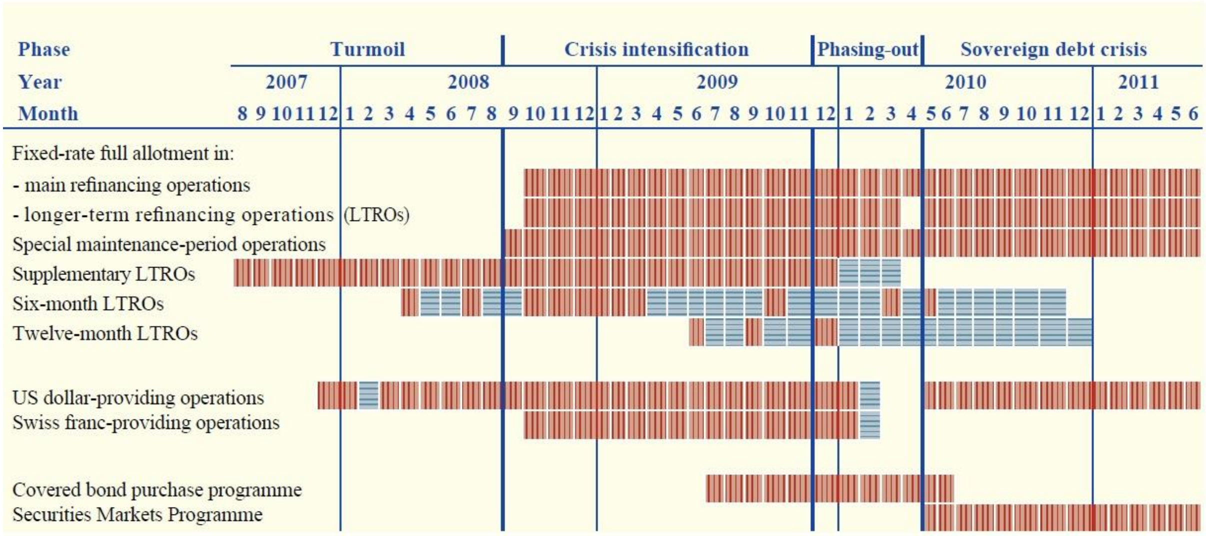
Fixed rate full allotment (FRFA) was introduced on all refinancing operations. In this way all euro area financial institutions, subject to adequate collateral, had access to virtually unlimited liquidity at the rate of the MRO which by May stood at 1%. This was to ensure that banks which no longer had access to the interbank market would still be able to access liquidity to continue normal operations and react properly to the ECB's monetary policy signals.

Currency swap agreements were entered into with the Fed and the Swiss central bank to provide currency against euro area eligible collateral to institutions which could not obtain it though the normal channels.

Lightened collateral requirements were introduced through the NCBs. At their own risk the NCBs were allowed to set lower national requirements for collateral. Banks were in this way able to refinance illiquid assets as a substitute for the interbank market.

The Covered bond market is an important source of financing for banks. The *covered bond purchase program* was introduced to put life back in this segment of the market which relies on the ability of banks to trust that collateral provided is safe, something which the recent collapses had put into question.

Figure 3: Chronology of the ECS's non-standard measures from August 2007 to June 2011



Note: The reddish brown bars indicate that operations were conducted in the specific month, while the blue bars indicate that no new operations were conducted but that the liquidity provided in previous operations remained in place.
Source: (ECB 2011a, 57)

3 Method

In their 2012 article, "Counterfactual Analysis in Macroeconometrics: An Empirical Investigation into the Effects of Quantitative Easing", Pesaran and Smith (2012), P&S hereafter, set out an appealing framework for econometric counterfactual ex-ante macro policy evaluation. Because I base my own analysis of the euro on the method presented in this article I give a summary of P&S's method and of the result that they report.

3.1 Counterfactual policy analysis - short presentation of an analysis by Pesaran and Smith

The article consists of two parts; first a presentation and discussion of the method, then its application to analysing the effects of QE in the UK. The main methodological point is that, subject to some assumptions which I will return to, the policy effects of an ad hoc policy change can be estimated by the use of a reduced form econometric model, a large-scale structural model (although ideal) may in fact not be required.

The authors define ad hoc as a policy which does not affect the structural relationship between policy and the economy, such as a one-time shock. QE is deemed to be such a policy since it is a one-time intervention aimed only at further easing monetary policy, not changing the way monetary policy responds to the economy.

The authors introduce four variables: the dependent output variable y_t, the policy variable x_t, a control variable z_t which may affect both y_t and x_t, and a vector of variables $\boldsymbol{w}_t$ which only affects z_t and y_t. Their argument is that a reduced form regression of y_t on x_t and $\boldsymbol{w}_t$ will suffice to elicit the counterfactual effect of a policy under the appropriate assumptions.

The structural form parameters are assumed to be policy and time invariant. If the model's parameters change at the time of the policy introduction, a counterfactual analysis based on the pre-introduction parameters cannot identify the effect of policy. By assuming that the policy change does not affect the parameters the authors are implying that this analysis covers ad hoc changes to policy. The ad hoc label suites the ECB non-standard monetary policy, as the measures introduced are not regarded as departures from traditional monetary policy, but complements. There is no structural break in the monetary policy response function, only exceptional policy measures introduced to facilitate the continued efficiency of existing instruments.

Based on the ad hoc nature of policy and assumed stability of parameters and invariance with respect to the policy change, P&S show that for a static model the following reduced form equation will suffice for the purpose of policy analysis:

$$y_t = \pi_t x_t + \pi_t' \boldsymbol{w}_t + v_{yt} \qquad (1.1)$$

Where π_t and π_t' are parameters, and v_{yt} is a disturbance with approximately white-noise properties.

Supposing the policy is introduced at time T, the vector of "policy on" realized values, $\boldsymbol{\Psi}_{T+h}(x) = \{x_{T+1}, x_{T+2}, \dots, x_{T+h}\}$, will differ from the vector of counterfactual "policy off" values, $\boldsymbol{\Psi}_{T+h}^0(x) = \{x_{T+1}^0, x_{T+2}^0, \dots, x_{T+h}^0\}$. The ex-ante nature of the policy evaluation means that there is also a third set of values, the (ex-ante) expected "policy on" values, $\boldsymbol{\Psi}_{T+h}^1(x) = \{x_{T+1}^1, x_{T+2}^1, \dots, x_{T+h}^1\}$, which also differ from the realized "policy on" values by virtue of implementation errors.

The effects of an ad hoc change in the policy variable is given by comparing expected y_t conditional on realised policy values to expected y_t conditional on counterfactual policy values:

$$\begin{aligned} E(y_{T+h} \big| \boldsymbol{\Omega}_T, \boldsymbol{\Psi}_{T+h}^0) &= E(\pi_1 \big| \boldsymbol{\Psi}_{T+h}^0) x_{T+h}^0 + \pi_2' E(\boldsymbol{w}_{T+h} \big| \boldsymbol{\Psi}_{T+h}^0) \\ E(y_{T+h} | \boldsymbol{\Omega}_T, \boldsymbol{\Psi}_{T+h}^1) &= E(\pi_1 | \boldsymbol{\Psi}_{T+h}^1) x_{T+h}^1 + \pi_2' E(\boldsymbol{w}_{T+h} | \boldsymbol{\Psi}_{T+h}^1) \end{aligned} \qquad (1.2)$$

$$\text{for } h = 1, 2, \dots, H$$

Where $\boldsymbol{\Omega}_T$ represents the information set available at time T, the last period before policy change. Subtracting first line of (1.2) from the second line gives the effect of the policy change on the dependent variable, which in the simplest case when the reduced form parameters ($\pi_1$and π_2), $\boldsymbol{w}_t$ and the errors v_{yt}all are invariant to the policy intervention reduces to:

$$d_{T+h} = \pi_1 (x_{T+h}^1 - x_{T+h}^0) \qquad (1.3)$$

P&S also show that more generally, when the reduced form parameters are not invariant to the policy change, but $\boldsymbol{w_t}$ and v_{yt} are unaffected, the difference may be expressed in a slightly more complicated way. I will not pursue this possibility in my thesis.

For my purpose it is however important to note that P&S introduce dynamic effects in the form of an ARDL model in the same three variable categories:

$$y_t = \lambda \mathrm{y}_{\mathrm{t}-1} + \pi_{10} x_t + \pi_{11} x_{t-1} + \pi_t' \boldsymbol{w}_t + v_{yt} \tag{1.4}$$

P&S show that the dynamic counterpart to (1.3) is:

$$d_{T+h} = \pi_{10} \sum_{j=0}^{h-1} \lambda^j \left(x_{T+h-j}^1 - x_{T+h-j}^0 \right) + \pi_{11} \sum_{j=1}^{h} \lambda^{j-1} \left(x_{T+h-j}^1 - x_{T+h-j}^0 \right) \tag{1.5}$$

when the model is (1.4).

According to P&S, one motivation for the lags of the policy variable x_t is to control for the possible endogeneity of x_t. The example P&S gives is the case of a monetary policy interest rate rule.

The paper presents important arguments for why the use of reduced form estimation is to be preferred for policy analysis as opposed to structural form. The first point is that if one is to use the structural form, all the parameters must be invariant to the policy intervention, but in many cases it may be more realistic to assume that the total effect is invariant whilst the marginal effects estimated in the structural equation are not. Specification errors may also occur more frequently in the structural form setup. One of the main reasons for preferring a reduced form model to a larger structural model is that it is much more transparent and less complicated, making it easier to evaluate assumptions and invariance.

P&S have applied this framework to the evaluation of the effect on GDP growth in the UK of QE, represented by a 100 basis point, one time, reduction in the spread of long over short interest rates. The 100 basis points change is chosen on the grounds of realism and the analysis could easily be “scaled to” any other value. Output growth is measured as the quarterly change in the log values of real GDP, whilst the spread is measured as the difference between $0{,}25 \log(1 + R/100)$ for long and short interest rates, R.

The ARDL with only y_t and x_t is estimated first and the results compared to the regression including also EU and US growth as the vector of $\boldsymbol{w}_t$ variables. The parameters are estimated over two intervals, the interval of observations before QE was introduced and the entire sample. Stability is assumed, but no tests are produced.

The conclusion is that there was a marked effect of QE, but it was short-lived. The inclusion of control variables such as output in the US and EU reduces the estimated effect of the simplest model.

3.2 Testing the stability of the parameters

The assumptions of the model presented by P&S require the reduced from coefficients to be stable. I will in this section present a method of assess the stability of these coefficients.

A simple way of assessing stability is to estimate the model recursively. Recursive estimation is done by first estimating the model on a short sample, then estimating it repeatedly, extending the model by one observation for each time. Plots of the coefficients against time, i.e. the sample period, gives an intuitive way of assessing whether there are any breaks in the parameters. In PcGive the estimates of the coefficients can be plotted together with an approximation of the 95% confidence interval ($\pm 2\sqrt{\left(Var\widehat{\beta_i}(j)\right)}$, for iteration j of coefficient i). A rule of thumb is therefore that a parameter is unstable if the graph of the sequence of recursive point estimates "jumps" or "drifts" outside the graphs which represent the corresponding 95% confidence interval. Because each new observation carries a lot of weight when the initialisation sample is small, the graph will exhibit volatility in the beginning, but in the case of stability, it will converge to a stable value as the length of the estimation sample is extended. As just noted, if there are any sudden jumps in the latter part of the graph, this may indicate instability.

Recursive estimation method also produces recursive residuals. In PcGive these residuals are graphed as the so called 1-step residuals, together with a 95% confidence interval.

The most common tests of structural breaks are perhaps the Chow tests. They are in effect F-tests of the H_0 that the regression coefficients are the same over two sub-samples. Using as the unrestricted sum of squares residual (SSR_U) the SSR from the estimations of the first part of the sample, and the restricted SSR (SSR_R) as the SSR from the estimation of the whole sample a typical Chow test would look like this:

$$F_{ChowP} = \frac{SSR_R - SSR_U}{SSR_U}\frac{T_1 - K}{T - T_1} \tag{1.6}$$

With T_1 as the end of the first part of the sample, T as the entire sample and K as the number of parameters.

PcGive provides three such Chow tests, each calculated in a slightly different way. The 1-step Chow test starts with a small sample and calculates the test adding one observation at a time, such that $T - T_1 = 1$, until the end of the sample. In the break-point, or N-down test, T_1 is increased by one then two and so on until $T = T_1$. Finally in the forecast, or N-up, Chow test the first sample T_1 is kept fixed and the total sample is increased one at a time.

PcGive graphs them together with a 1% critical value where the Chow tests are scaled such that the 1% level becomes a straight line.

4 A short survey of the literature on non-standard monetary policy for the euro area

Both the euro area and the non-standard measures are relatively new, so there is not much literature yet. A few authors with connections to the ECB have produced a number of working papers on the issue however, and I will try to sum up these studies.

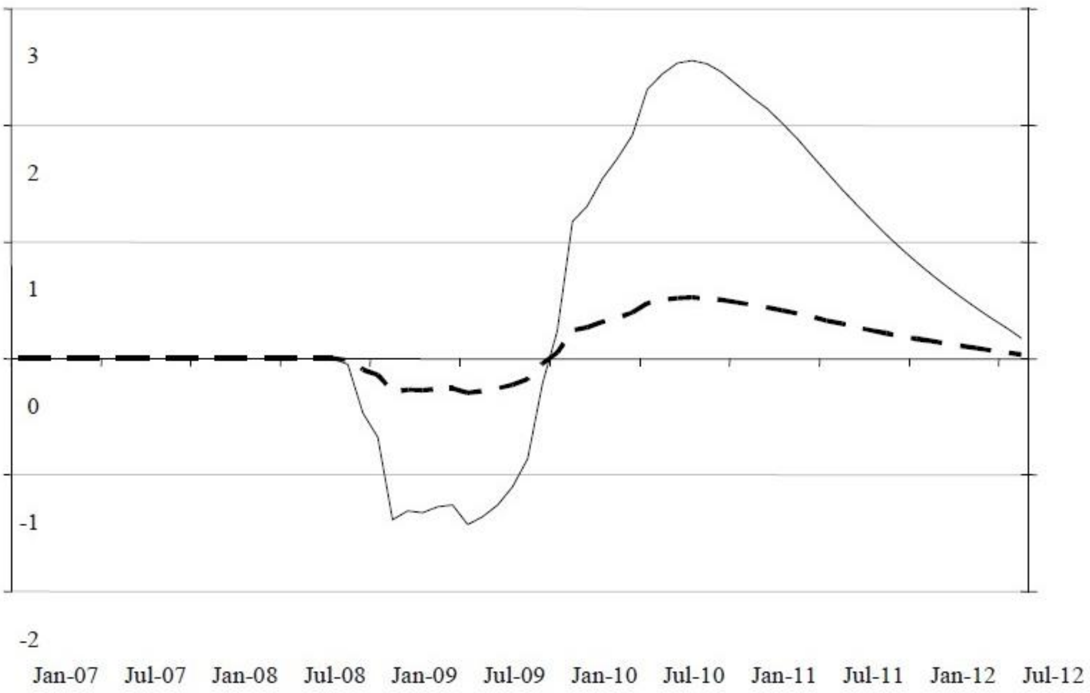
The main reference and methodological basis for these working papers is a paper by Giannone et al. (2012) originally published in 2009. This paper “Money, credit, monetary policy and the business cycle in the euro area” contains a model for the euro area with the aim of studying the features of financial intermediation over the business cycle. The dataset for the model contains 39 monthly variables from 1992 to 2010. In order to “allow the data to speak”, the authors adopt a general VAR model and use so called Bayesian shrinkage to limit its size (in terms of estimated parameters). The model is then estimated once on the data before the crisis and once on the data for the crisis, aiming to establish if the mechanisms have changed in response to the crisis.

For the second part of the exercise the coefficients from the pre-crisis estimations are used to estimate the time-path of variables conditional on actual output through the crisis. In the event of a change in coefficients there would be a large difference between the estimated and the actual values of the variables. This exercise is a more in-depth way of establishing evidence of coefficient stability than I will be able to do with conventional Chow tests and a reduced form model.

A main result of the estimation is that the mechanisms of especially short-term loans, deposits and the EURIBOR have remained relatively unchanged while the longer term indicators show signs of change. The authors suggest that the ECB’s non-standard measures may be the reason why the short term indicators have remained relatively stable, in a sense a tentative indirect proof of their impact.

Based on the model in the paper by Giannome et al. (2012), Lenza et al. (2010) have written a paper that explicitly examine the effects of the ECB’s non-standard measures. The first parts of the paper explain the mechanisms involved and the structure under which the measures were introduced. Since I have already covered these issues I will jump straight to the results. Based on the behaviour of certain money market rates at the time of the crisis the authors construct counterfactual values for the EURIBOR 3 and 12 month rates. Using the model developed by Giannone et al. (2012), the authors estimate paths for each variable of interest conditional on first realised values for the money market rates, then on the counterfactual. The difference between these conditional expectations is an estimate of the effect of the measures. We see that this approach has much in common with P&S's method, although the specified models are different. For the purpose of this thesis, the effect on GDP is the most interesting. Figure 4 below is taken from their paper. It shows that the estimated effect is negative to begin with, before it becomes markedly positive, then trailing off after two and a half years.

Figure 4: Effect of non-standard measures on industrial production in annual percentage points



Source:(Lenza, Pill, and Reichlin 2010)

The final paper that I have found is by Fahr et al. (2011). It also makes use of a VAR set-up, but aims to investigate only the FRFA aspect of the non-standard measures. The reason for not using a more defined model is that the VAR lets the data speak as opposed to a model with more structure, which requires the model builders to specify relationships. This model is of monthly frequency and includes a range of money market and financial indicators with 10 lags of each, i.e. less than a year. In evaluating the effects of non-standard measures the authors create counterfactuals by estimating the impulse response in the pre-crisis model to changes in the relevant policy variables. On the basis of this they also find a substantial effect from the introduction of FRFA, however less than the other with no initial negative effect.

5 Replication of the results from the paper by Pesaran and Smith

To make sure I had the correct understanding of the method, I started by replicating the results from the paper by P&S which I described above. I obtained the data-set they used by following the references in the article[4], and by correspondence with the authors. After transforming some of the data-series, as described in the article, I set up the models and began the analysis[5].

I first set up and estimated the ARDL model (1.4) with one lag of output growth and spread, and obtained exactly the same estimates as the authors (columns 2 and 3 in table 5-1]. I used two samples, the first ending in the last period before QE was introduced (1980Q3-2008Q4) and the second covering the entire sample from 1980Q3 to 2011Q3. The purpose was to check for the presence of structural breaks in the variables. The presence of any such breaks would indicate that the economy responded differently to monetary policy before and during the crisis. In which case forecasts of the crisis period based on pre-crisis parameters might give the wrong conclusions as to the effect of monetary policy.

Table 5-1: Replicated unrestricted results of the first model by P&S, no control variables

$\boldsymbol{y_t}$: **dlogGDP by OLS**	**Sample period**			
	1980Q3 – 2008Q4		1980Q1 – 2011Q3	
λ: dlogGDP_1	0,3986		0,4785	
		(0,0839) 4,75		(0,0712) 6,72
$\boldsymbol{\pi_{10}}$: *lSpreadUK*	-0,9140		-1.0085	
		(0,3226) -2,83		(0,3269) 3,08
$\boldsymbol{\pi_{11}}$: *lSpreadUK_1*	1,1571		1,1281	
		(0,3269) 3,54		(0,3269) 3,45
$\boldsymbol{R^2}$	0,309768		0,380306	
$\hat{\boldsymbol{\sigma}}$	0,00525		0,00538	
F-test on $\boldsymbol{\pi_{10}+\pi_{12}=0}$	10,6570		11,0690	
p-value	[0,001]		[0,0012]	

SE in parenthesis, followed by t-values

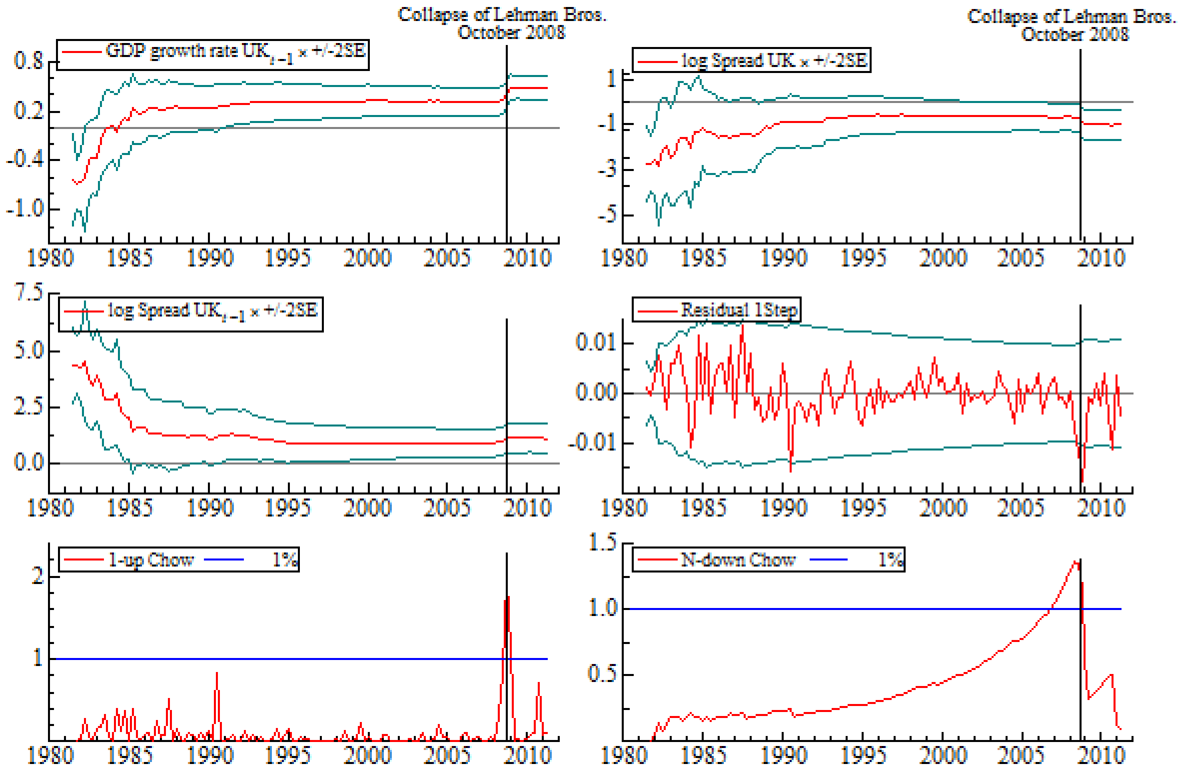
The estimates on the spread parameters shown in the table are quite similar, but just looking at these is not enough to tell if there is a structural break. I will use the method described in section 3.2 to take a closer look. The results are presented in figure 5 below. The three first panels graph recursive estimates of all the coefficients together with their $\pm 2 * \mathrm{SE}$, the fourth graphs the residual 1-step with its $\pm 2 * \mathrm{SE}$, and the two remaining are the Chow tests.

[4] Cambridge University: http://www-cfap.jbs.cam.ac.uk/research/gvartoolbox/download.html and by correspondence with the authors via e-mail.

[5] The appendix includes the printout of the batch file I used.

The coefficient on the lag of GDP growth exhibits a statistically significant break at the time of the crisis, in late 2008. This is not very surprising considering the sudden steep decline in GDP. The more important fact is that the coefficients on the spread exhibit a much smaller, and statistically insignificant (at the 5% level), break. It is these coefficients which are of most interest for the purpose of this exercise. Looking at the graph of the 1-step residuals, it is clear that the break stems from the same steep and sudden decline in GDP growth as the break in the lag on GDP growth, i.e. it does not indicate any problem for the spread coefficients. The two Chow tests both exhibit spikes at the turn of 2008 – 2009, but they are not persistent.

Figure 5: Structural break tests for replication of P&S's results



A one-time policy shock is not supposed to have permanent effects on the economy, so P&S impose the restriction of zero long-run effect of the policy variable. In their article they do not explicitly test this assumption, though. To supplement their analysis I tested the linear restriction (1.8). The F-test statistics reported in the table 5-1 show values way below the critical values even at the 1% level, indicating that the hypothesis of zero long-run effect has to be rejected statistically, and the imposition of this restriction is not valid. I will continue using the restricted model because it is what P&S did and I am trying to replicate their results.

Imposing the restriction (1.8) amounts to computing the first difference of the spread and estimating the following model:

$$y_t = \lambda y_{t-1} + \pi_{10}\Delta x_t + v_{yt} \tag{1.7}$$

A model of this form implicitly imposes the restriction that

$$\pi_{10} + \pi_{11} = 0 \tag{1.8}$$

which is the same as saying the long-run effect is zero. The results of this restricted estimation are presented in table 5-2.

Table 5-2: Replicated restricted results of the first model by P&S, no control variables

$\boldsymbol{y_t}$: **dlogGDP by OLS**	
λ: dlogGDP_1	0,4232
	(0,0835) 5,07
$\boldsymbol{\pi_{10}}\Delta_t$:	-1,0183
	(0,3200) -3,18
$\boldsymbol{R^2}$	0,29061
$\boldsymbol{\hat{\sigma}}$	0,00530

SE in parenthesis, followed by t-values

P&S used counterfactual values for the spread estimated by Joyce et al. (2011) to be 100bps. I constructed the counterfactual spread by adding 100bps to the original long term interest rate before computing the spread in the same way as above[6].

Dynamic forecasting conditional on actual and counterfactual spreads 11 periods ahead produces two graphs, the difference between which is the quarterly effect of QE on GDP growth in the UK. The two forecasts converge after a little over a year with the initial impact at 0,002447, or 24,47pps. Increasing this number to the power of four produces an annualised effect, bringing the effect close to 1pp. This indicates that QE, evaluated as a reduction in the spread of 100bps, had the effect of increasing quarterly GDP growth by an annualised one percentage point.

Adding conditioning variables, $\boldsymbol{w}_t$, serves to introduce more structure to the model and makes sure that effects from exogenous variables are not falsely ascribed to the policy variable. P&S use GDP growth in the USA and euro area as conditioning variables under the assumption that they are unaffected by changes in the policy variable. We can test this in a model with the conditioning variable as the dependent variable and the spread and the other

[6] Again, refer to the attached batch file

conditioning variable as the regressors. Estimating this model gives very small coefficients of little significance on the spread variable, indicating that it does indeed not affect the conditioning variable.

The estimates in the two tables, 5-3 and 5-4, below result from the extended model, the first from the unrestricted and the second with the zero long-run restriction imposed.

Table 5-3: Replicated unrestricted results from second model by P&S, conditional on euro area and USA GDP growth

y_t: **dlogGDP by OLS**	**Sample period**	
	1980Q3 – 2008Q4	1980Q1 – 2011Q3
λ: dlogGDP_1	0,3217	0,3844
	(0,0866) 3,71	(0,0743) 5,17
π_{10}: *lSpreadUK*	-0,7693	-0,8249
	(0,3113) -2,47	(0,3108) -2,65
π_{11}: *lSpreadUK_1*	1,1116	1,0103
	(0,3103) 3,58	(0.3068) 3,29
π_{21}: *dlogGDPEA*	0,1546	0,1616
	(0,0599) 2,58	(0,0539) 3,00
π_{22}: *dlogGDPUSA*	0,1349	0,1473
	(0,0736) 1,83	(0,0736) 2,00
R^2	0,35620	0,46929
σ	0,00520	0,00502
F-test on $\pi_{10}+\pi_{12}=0$	9,63160	9,16250
p-value	[0,0024]	[0,0030]

SE in parenthesis, followed by t-values

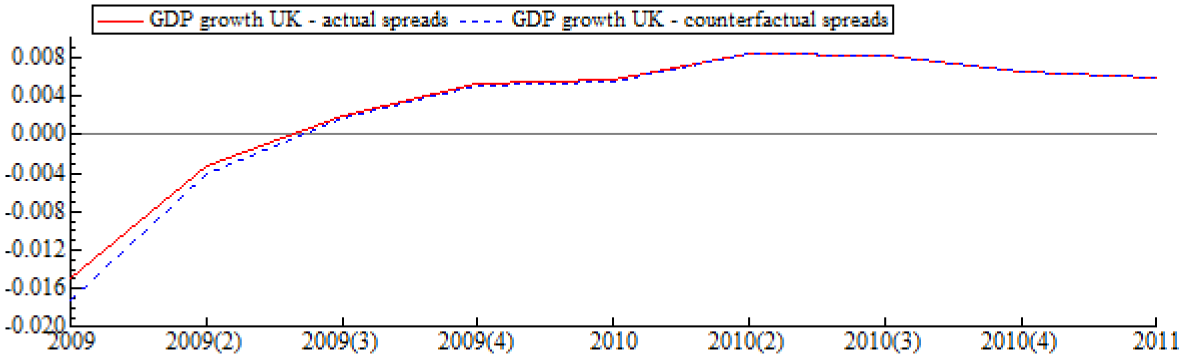
Table 5-4: Replicated restricted results from second model by P&S, conditional on euro area and USA GDP growth

y_t: **dlogGDP by OLS**	
λ: dlogGDP_1	0,3469
	(0,088) 3,94
$\pi_{10}\Delta_t$:	0,9456
	(0,3101) -3,05
π_{21}: *dlogGDPEA*	0,1104
	(0,0585) 1,89
π_{22}: *dlogGDPUSA*	0,1551
	(0,0749) 2,07
R^2	0,35620
σ	0,00520

SE in parenthesis, followed by t-values

The result was slightly lower than the previous one with the initial effect of the reduction in the spread being 0,002272, or 22,72pps, bringing the annualised rate to approximately 0,9 pp. This indicates that some of the effect on GDP growth in the UK can be ascribed to general world growth, which seems natural given the integrated state of the world economy.

Figure 6: Forecast (restricted model) GDP UK growth conditional on actual (solid) and counterfactual (dashed) spreads.



The graph, and the centre column of the table 5-6, gives quarterly results for the two first years after the crisis. In the table I have calculated the annual rate. In the right hand column I have annualised the effects for each quarter by raising each to the power of four. The latter are the ones reported by P&S. We see that even though the first quarter is estimated to have given a nearly one pp effect, the first year as a whole is estimated to have given just a third of a pp. If the results are correct one may ask oneself if the money spent and the risk incurred by the BoE was worth the reward.

Table 5-5: Effect of QE on GDP growth in the UK, measured in pps, quarterly, annualised and annual.

	Quarterly effect	Annualised effect
2009Q1	0,2272	0,9120
2009Q2	0,0787	0,3152
2009Q3	0,0270	0,1080
2009Q4	0,0093	0,0374
Annual 2009 (pps)	**0,3426**	**0,3431**
2010Q1	0,0025	0,0102
2010Q2	0,0014	0,0057
2010Q3	0,0017	0,0068
2010Q4	0,0005	0,0019
Annual 2010 (pps)	**0,0061**	**0,0061**

In the next section I will adopt the method to estimating the effects of the ECB's non-standard monetary policy.

6 The effect of non-standard measures on GDP growth in the euro area

In this section I have applied P&S's methods to my own data for the euro area. The main benefit of using a model such as the one put forward by Persaran and Smith is that it is small. By being small it allows for transparency and eases the job of checking assumptions and invariance of variables. It also saves time, as the alternative would be a fully specified structural model, or a large VAR like the one Giannone et al. (2012) created. With close to 40 variables however, it becomes complicated.

6.1 Data[7] and the choice of policy variable

The dependent variable in my models, y_t, is GDP growth in the euro area. I have collected data for seasonally adjusted real GDP (base year 2005) and calculated the quarterly growth rate in the usual way: $\frac{GDP_t - GDP_{t-1}}{GDP_{t-1}}$.

The conditioning variables, $\boldsymbol{w}_t$, I have collected data for are GDP growth in three of the euro zones major trading partners, the UK, the USA and Japan, in addition to the oil price. These three GDP growth variables were constructed in the same way as the dependent variable, and included on the postulated basis that they are unaffected by changes in the policy variable while affecting the dependent variable. The oil price is included on the same basis and is the price in dollars of a barrel of crude oil on a one month futures contract.

The policy variable used in the P&S paper was the spread between the interest rate on 10 year government bonds and that on 3 month money market papers. The reason for this, given in the paper, was that QE was estimated to have produced a 100bps reduction in this annual spread. The question is whether I should use an equivalent measure for estimating the effect of non-standard policy, or whether there is one better suited to the euro area.

The suitability of a variable should be decided on the basis of whether it is the one through which policy affected the economy. If it turned out that the non-standard measures were transmitted to the economy through a different channel than QE in the UK, a proxy variable for this channel would have to be found.

As mentioned above, and discussed by Philippine Cour-Thimann and Bernhard Winkle (2012), there are important differences between the way QE and the ECB's non-standard measures were intended to influence the economy. The non-standard measures were introduced as a compliment to traditional interest rate policy in an effort to support the banking sector by providing funding and liquidity support, thereby aiming to preserve the

[7] Sources are listed in the appendix

traditional transmission mechanisms. QE on the other hand was intended to provide a monetary stimulus to the economy through direct purchases of assets in the market.

The main reason for the different approaches chosen by the ECB and the BoE stems from a fundamental difference between the euro area and UK financial structures in the way credit is allocated. In the euro area banks are the main suppliers of credit, with around 70 percent of external financing for non-financial firms coming from banks, whilst in the UK financial markets play a greater role.

In the UK, QE consequently worked through the purchase of private financial assets in the market. The purchases were of mostly long term papers, government bonds and to a lesser extent long term corporate bonds. By injecting money into the economy and driving up the prices of assets (hence driving down the yields) the BoE aimed to stimulate spending and to lower the cost of borrowing. The increase in the price of assets would increase the wealth of the holder, stimulating spending, simultaneously lowering the yield, reducing the cost of borrowing. Investors' rebalancing of portfolios would lead to the price of other long term assets increasing, thereby multiplying the initial effect of the BoE's purchases. The estimated effect was a 100bps reduction in the long term rates (Joyce et al. 2011).

The ECB's non-standard measures, on the other hand, did not take the form of outright purchases of assets, rather they in effect set the ECB up as an intermediator-of-last-resort in the inter-bank market (Giannone et al. 2011, 14). Because banks play a more important role in providing access to financing in the euro zone, the ECB's measures were aimed directly at them. Extending maturities and providing fixed rate full allotments (FRFA) on all refinancing operations ensured that all banks retained access to a market for liquidity. Without the access to ECB liquidity, in the environment at the time, the inter-bank market may have completely seized up denying banks the ability to satisfy their daily liquidity needs. This in turn would have led to a fire sale of assets and a disorderly deleveraging, with dire consequences for the economy as a whole which relies heavily on the credit supplied by banks.

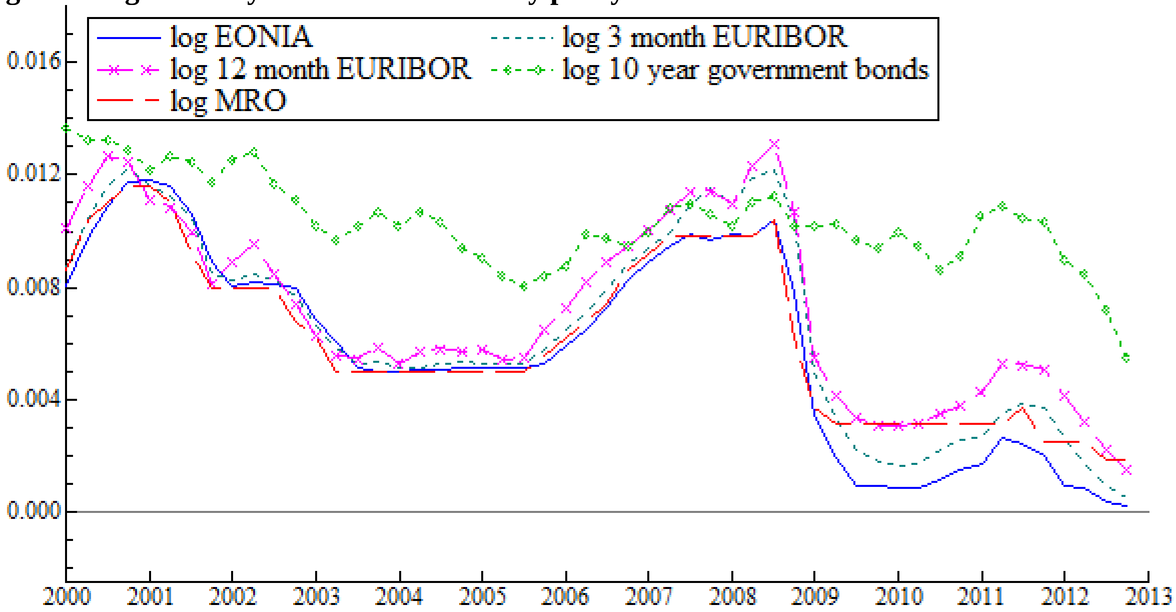
The immediate effect of the non-standard measures introduced by the ECB was to bring down the overnight EONIA (Euro OverNight Index Average) rate, which traditionally fluctuated around the MRO rate. A negative spread opened because of excess liquidity in the overnight inter-bank market. This excess liquidity, created by accommodating in full banks liquidity requirements, was to a large extent deposited with the ECB over-night instead of the inter-bank market. Banks which were not trusted would have to borrow at the MRO rate whilst the rest could access finance at the, now lower, EONIA rate, thereby addressing the problem of moral hazard.

FRFA also at longer maturities served to reduce the longer term money market rates, such as the 3 month EURIBOR (Euro Inter-bank Offered Rate). The spread between this and that on the MRO also turned negative for a time.

On long maturity government bonds, such as the 10 year, the only effect during the time frame of the crisis was through portfolio rebalancing. Only later with the introduction of the Securities Market Program in response to the sovereign debt crisis was there an explicit targeting of these longer maturity papers. This counts in favour of finding a new more suitable policy variable compared to the one employed by P&S.

Figure 7 graphs the variables I have mentioned. The negative spreads between the short term rates and the main policy rate are easy to spot, so too is the apparent lack of movement in the long term government bond rate (at the time of the crisis).

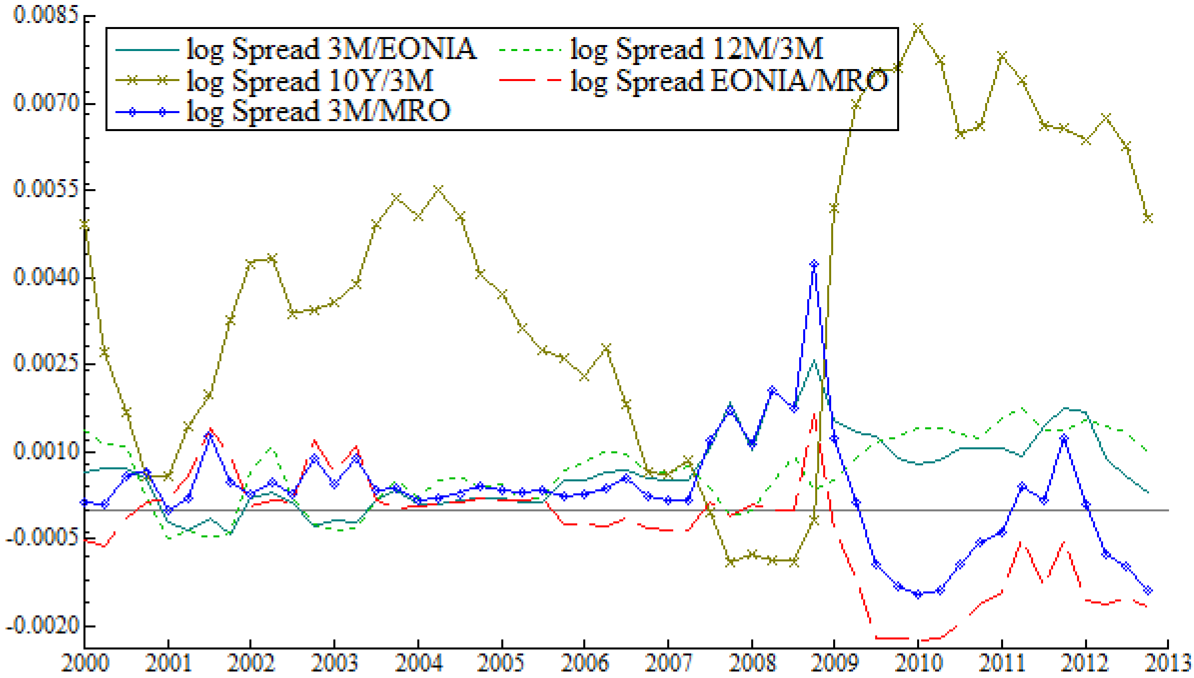
Figure 7: log of money market and monetary policy rates



Because the dependent variable, GDP growth, is quarterly I transformed the policy variables to log of quarterly rates by applying the same formula as used by P&S: $0{,}25\log(1+R/100)$.

Just like P&S I will use a spread as a policy variable since the relative nature of a spread better captures tensions, and absence of normality. Using the above rates I calculated spreads of long over short rates simply by subtracting the short rate from the long. Figure 8 below graphs them.

Figure 8: Spreads between the log rates, long over short, 3M and 12M are EURIBOR rates (3 and 12 month respectively)



It is clear from the graph that something happened towards the end of 2007, and that it got dramatically worse in the fourth quarter of 2008. The 10 year/3 month spread seems to be the most dramatic expression of this, but if one looks at the previous graph it is clear that the reason for the steep rise is mostly the fact that the 3 month rate followed the main policy rate. Hence there is not really any interesting information on non-standard measures in this spread. This is the final argument for dropping it and using another spread than P&S.

Variations of the remaining four spreads: 3 month EURIBOR/EONIA, 3 month EURIBOR/MRO, EONIA/MRO and 12 month EURIBOR/3 month EURIBOR have all been used in various articles examining the effects of the ECB's non-standard policy (Giannone et al. 2011, Lenza, Pill, and Reichlin 2010, 30, Fahr et al. 2011) .

6.1.1 Creating counterfactual values of the policy variable

Based on the arguments presented above in section 6.1 I created counterfactuals for three of the variables. It is obvious that there can be no counterfactual for the fourth, the MRO rate, because it represents conventional monetary policy which it is not the object of this thesis to analyse. The relevant variables are therefore the EONIA rate and the 3 and 12 month EURIBOR rates.

What would the relevant interest rates have been in the absence of the no-standard measures introduced by the ECB? The general consensus, and unsurprising, is that they would have been higher.

I have decided to specify a counterfactual path for the EONIA rate based on a "least bad" scenario. The relationship between the EONIA and the MRO rate before the financial crisis shows that the EONIA fluctuated slightly above the MRO, by an average factor of 0,5pps. Since the measures introduced by the ECB had the effect of turning this spread negative it would not be too far-fetched to assume that the EONIA rate would have continued at or above its historical level in the absence of the measures. Accordingly I have created a counterfactual for the EONIA rate which from the 1st quarter 2009 is equal to the MRO rate plus 0,5pps.

By also allowing banks access to longer term funds through extended maturities and full allotments the ECB contributed to bringing down also longer term rates. As my counterfactual EURIBOR rates I have used the ones presented by Lenza et al. (2010). These rates[8] are estimated using the VAR model of the euro area developed by Giannone et al. (2012). In their paper they estimate only 12 months of counterfactuals, but this should be sufficient for my purpose because of the assumption that there is no long-run effect of policy and it is therefore the effect in first periods which is most interesting.

The figures below (9 and 10) show the relationship between the actual and counterfactual rates and spreads I will use in the next sections to estimate the effect of the ECB's non-standard policy on GDP growth in the euro area.

[8] The rates were given only in a figure, in monthly rates, so there may be some discrepancies between mine and their rates. .

Figure 9: Log of actual and counterfactual rates in addition to the log of the main MRO rate, again 3M and 12M are EURIBOR rates (3 and 12 month respectively)

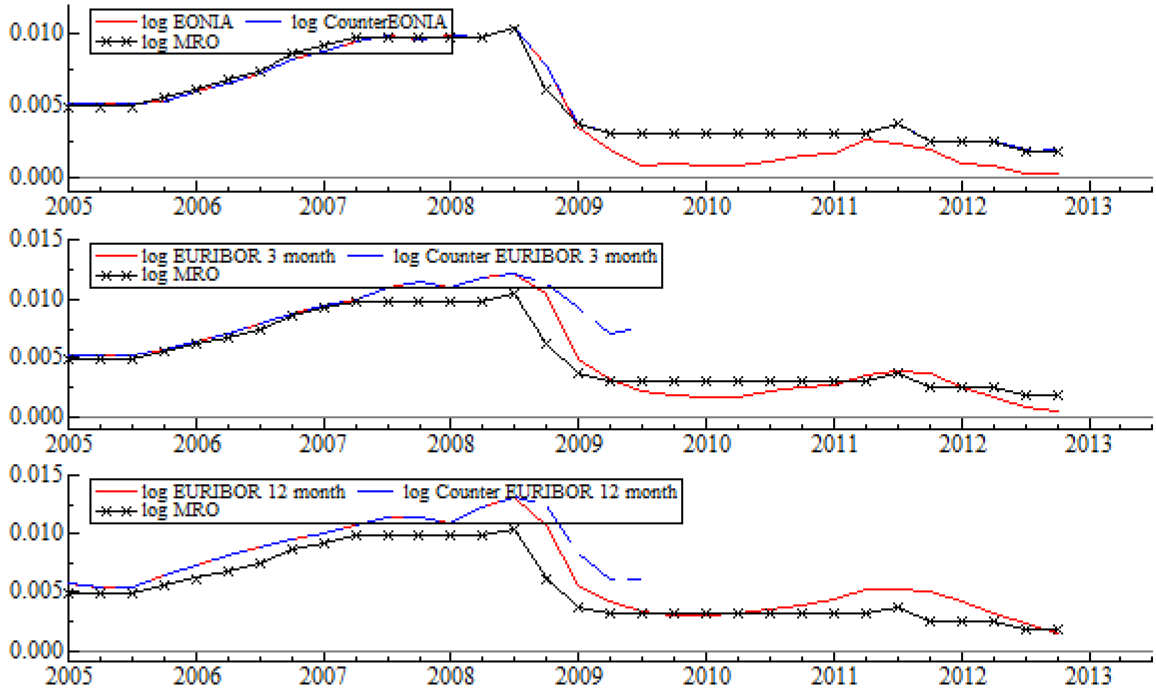
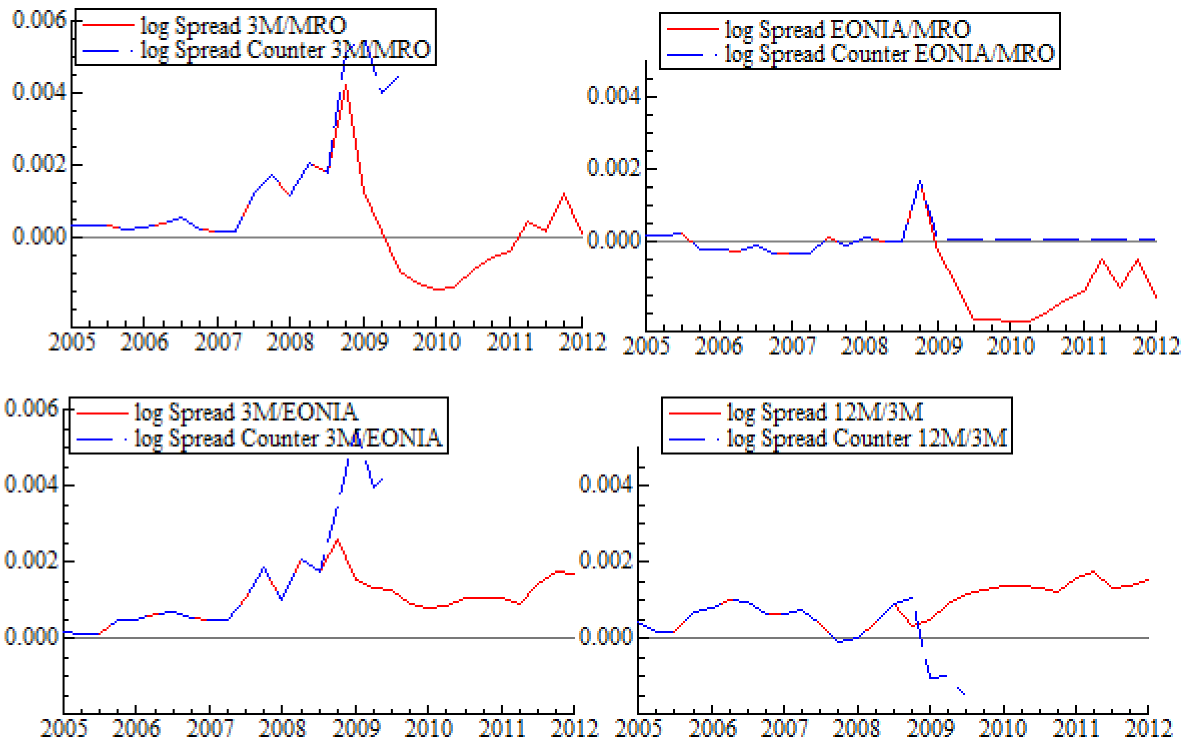


Figure 10: Log of actual and counterfactual spreads, again 3M and 12M are EURIBOR rates (3 and 12 month respectively)



All of the above counterfactuals exhibit clear breaks from pre-crisis levels, which gives a relevant basis for the analysis of the effects.

6.1.2 Testing the assumption that the policy variable does not affect the conditioning variables

One of the assumptions of the method put forward by P&S is that the policy variable, x_t, should not affect the conditioning variables, $\boldsymbol{w'}$. To test this assumption I used the same method as in the replication section. I have four different policy variables, and three different conditioning variables. All these three conditioning variables must be unaffected by any changes in any of the policy variables.

I set up 12 models of the general form:

$$w_{USA} = \beta_1 w_{USA,\mathrm{t}-1} + \sum_{j=2}^{6}\sum_{k=t}^{t-4}\beta_j x_k + \sum_{j=7}^{8}\sum_{k=t}^{t-1}\beta_j w_{UK,k} + \sum_{j=9}^{10}\sum_{k=t}^{t-1}\beta_j w_{Japan,k} + \emptyset + u_{wt} \tag{1.9}$$

With $\emptyset$ containing, depending on the model, spreads for the UK and US, and GDP growth for the euro area, all with one lag. The general conclusion is that the assumption holds, although some of the policy variables in some of the models are statistically significant at the 5% level. The batch files for the estimations are to be found in the appendix.

6.2 Estimating the model based on the Pesaran and Smith specification with conditioning variables (M2)

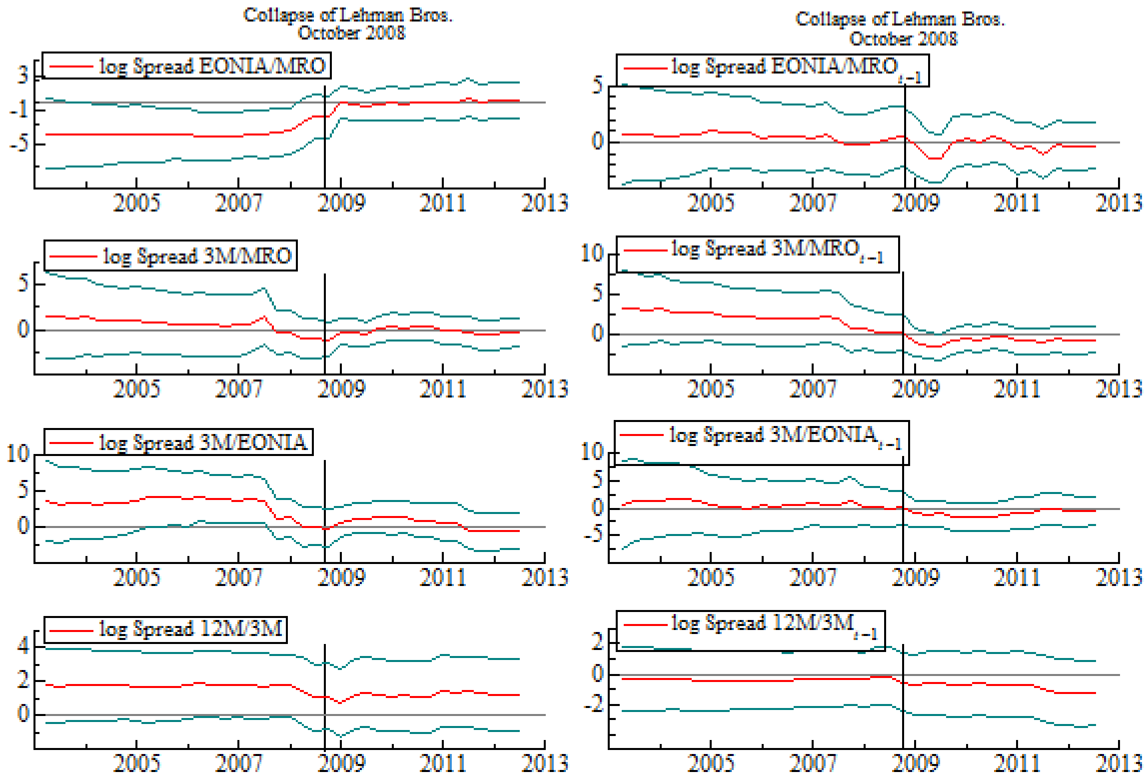
In the following I have used all four candidates for policy variable identified earlier in section 6.1.1, namely the following spreads: EONIA/MRO, 3M/MRO, 3M/EONIA and 12M/3M.

Concerning the conditioning variables I first followed P&S in including only two: GDP for the USA and GDP for Japan. Later I will extend the model with GDP for the UK. Preliminary estimation showed that inclusion of the oil price in $\boldsymbol{w_t}$ did not give any extra explanatory power to the model, and that the coefficient on the oil variable was negligible. Hence the models I use in the rest of the section (termed M2) will include, like the second set of models by P&S, lagged dependent variable, the policy variable and two conditioning GDP growth variables:

$$\mathrm{M2_U}: y_t = \lambda \mathrm{y}_{t-1} + \pi_{10}x_t + \pi_{11}x_{t-1} + \pi_{21}w_1 + \pi_{22}\mathrm{w}_2 + v_{yt} \tag{1.10}$$

I first estimated the models on this unrestricted form and ran the tests for stability explained in section 3.2. The results, showed in the figures (11 and 12) below, are quantitatively the same as those for the P&S article, but the coefficients appear to be less stable than in the UK data used by P&S.

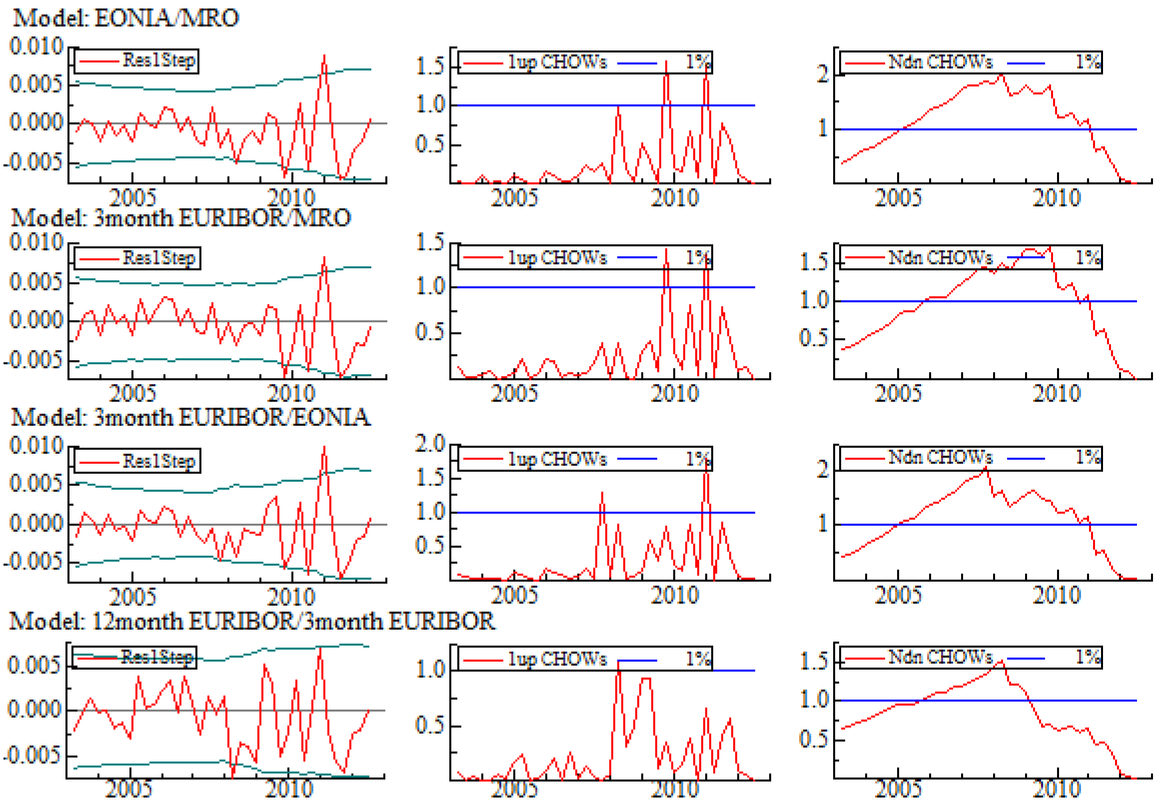
Figure 11: Recursive estimations of spread coefficients from unrestricted M2, graphed with ± 2*standard error



The reduced form coefficients on the 12M/3M spread and the 3M/MRO spread are quite stable, although they exhibit a hump at the time of the crisis none of them exceed the 95% confidence interval. The reduced form coefficients on the two other spreads show greater signs of parameter instability, slightly breaking the 95% confidence interval around the pre-crisis estimates.

The 1-step and N-down Chow tests, together with the residual 1-step test are shown in figure 12 below. Most of the volatility at the end of the 1-step residuals test occurs after the time period which I am studying, although the spikes due to the rapid contraction in GDP are visible. The two Chow tests indicate possible structural breaks, with the N-down Chow peaking at the time of the crisis.

Figure 12: Residual 1-step, 1-up Chow test and N-down (break-point) Chow test for each model, unrestricted M3



In sum the two figures do not give irrefutable evidence for a structural break, the coefficient estimates are on the whole within their confidence intervals, and the Chow tests do not catastrophically breach the critical values.

The F-tests for the zero long-run effect in this model gives considerably more convincing results than those for the replicated P&S model. Testing the H_0:

$$\pi_{10} + \pi_{11} = 0 \tag{1.11}$$

gave the results presented at the bottom of table 6-1 below. The p-values vary from model to model with the EONIA/MRO exhibiting the lowest significance with a p-value of 0,3, while in the 3M/EONIA model the restriction is valid at the 93% significance level.

The restriction (1.11) was imposed in the same way as earlier, by first transforming the unrestricted model ($\mathrm{M2_U}$) to ECM form and then restricting the long-run coefficient to zero: $(\pi_{10} + \pi_{11}) = 0$. The resulting model (1.12: $M2_R$) takes the following form:

$$\mathrm{M2_R}\colon y_t = \lambda \mathrm{y_{t-1}} + \pi_{10}\Delta x_t + \pi_{21}\mathrm{w_1} + \pi_{22}\mathrm{w_2} + v_{yt} \tag{1.12}$$

Tests of autocorrelation, hetroskedasticity, departure from normality and general model misspecification, showed no evidence of misspecification in the three first models. None of the tests had p-values lower than 0,2. The last model however failed the test for autocorrlelation at the 1% level, but passed the others at or above the 13% level.

Table 6-1: Results from estimation of restricted M2

y_t: ***GDPGrowthRateEA* by OLS**	**EONIA/MRO**	**3M/MRO**	**3M/EONIA**	**12M/3M**
GDPGrowthRateEA_1:	0.5954	0.5829	0.5747	0.5404
	(0.1144) 5.21	(0.1137) 5.13	(0.1154) 4.98	(0.1190) 4.54
Δ_t *policy variable:*	-1.2097	-0.8254	-0.1910	0.8145
	(1.0890) -1.11	(0.8518) -0.969	(1.2480) -0.153	(0.8647) 0.942
GDPGrowthRateUSA:	0.0782	0.1193	0.1306	0.2206
	(0.0768) 1.02	(0.0630) 1.83	(0.0769) 1.70	(0.0676) 3.26
GDPGrowthRateJapan:	0.2915	0.2664	0.2947	0.1488
	(0.0538) 5.42	(0.0643) 4.14	(0.0688) 4.29	(0.0468) 3.18
$\boldsymbol{R^2}$:	0.82461	0.82313	0.81837	0.60584
$\boldsymbol{\sigma}$:	0.00238	0.00239	0.00242	0.00306
F-test on $\boldsymbol{\pi_{10}}+\boldsymbol{\pi_{12}} = \mathbf{0}$:	1.61870	1.37980	0.00716	0.90843
p-value:	[0.2122]	[0.2485]	[0.9331]	[0.3449]

SE in parenthesis followed by t-value.

The coefficients on the policy variable exhibit a fair amount of uncertainty with none of them statistically different from zero below the 27% level. The signs on the coefficients however correspond well with economic theory, and some of the coefficients are quite sizable. A negative sign of both the EONIA/MRO spread and the 3M/MRO spread, stemming from an increase in the EONIA or 3 month EURIBOR rates would make it more expensive for banks to access funds. This would in turn filter through to the rest of the economy through higher rates on loans and hence a reduction in the amount of loans to businesses. The economy would in turn suffer from reduced investment and demand, driving growth down

The coefficient of the spread between the 3 month EURIBOR and over-night EONIA also has a negative sign, reducing growth as it increases. This spread is indicative of turmoil in the financial markets as it indicates difficulty in obtaining longer term financing. A large spread could mean that institutions were no longer willing to lend for long periods, being afraid of not getting their money back. Denying banks the access to longer term funds would mean that they would have difficulty planning, and have to reduce the amount of loans they provide to businesses in order to shore up their base.

The last spread, 12 month over 3 month EURIBOR rates, exhibits a positive sign. A larger spread might indicate expectations of higher growth in the future, hence the positive relationship to GDP growth.

Regarding the conditioning variables it is interesting to note that in all but the last model, GDP growth in Japan is more significant and with greater impact than US growth.

After the estimation of the four models up to the last quarter of 2008 conditional on the realised spreads, I have forecasted GDP growth 11 periods ahead[9]. These forecasts correspond to the first conditional expectation presented in the paper by P&S. Estimating the same models conditional on the counterfactual policy values, and forecasting, gives the second expression.

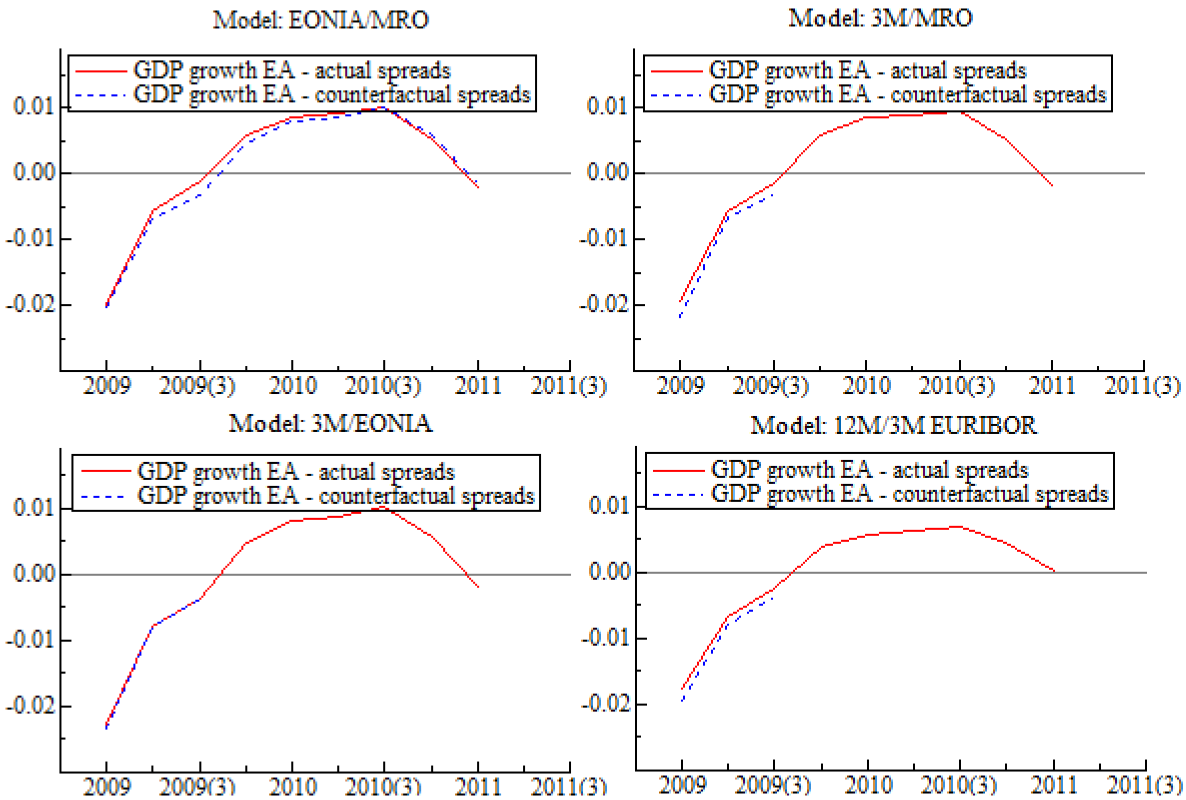
$$
\begin{aligned}
E(y_{T+h}|\mathbf{\Omega}_T, \mathbf{\Psi}^0_{T+h}) &= E(\pi_1|\mathbf{\Psi}^0_{T+h})x^0_{T+h} + \pi_2' E(\boldsymbol{w}_{T+h}|\mathbf{\Psi}^0_{T+h}) \\
E(y_{T+h}|\mathbf{\Omega}_T, \mathbf{\Psi}^1_{T+h}) &= E(\pi_1|\mathbf{\Psi}^1_{T+h})x^1_{T+h} + \pi_2' E(\boldsymbol{w}_{T+h}|\mathbf{\Psi}^1_{T+h})
\end{aligned}
\tag{1.13}
$$

[9] The number 11 is chosen simply because it is the same as in Pesaran and Smiths paper. In practice because my counterfactuals only cover 3 periods ahead I could also have chosen 3. In this way however the graphs gives a more complete impression if the situation.

6.2.1 Assessing the effect of non-standard measures

Figure 13 below shows the two conditional forecasts for each model, the solid line representing forecast GDP growth using realised spreads, and the dashed one using counterfactual spreads.

Figure 13: Results from restricted M2, forecast quarterly growth rates conditional on actual (solid) and counterfactual (dashed) spreads



The forecasts for the three last spreads are shorter due to the short series of counterfactuals for the three rates except the MRO. Note also that because of the transformation to quarterly rates of all the spreads to match the quarterly nature of the growth rate of GDP, the results show the quarterly effect on growth rates for GDP in the Euro area.

The same results are presented in the first part of table 6-2 below. I have simply calculated the difference between the two forecasts for each quarter. For the fourth quarter, where I have no estimates because of the short series of the counterfactuals, I took the average of the three preceding quarters. The shaded area represents original data whilst the rest have been calculated/constructed by me.

The annual effect on GDP is perhaps easier to interpret, so I have calculated this as well. The numbers in the lower part of the table have been annualised by raising the quarterly rates to the power of four: $\left(\left((1+r)^4\right)-1\right)$. The approximate annual effect reported at the bottom is simply the product of these annualised quarterly rates[10].

Table 6-2: Effect of non-standard measures, measured in pps - difference between forecast using actual and counterfactual spreads, restricted M2.

Quarterly	EONIA/MRO	3M/MRO	3M/EONIA	12M/3M
2009Q1	0,0389	0,2454	0,0561	0,1621
2009Q2	0,1285	0,1100	-0,0133	0,1267
2009Q3	0,2014	0,1852	0,0051	0,1252
2009Q4 avofrest	0,1193	0,1802	0,0160	0,1380
Annualised				
2009Q1	0,1558	0,9851	0,2244	0,6500
2009Q2	0,5148	0,4406	-0,0530	0,5079
2009Q3	0,8079	0,7430	0,0202	0,5019
2009Q4	0,4780	0,7227	0,0638	0,5533
Average annual effect	**0,4891**	**0,7229**	**0,0639**	**0,5533**

The non-standard measures introduced by the ECB clearly had an effect on GDP growth in the euro area. These estimates indicate however that the effect was relatively limited compared to the steep reduction in GDP seen at the time. The highest estimate of the effect is 0,98 pps annualised for the first quarter in the case of the 3M/MRO spread, declining after that to less than a quarter of a pp. The EONIA/MRO and 12M/3M show slightly smaller effects on average through the first year, and although the effect from the 12M/3M spread seems to be quite stable though the year, half a percentage point seems to be a very small reward.

The measures introduced by central banks across the world, including the ECB, were billed as saving the world as we knew it. The results of my estimations indicate a less dramatic view. As we have seen however, other evaluations of ECB non-standard policy have arrived at results indicating a larger effect of the non-standard measures.

Including only one lag of the policy rate may be too simple a set-up to capture the effects of the time lagged nature of monetary policy. This is a hypothesis I investigate in the next section.

[10] Alternately one could use the more accurate calculation: $\left(\left((1+r_1)*(1+r_2)*(1+r_3)*(1+r_4)\right)-1\right)$. The two differ in this case only by 0,003.

6.3 Estimating the model based on Autometrics model selection (M3)

P&S used automated model selection to specify the number of lags to include in their model and they ended up with the one I presented above. As we have seen, I have used the same model specification in my model for euro data. There is however no specific reason why this specification should hold for the euro area when it was intended for the UK. In addition I have used other policy variables which may not affect the economy in the same way as the ones used by P&S. This all counts in favour of specifying a new model specific to the euro area and the new spreads.

Choosing which variables to include must depend on whether they are significant or not. Monetary policy affects the economy only after a certain length of time, so including more than a single lag of the variable makes sense. I chose to start out with a model including 4 lags of all the four GDP growth variables and the policy variable in question. I could then have run successive estimations removing the variables I deemed to be of low enough significance and ending up with a final new model. However, PcGive includes a well-documented algorithm for variable selection called Autometrics which does just this after the user has specified a general initial model.

Autometrics starts by the user specifying an initial general unrestricted model (iGUM). This model should be well specified in the light of the usual diagnostics tests. This is an important point because it stresses that Autometrics is not a method to be used in the absence of economic theory. If there is no hypothesis about how the dependent variable is determined, one cannot expect that Autometrics will produce a relevant final model by selecting variables from a large and arbitrary list of "input" variables. After choosing the significance level at which reduction is performed (the authors recommend to keep the default of 0,05) the algorithms reduce the model step-by-step.

Step one in the algorithm is pre-search lag reduction which is performed in two sequences. Testing for joint significance by F-test of the lags (for example all lag 4 for all variables), only those which fail in both sequences are removed. Before proceeding the new model is tested against an empty model. If this is rejected the model is given the name GUM(0) and Autometrics takes over.

Based on their significance, variables are removed from GUM(0) individually or in blocks. The resulting models are run through diagnostics tests and if they fail any of them models are discarded, if they pass, reduction is continued until all the models which failed have been removed. The last model before a test fails becomes a terminal model. In the case where the reduction of GUM(0) leads down many paths there will be multiple terminal models. In deciding how to proceed the terminal models are tested against their union. Rejection and re-testing is performed until one model is left which becomes GUM(1).

The process is repeated until a final model is arrived at, see Doornik and Hendry (2007) and Hendry (2000).

Applying Autometrics to the initial GUM for each policy variable with four lags of dependent, policy and conditioning variables lead to the following four models of the general form:

$$y_t = \boldsymbol{\lambda}\boldsymbol{y}^{\mathrm{T}} + \boldsymbol{\pi}_1\boldsymbol{x}^{\mathrm{T}} + \boldsymbol{\pi}_2\boldsymbol{w}^{\mathrm{T}} + v_{yt} \qquad (1.14)$$

with the variables in each model presented in table 6-3 below. I checked that the initial GUMs passed the tests for autocorrelation, normality and model miss specification. The last two models failed the Chow test for a break after 2009Q1 at 3% level.

Table 6-3: The models arrived at through the use of Autometrics

Varaible/**Model**	**EONIA/MRO**	**3M/MRO**	**3M/EONIA**	**12M/3M**
$\boldsymbol{x}^T$*: lSpread*	EONIAMRO_1 EONIAMRO_3	3MMRO 3MMRO_1 3MMRO_2 3MMRO_3	3MEONIA 3MEONIA_2 3MEONIA_3	12M3M 12M3M_1 12M3M_3
$\boldsymbol{y}^T$*: Euro area*	EA_1 EA_3	EA_1 EA_2 EA_3	EA_1	EA_1
$\boldsymbol{w}^T$*: GDPGrowthRate*				
USA			USA_1 USA_2 USA_3	USA_1 USA_3 USA_4
Japan	Japan Japan_1	Japan Japan_1	Japan Japan_1 Japan_4	Japan Japan_4
UK	UK UK_3	UK_2	UK UK_3	UK UK_1 UK_3 UK_4

The number following the underscore represent the lag, significanse level in the Autometrics settings is set to the standard 0.05

As in the previous two cases I tested for structural breaks in the reduced form policy coefficients by graphing the estimated coefficients and the Chow tests.

Figure 14: Recursive estimations of spread coefficients from unrestricted M3, graphed with ± 2*standard error

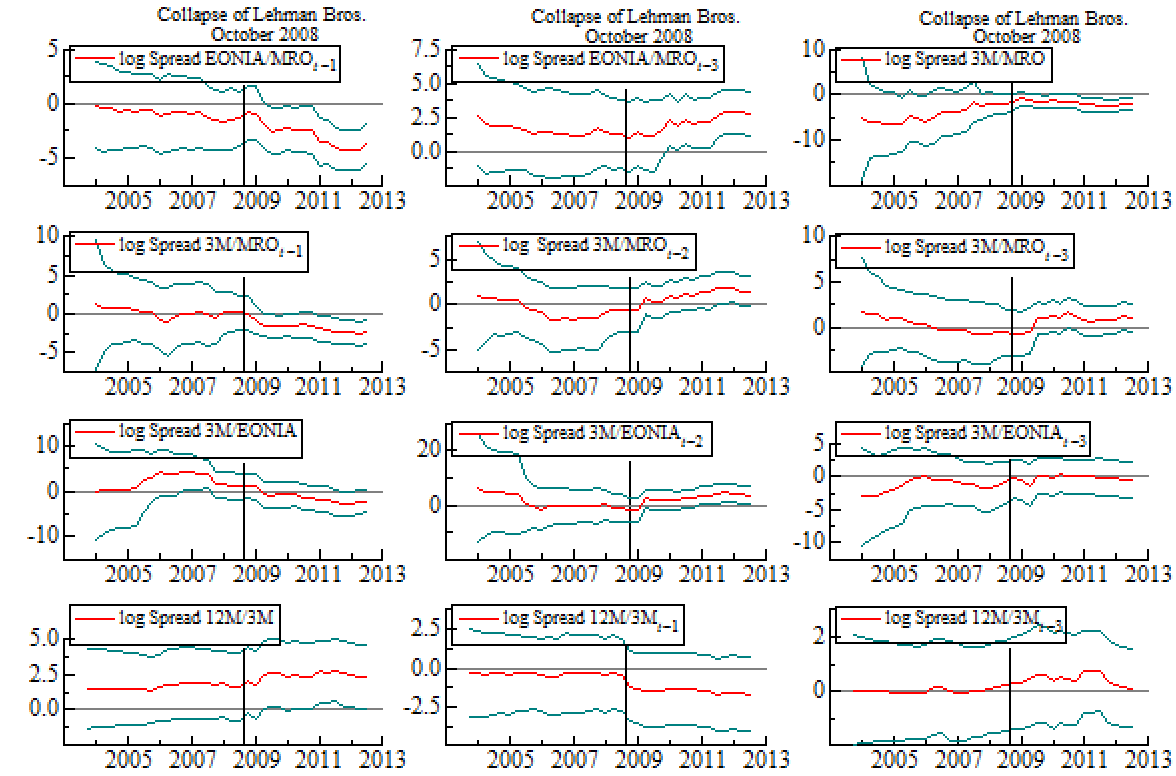
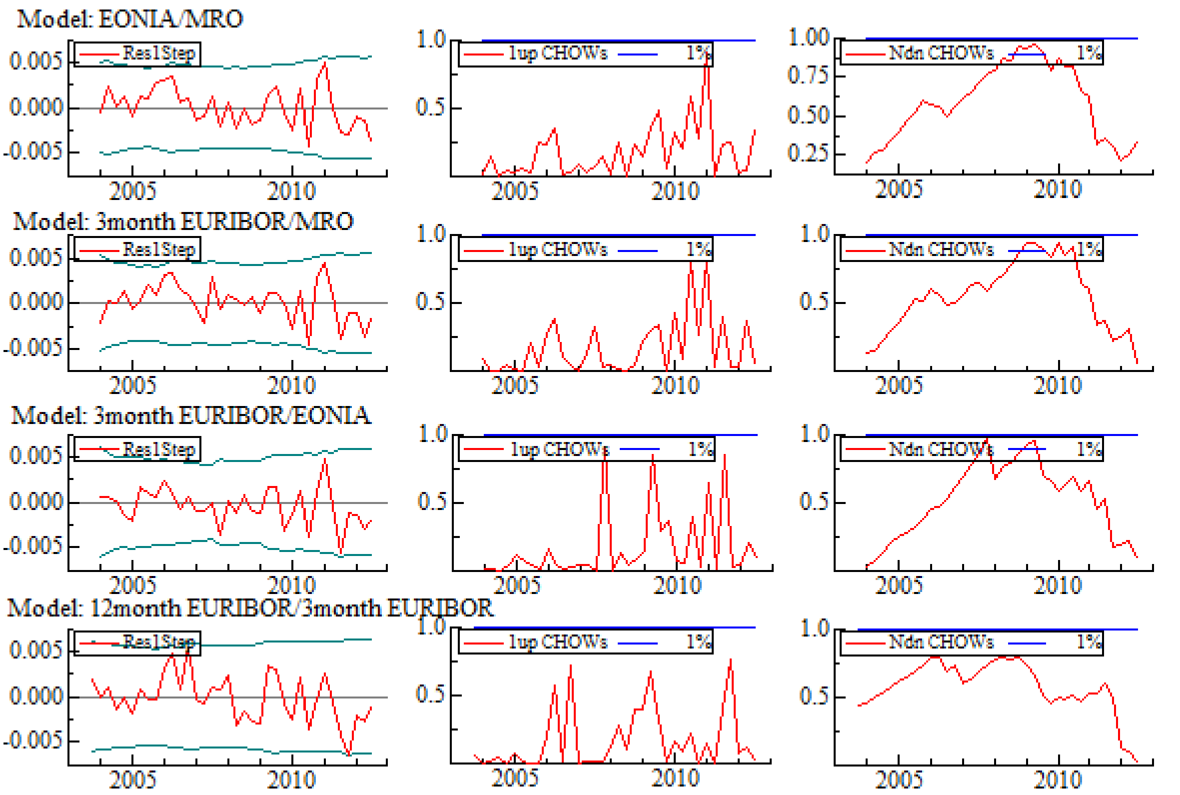


Figure 15: Residual 1-step, 1-up Chow test and N-down (break-point) Chow test for each model, unrestricted M3



When compared to the results obtained for the model in the previous section, it is apparent that the coefficients of the final models from Auotmetrics have parameters which are more stable than those in the model above. This is evident both by looking at the coefficients, which show less change around the time of the crisis, and by looking at the Chow tests, where none of the models exceed the 1% critical level, and the coefficients on the policy variables which in these new models are much higher and more significant.

In the same way as before I imposed the zero long-run effect on the unrestricted models after testing for its presence using a general restrictions χ^2 test. As is clear from the p-values (in brackets) in table 6-4 below, the models perform quite well. In relation to the model used by P&S they pass with ease. Only the 12M/3M model shows less sign of a zero long-run effect.

Imposing the restriction amounts to dropping the variable on $\sum \boldsymbol{\pi}_1$after transforming the models to ECM form. I will refer to these models as the restricted M3 models. The results of the estimation of these M3 models are presented in table 6-4 below[11].

The models presented have all been generated based on the entire sample of observations for each policy variable. This is not a problem in the absence of instability of the parameters. The tests presented above give little or no indication of any such breaks, but estimating the models only up to 2008Q4 produce parameter coefficient significance on the policy variables which is considerably lower in the pre-crisis sample than in the full sample. Estimating up to 2012Q2 gives approximately the same significances as the 2012Q3 estimates. I will however continue using the 2008Q4 results which are presented in table 6-4 below.

[11] The rest of the coefficients are reported in table 9-6 in the appendix, to avoid clutter.

Table 6-4: Results from estimation of restricted M3

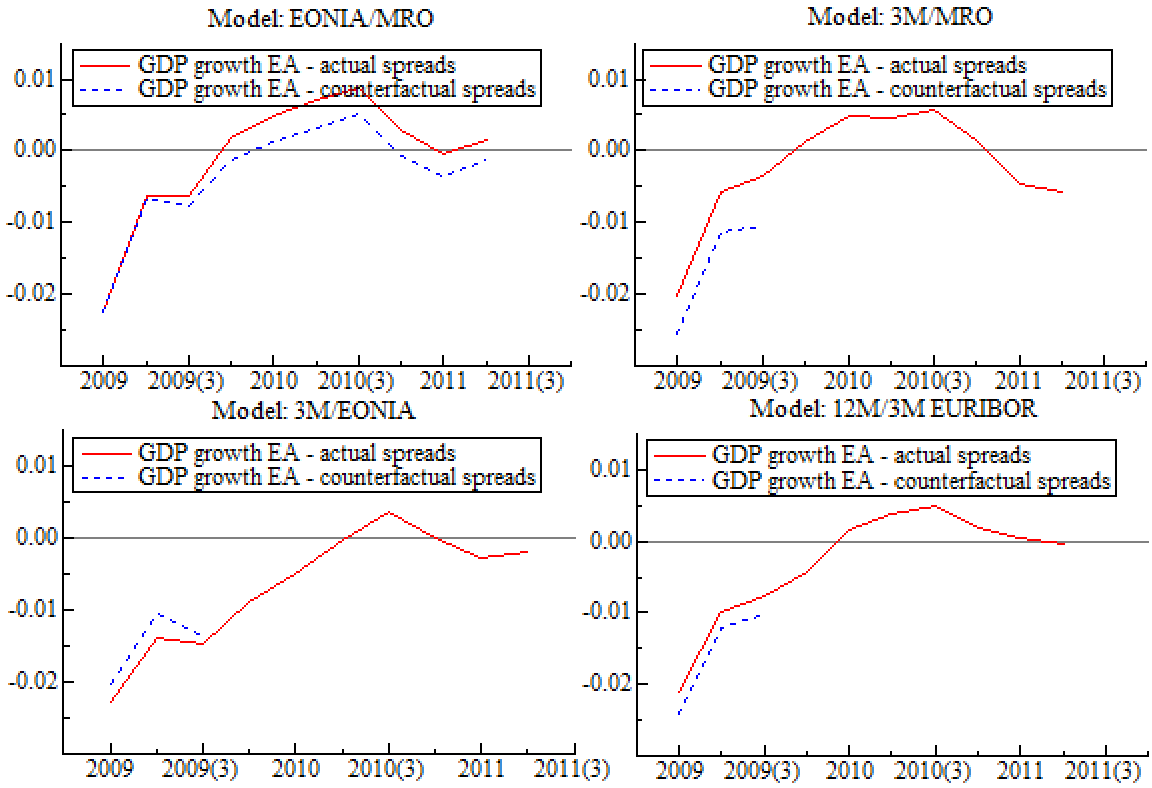
y_t: *GDPGrowthRateEA* by OLS	EONIA/MRO	3M/MRO	3M/EONIA	12M/3M
Δx_t:		-1,5687		1,3946
		(0,9758) -1,61		(0,9468) 1,47
Δx_{t-1}:		-1,0601		
		(1,2490) -0,849		
$\Delta_{(t-2)}$:		-0,9257	-0,1272	
		(1,0040) -0,922	(1,2960) -0,0982	
Δx_{t-3}:	-0,8327			
	(1,3530) -0,6150			
$\Delta_2 x_t$:			1,2326	
			(1,3950) 0,883	
$\Delta_2 x_{t-1}$:	-1,0282			0,2656
	(1,2210) -0,8420			(0,5811) 0,457
R^2:	0.85933	0.86787	0.87866	0.71611
σ:	0.00224	0.00225	0.00225	0.00286
GenRes $\chi^2(1)$:	1.02590	0.09198	0.78660	3.14200
p-value	[0.3111]	[0.7617]	[0.3751]	[0.0763]

SE in parenthesis, followed by t-value

6.3.1 Assessing the effect of non-standard measures

Using the same counterfactuals as previously and estimating the models up to the 4 quarter of 2008 and then forecasting gives the graphs in the figure (16) below.

Figure 16: Results from restricted M3, forecast quarterly growth rates conditional on actual (solid) and counterfactual (dashed) spreads



As is clear from these graphs and table 6-5, the effect on GDP growth is larger than in the previous (M2) specification. The overall shapes of the realised forecasts are the same, but the behaviour of the counterfactual forecasts show a marked difference. The previous models did not show any indication of increasing effect as time passed. In these M3 models, although the short sample makes it difficult to say with much certainty, the effect is increasing over time. The behaviour of the counterfactual forecast in the 3M/EONIA case is particularly interesting. In this case, the effect is first negative and increasing, before it decreases. Had the sample of counterfactuals been longer we might have seen it turn positive (in the unrestricted case it does). This pattern of increasing effect indicates that the model has captured the time lagged nature of monetary policy on the real economy. It is interesting to note that Lenza et al. (2010) have found the same kind of effect using the Giannone et al. (2012) model.

Table 6-5: Effect of non-standard measures, measured in pps - difference between forecast using actual and counterfactual spreads, restricted M3.

Quarterly	EONIA/MRO	3M/MRO	3M/EONIA	12M/3M
2009Q1	0,0005	0,5440	-0,2327	0,3134
2009Q2	0,0342	0,5532	-0,3273	0,2186
2009Q3	0,1406	0,6907	-0,1166	0,2614
2009Q4 av. of rest	0,2944	0,5960	-0,2255	0,2645
Annualised				
2009Q1	0,0020	2,1938	-0,9274	1,2593
2009Q2	0,1367	2,2314	-1,3029	0,8774
2009Q3	0,5636	2,7915	-0,4654	1,0499
2009Q4	1,1826	2,4053	-0,8990	1,0621
average annual pps	0,4712	2,4055	-0,8987	1,0622
Difference from restricted M2	-0,0177	1,6829	-0,9625	0,5089

The increasing nature of the effect will lead an underestimated Q4 effect, as I have calculated it by averaging the previous three quarters. The constructed annualised values of quarterly rates show a significant increase over the M2 model. The increasing nature is clearly observable and the effect for the last quarter is measured to over 1 pp in all but the 3M/EONIA case. This case is special because it is increasing from a negative value.

The reason for the difference in results between my M2 and M3 models is that including more lags captures effects which take longer time to affect the economy. Allowing for differing numbers of lags for the different spreads captures the fact that they may impact the economy with differing time lags.

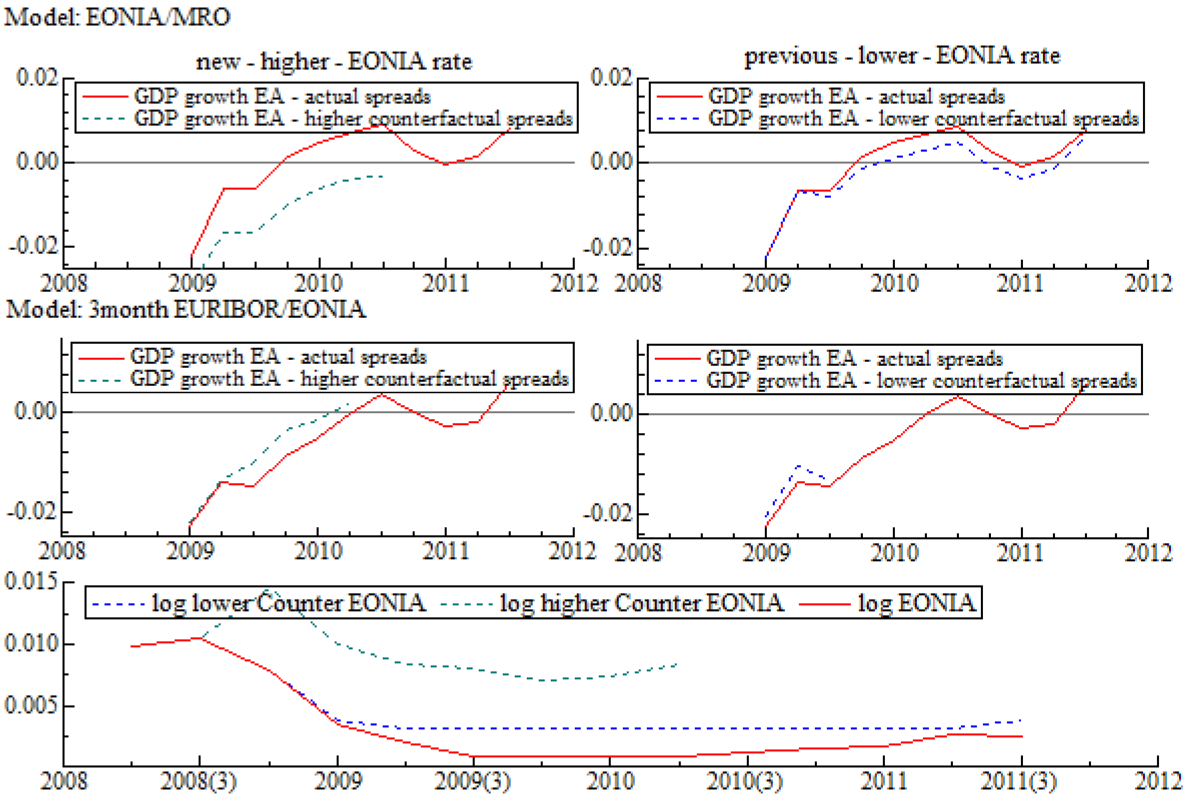
The fact that these last models perform better in the structural break tests and have higher significance on the spread coefficients in addition to providing results which differ with respect to the previous in accordance with economic theory, may suggest that these are more relevant for the analysis. They also give results which are more in tune with previous estimates indicating a more significant effect of non-standard measures than the previous model.

6.3.2 The curious case of a higher counterfactual EONIA rate

In the preceding estimations I have, as I stated in 6.1.1, used best case counterfactual values for the EONIA rate based on the theory that they would behave approximately as before. A paper by Fahr et al. (2011) used a VAR model and impulse response analysis to estimate a counterfactual EONIA rate. This rate is considerably higher than the one I used. As a final attempt to “narrow in” on the true effect of the non-standard measures I will briefly sum up the results from the estimations using this counterfactual.

Since only two of the models contain the EONIA rate, only these will be affected: EONIA/MRO and 3M/EONIA. Changing nothing but the counterfactual values of the EONIA rate I estimated the Autometrics models. Figure 17 below gives the results in the same manner as above, in quarterly rates, in addition to a comparison of the new and the old counterfactual series and actual EONIA rate.

Figure 17: Results from restricted M3, new counter EONIA rate, forecast quarterly growth rates conditional on actual (solid) and counterfactual (dashed) spreads



The results with the previous EOINIA rate are given in the right hand panels and the results from the new EONIA are given on the left. For the EONIA/MRO model there is no qualitative difference, only a more pronounced effect, which is anticipated since the new EONIA rate is so much higher. The result for the 3M/EONIA model is however quite intriguing. In both cases the effect of the non-standard measures is negative, but in the previous case with a lower EONIA, the effect is turning positive. On the left there is no prospect of the effect becoming positive. The reason for this seemingly counterintuitive result is that the new higher EONIA rate makes the spread between the 3 month EURIBOR and the EONIA go positive, giving the negative effect on GDP growth (remember the negative sign on the coefficient).

7 Conclusion

The aim of this thesis has been to investigate the effects of the unconventional monetary policy measures introduced by the ECB in the wake of the financial crisis in late 2008. To do this I have employed a method developed by P&S in their paper examining the effects of QE in the UK.

Their method was developed to allow easier ex-ante counterfactual policy evaluation by using a reduced form model instead of the more cumbersome structural form models most often employed. Their argument is that if one has a policy variable which influences the dependent variable and other structural variables, but not a set of conditional variables, it is enough to regress the policy variable and the conditioning variables on the dependent variable to get the effect of the policy. Two such regressions, one conditional on actual policy variable values and one conditional on counterfactual policy variable values and taking the difference between them will give the effect of the policy. This reduces the amount of work compared to larger structural models such as the large VARs employed by the other authors mentioned in this thesis. Hence, if this kind of model gives satisfactory results it could play an important part in policy evaluation. The main drawback with this kind of model however, is that it does not give any explanations as to what is happening or why. It obviously does not explain the structure of the process in question. If results differ from the expected, it might therefore be difficult to figure out which mechanisms produce the effect.

Because of the different instrument used and the difference in institutional and financial structure between the UK and the euro area I could not use the same policy spread variable as P&S. I instead used four alternative variables which should be of more relevance for the euro area. In the thesis I showed results using all four policy variables. The counterfactual spread variables I constructed based on values obtained from earlier papers.

In my first attempt at applying P&S's method to data from the euro area I used the same model set-up as they did, an ARDL model with one lag and two control variables. I also included tests for structural breaks in the reduced form coefficients, and tests for the validity of the zero long-term constraint. Having shown that the coefficients were relatively stable and the zero long-term constraint was a valid restriction, I estimated the effect of the non-standard policy after imposing the zero long-term constraint, producing the restricted M2 results. These indicate a positive, but rather small effect of the measures, akin to the results arrived at by P&S for the UK.

The different policies pursued by the ECB relative to the BNoE gives no good reason for keeping the model on the same form as P&S had for the UK. In my second set-up I let the

Autometrics algorithm choose my model specification. Based on an initial GUM ARDL with four lags of all variables, the algorithm produced a different model for each spread variable. Testing for structural breaks and zero long-run effect gave better results than in the previous set-up. Estimating the models in the same way as in the previous case produced larger and more interesting results. The most interesting of which was that in all the models the effect showed signs of increasing with time, in line with economic theory on the medium-term impact of monetary policy.

Finally I introduced new counterfactual EONIA values obtained from a working paper by the ECB. These were substantially higher than the ones I used throughout the thesis, and they had a substantial effect on the two models in which they are included. In both cases the effect of the non-standard measures became greater, but in the 3M/EONIA case the effect remained negative all the time.

The reduced form model set-up seems to work, and gives economically interpretable results, but especially because of the lack of structure it might be difficult to know when one has a well specified model. All in all the non-standard measures seem to have had a relatively positive effect on GDP growth in the euro area, but whether they averted another great depression is not clear from these results.

8 References

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9 Appendix

9.1 Appendix I: Description of variables

9.1.1 Reproduction

Table 9-1: Variables used for reproduction, excluding counterfactual variables

Variable	Description	Format	In original?
RshortUK	3-month rate	Percentage	Yes
RlongUK	10-year rate	Percentage	Yes
GDPUK	Real Index 2005=100	Index	Yes
GDPEA	Real Index 2005=100	Index	Yes
GDPUSA	Real Index 2005=100	Index	Yes
dlogGDP	Quarterly growth rate	Rate	No
lSpreadUK	Long over short spread	log	No
Var14	Scaling variable = 1 for 2009Q1 – 2011Q3		No

9.1.2 Own data and analysis

Table 9-2: Variables used for own analysis, excluding counterfactual variables

Variable	**Description**	
GDPGrowthRateEA	Real GDP growth rate (base year 2005) euro area	Qarterly rate
lSpreadEONIAMRO	Spread (long minus short) of log EONIA and log MRO rate	Quarterly log
lSpread3MMRO	Spread (long minus short) of log 3 month EUNIBOR and log MRO rate	Quarterly log
lSpread3MEONIA	Spread (long minus short) of log 3 month EURIBOR and log EONIA rate	Quarterly log
lSpread12M3M	Spread (long minus short) of log 1 year EURIBOR and 3 month EURIBOR rate	Quarterly log
dlSpread[…]	$(lSpread[...])_t - (lSpread[...])_{t-1}$	ΔQuarterly log
d2lSpread[…]	$(lSpread[...])_t - (lSpread[...])_{t-2}$	Δ2Quarterly log
GDPGrowthRateUSA	Real GDP growth rate (base year 2005) USA	Qarterly rate
GDPGrowthRateJapan	Real GDP growth rate (base year 2005) Japan	Qarterly rate
GDPGrowthRateUK	Real GDP growth rate (base year 2005) Japan	Qarterly rate

9.2 Appendix II: Tables

Table 9-3: Results restricted M3

Policy variable EONIA/MRO: the estimation sample is 2000(1) - 2008(4)				
	Coefficient	**Std.Error**	**t-value**	**t-prob**
GDPGrowthRateEA_1	0,506608	0,1832	2,76	0,01
d2lSpreadEONIAMRO_1	-1,02819	1,221	-0,842	0,4067
lSpreadEONIAMRO_3	-0,832703	1,353	-0,615	0,5433
GDPGrowthRateJapan	0,259089	0,0665	3,9	0,0006
GDPGrowthRateJapan_1	-0,103628	0,08581	-1,21	0,2373
GDPGrowthRateUK	0,200986	0,08717	2,31	0,0288
GDPGrowthRateUK_3	0,146891	0,09463	1,55	0,1318
Constant	-0,0007210	0,0009984	-0,722	0,4762

Policy variable 3M/MRO: the estimation sample is 2000(1) - 2008(4)				
	Coefficient	**Std.Error**	**t-value**	**t-prob**
GDPGrowthRateEA_1	0,387903	0,2035	1,91	0,0678
GDPGrowthRateEA_2	0,01047	0,197	0,0532	0,958
GDPGrowthRateEA_3	0,2259	0,173	1,31	0,203
dlSpread3MMRO	-1,56867	0,9758	-1,61	0,12
dlSpread3MMRO_1	-1,0601	1,249	-0,849	0,4039
dlSpread3MMRO_2	-0,925742	1,004	-0,922	0,365
GDPGrowthRateJapan	0,290856	0,06754	4,31	0,0002
GDPGrowthRateJapan_1	-0,0010469	0,08836	-0,0118	0,9906
GDPGrowthRateUK_2	0,156704	0,1011	1,55	0,1333
Constant	-0,0006599	0,0009032	-0,731	0,4715

Policy variable 3M/EONIA: the estimation sample is 2000(1) - 2008(4)				
	Coefficient	**Std.Error**	**t-value**	**t-prob**
GDPGrowthRateEA_1	0,554519	0,1461	3,8	0,0009
d2lSpread3MEONIA	1,23263	1,395	0,883	0,3858
dlSpread3MEONIA_2	-0,127215	1,296	-0,0982	0,9226
GDPGrowthRateUSA_1	0,0714108	0,1119	0,638	0,5294
GDPGrowthRateUSA_2	0,0232614	0,1075	0,216	0,8306
GDPGrowthRateUSA_3	0,108848	0,1165	0,934	0,3594
GDPGrowthRateJapan	0,223219	0,07165	3,12	0,0047
GDPGrowthRateJapan_1	-0,073304	0,09349	-0,784	0,4407
GDPGrowthRateJapan_4	0,0318181	0,06822	0,466	0,6451
GDPGrowthRateUK	0,189734	0,09146	2,07	0,0489
GDPGrowthRateUK_3	0,0678313	0,1145	0,592	0,5591
Constant	-0,0018045	0,001051	-1,72	0,0989

Policy variable 12M/3M: the estimation sample is 2000(1) - 2008(4)				
	Coefficient	**Std.Error**	**t-value**	**t-prob**
GDPGrowthRateEA_1	0,278845	0,1405	1,99	0,0534
dlSpread12M3M	1,39464	0,9468	1,47	0,1478
d2lSpread12M3M_1	0,265575	0,5811	0,457	0,6499
GDPGrowthRateUSA_1	0,159722	0,09921	1,61	0,1146
GDPGrowthRateUSA_3	0,0803524	0,1015	0,791	0,4329
GDPGrowthRateUSA_4	0,181206	0,08898	2,04	0,0477
GDPGrowthRateJapan	0,120426	0,05642	2,13	0,0384
GDPGrowthRateJapan_4	-0,0032827	0,05312	-0,0618	0,951
GDPGrowthRateUK	0,221107	0,1019	2,17	0,0355
GDPGrowthRateUK_1	0,0289744	0,1148	0,252	0,8018
GDPGrowthRateUK_3	0,163524	0,1164	1,4	0,1671
GDPGrowthRateUK_4	-0,146733	0,1287	-1,14	0,2603
Constant	-0,0017848	0,001262	-1,41	0,1643

9.3 Appendix III: Data

9.3.1 Variables

All variables in the final dataset I used in my analysis are quarterly. Most of these were also collected as quarterly, but the rate on the MRO had to be aggregated. The data on the MRO rate was given as level at time of change. I did this by simply using the value as it stood at the end of each quarter. My reason for choosing this method instead of averaging over period was that it gave a better picture of the events around the end of 2008. The data for the money market rates, EONIA, EURIBOR and 10 year government bonds were collected as quarterly, but are averages over the period.

Because the dependent variable, GDP growth, is quarterly I transformed the policy variables to log of quarterly rates as well by applying the same formula as used by P&S: $0{,}25\log(1+R/100)$.

The GDP growth variables for the euro area, USA and Japan are based on seasonally adjusted real (base year 2005) data transformed to growth rates in the usual way: $\frac{GDP_t - GDP_{t-1}}{GDP_{t-1}}$. The euro area series has been merged from two different series with different base years by using the proportion between them in the overlap period.

9.3.2 Sources

My primary source is the ECB/Eurostat, but I also have some data from the OECD. For both of these I have used their online databanks[12].

As far as possible I have used the ECB/Eurostat data so as not to encounter problems with divergent calculation methods. I say ECB/Eurostat because there is a close cooperation between the two institutions regarding the collection and processing of statistical material, with Eurostat data being used as input for many of the data series found in the ECB data warehouse.

Of the data used for the analysis only the second part of the euro area GDP came from the OECD.

I have selected the data online and downloaded it to excel where I have combined the various data series and made them compatible with one another. All the series except for the ECB interest rates and real EA GDP required only formatting adjustments. By formatting I mean setting the data in the right order from oldest to newest, giving appropriate labels and ordering so that they all start at the same date.

[12] ECB: http://sdw.ecb.europa.eu/home.do,
Eurostat: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
OECD: http://stats.oecd.org/index.aspx?r=622676

9.3.3 Data set

The data set included here starts in 1994 even though some of the regressions begin in 1979. 1979 is the earliest date I have values for for some of the variables, most of the relevant variables start earliest in 1994 and I will include only this period. I have had to split the tables in two, the first 9 variables are I the first and the last 9 are in the second.

Table 9-4: First part of the data set, #N/A means data missing

Quarter	GDP_EA17_SA_Q_1970_RCL_MEuro_ECB+OECD	GDP_UK_SA_Q_1971_RCL_MEuro_Eurostat	GDP_USA_SA_Q_1971_RCL_MEuro_Eurostat	GDP_Ja_SA_Q_1980_RCL_MEuro_Eurostat	Deposit facility - end of quarter Level	Marginal lending facility - end of quarter Level	Gbenhmarkbond_Q_10y_EA_ECB	Eonia_rate_Q_Aobsperiod_ECB	EURIBOR_3M_rate_Q_Aobsperiod_ECB
1994-1	1603109,98	318451,2	1752371,2	817071,2	#N/A	#N/A	6,9733	#N/A	6,84
1994-2	1614230,7	322696	1776344,3	808228,2	#N/A	#N/A	7,86	#N/A	6,37
1994-3	1626861,81	326964,8	1787778,3	823935,1	#N/A	#N/A	8,73	#N/A	6,3833
1994-4	1639659,11	329283,7	1807632	815416,3	#N/A	#N/A	9,14	#N/A	6,5067
1995-1	1644288,13	330989,9	1812073	820271,6	#N/A	#N/A	9,32	#N/A	6,9433
1995-2	1653734,57	332776	1815971,4	831892,8	#N/A	#N/A	8,93	#N/A	7,1367
1995-3	1658613,08	336630,6	1831223,4	837516,1	#N/A	#N/A	8,5133	#N/A	6,6933
1995-4	1664595,92	338248,8	1843983,6	837900,4	#N/A	#N/A	8,1533	#N/A	6,5067
1996-1	1664674,89	341959,6	1856623,3	844228,9	#N/A	#N/A	7,6433	#N/A	5,63
1996-2	1676789,23	343388,7	1888714,7	852921,3	#N/A	#N/A	7,5367	#N/A	5,1367
1996-3	1685750,67	345891,4	1905152,3	853000,2	#N/A	#N/A	7,2767	#N/A	5
1996-4	1691119,44	349085,3	1925950,5	866089,1	#N/A	#N/A	6,4733	#N/A	4,5867
1997-1	1697166,73	353026,5	1940760,4	872326,8	#N/A	#N/A	6,2033	#N/A	4,44
1997-2	1718914,54	356565,4	1969536,2	864052,1	#N/A	#N/A	6,22	#N/A	4,3267
1997-3	1730078,5	360027	1994252,9	867566,9	#N/A	#N/A	5,81	#N/A	4,3233
1997-4	1747475,33	363989,5	2009545,1	867084,4	#N/A	#N/A	5,6	#N/A	4,4333
1998-1	1757790,27	367068,9	2028534,7	850338	#N/A	#N/A	5,1167	#N/A	4,2033
1998-2	1765108,55	369708,8	2046780,8	845876	#N/A	#N/A	4,99	#N/A	4,0567
1998-3	1775275,62	371946,4	2073788,3	848526,5	#N/A	#N/A	4,56	#N/A	3,9367

1998-4	1779978,19	375270,9	2109677,7	853110	#N/A	#N/A	4,1467	#N/A	3,6233
1999-1	1794854,59	377286	2128466,4	845726,3	2	4,5	3,9986	3,0537	3,0886
1999-2	1807633,86	378476,8	2145104,9	848946,1	1,5	3,5	4,2582	2,6086	2,6349
1999-3	1827290,76	385048,5	2172393,7	848313,1	1,5	3,5	5,0507	2,4658	2,6994
1999-4	1847683,54	390177,7	2211397,8	852117,8	2	4	5,3175	2,8314	3,4306
2000-1	1871626,14	393977,7	2217185,1	866329,7	2,5	4,5	5,6137	3,2835	3,5486
2000-2	1887518,37	399518,4	2260429,2	867584,6	3,25	5,25	5,4266	3,9847	4,2848
2000-3	1895717,91	400705,2	2262338,2	865761,2	3,5	5,5	5,4384	4,4425	4,7388
2000-4	1908063,63	401632,2	2275741,5	871278,2	3,75	5,75	5,2765	4,8052	5,0282
2001-1	1925530,3	406974,5	2268266,2	877408,3	3,75	5,75	4,9884	4,8387	4,7447
2001-2	1927372,32	409658,3	2283116,3	875330,3	3,5	5,5	5,1929	4,7408	4,5885
2001-3	1928916,11	411865,3	2276826,6	865986,8	2,75	4,75	5,1167	4,3408	4,2779
2001-4	1931761,92	413381,1	2284784,2	864609,4	2,75	4,75	4,8119	3,6286	3,4522
2002-1	1934838,13	415112,5	2304296,3	863109,6	2,75	4,75	5,1327	3,2806	3,3615
2002-2	1945817,6	418552,9	2316554,1	871879,1	2,75	4,75	5,2586	3,3243	3,4461
2002-3	1951521,55	422094,5	2328309,6	877338,9	2,75	4,75	4,7682	3,3041	3,3589
2002-4	1952237,07	426064,9	2329113,4	880831,2	1,75	3,75	4,5412	3,2373	3,1162
2003-1	1951351,19	428627,5	2338819,2	876014,8	1,5	3,5	4,1579	2,7668	2,6854
2003-2	1952676,67	433828,7	2358632,7	887077,3	1	3	3,9606	2,4418	2,3591
2003-3	1961610,4	439129,7	2397456	890202,6	1	3	4,1642	2,0655	2,1391
2003-4	1975595,1	444398,8	2419138,3	900012,4	1	3	4,3641	2,0155	2,1493
2004-1	1985762,6	447678	2435073,5	909236,4	1	3	4,1501	2,0189	2,0618
2004-2	1996515,06	448744,8	2450747,5	909124,4	1	3	4,3566	2,0395	2,0834
2004-3	2003847,12	448759,5	2468993,7	909899,7	1	3	4,2071	2,0533	2,1163
2004-4	2010801,72	451577,8	2489189	907982,5	1	3	3,8414	2,0824	2,164
2005-1	2014643,58	454338,9	2514870,2	909877,1	1	3	3,6742	2,0642	2,1404
2005-2	2029485,58	459971,6	2526063	921750,3	1	3	3,4084	2,0689	2,1244
2005-3	2041693,7	463665	2546117,7	924753,2	1	3	3,2624	2,0758	2,1305
2005-4	2054926,63	468631,7	2559199,4	926670,4	1,25	3,25	3,4214	2,142	2,3437

2006-1	2074180,47	470967,9	2591511,9	930910,9	1,5	3,5	3,5612	2,402	2,6136
2006-2	2096185,3	472410,4	2602021,5	934397,5	1,75	3,75	4,0503	2,6347	2,8957
2006-3	2110573,48	473386,7	2602363,2	933759,2	2	4	3,9681	2,9418	3,2215
2006-4	2132504,89	477861,9	2620046,6	945903,5	2,5	4,5	3,862	3,3627	3,5902
2007-1	2149995,23	483276,2	2623603,4	955699,1	2,75	4,75	4,0802	3,6091	3,8204
2007-2	2159558,32	489239,2	2647214,9	956196,2	3	5	4,4249	3,8553	4,0678
2007-3	2173204,17	495010,4	2666546,1	952971,1	3	5	4,4772	4,0469	4,4937
2007-4	2182670,17	495926,7	2677839,4	961332,1	3	5	4,3448	3,9507	4,7184
2008-1	2194023,21	496351,6	2665943,3	968129	3	5	4,1498	4,0451	4,4763
2008-2	2185903,89	491848,4	2674724,7	955666,4	3	5	4,5004	4,0008	4,8593
2008-3	2172841,05	483160,3	2649887,5	946107,1	3,25	5,25	4,6098	4,2527	4,9817
2008-4	2135909,23	473088,3	2588919,7	915337,8	2	3	4,1655	3,173	4,2424
2009-1	2076150,46	465995,9	2554256,1	878737,1	1	2,5	4,1443	1,374	2,0068
2009-2	2070254,91	465187,4	2552246,6	893372,5	0,25	1,75	4,1833	0,7716	1,308
2009-3	2078202,8	467028,1	2561429,9	893846,2	0,25	1,75	3,9525	0,3562	0,8709
2009-4	2086503,04	468956,7	2586829,8	910131,5	0,25	1,75	3,8381	0,3585	0,722
2010-1	2096243,55	471735,1	2601800,5	923021	0,25	1,75	4,062	0,3443	0,6613
2010-2	2117582,87	475096,9	2616268,8	932920	0,25	1,75	3,8496	0,3505	0,6876
2010-3	2126177,88	478005,8	2633128,4	945492,7	0,25	1,75	3,5178	0,4534	0,8749
2010-4	2133516,82	475926,6	2648742,1	941628,1	0,25	1,75	3,7229	0,5943	1,0208
2011-1	2147231,46	478035,1	2649264,5	923852	0,25	1,75	4,3046	0,6739	1,0958
2011-2	2151980,62	478694,4	2665521,3	917421,1	0,5	2	4,4622	1,0447	1,4159
2011-3	2153968,45	481383,5	2674001,3	940475,7	0,75	2,25	4,2765	0,9727	1,5614
2011-4	2146538,78	480050,3	2700948,5	941174,5	0,25	1,75	4,2018	0,7922	1,4954
2012-1	2145813,56	478851,5	2714090,5	954233,6	0,25	1,75	3,6511	0,3676	1,0429
2012-2	2142207,64	477072,1	2722550,4	953966,2	0,25	1,75	3,446	0,3378	0,6943
2012-3	2140717,88	481579,3	2743449,1	945533,8	#N/A	1,5	2,913	0,1319	0,3616
2012-4	#N/A	480134,2	2742464,4	#N/A	#N/A	#N/A	2,2228	0,0814	0,1959
2013-1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

Table 9-5: Second part of the data set, again #N/A means data missing

	EURIBOR_1Y_rate_Q_Aobsperiod_ECB	MRO_end of period	CounterEURIBOR3M	CounterEURIBOR1Y	CrudeOil_Ft_CushingOK	CounterEURIBOR3M_paper3periods	CounterEonia_MROratio	CounterEURIBOR12M_paper3periods	CounterEonia_pap2
1994-1	6,4367	#N/A	6,84	#N/A	14,8166667	6,84	#N/A	6,4367	#N/A
1994-2	6,4433	#N/A	6,37	#N/A	17,7433333	6,37	#N/A	6,4433	#N/A
1994-3	7,0533	#N/A	6,38	#N/A	18,5033333	6,3833	#N/A	7,0533	#N/A
1994-4	7,3333	#N/A	6,51	#N/A	17,6566667	6,5067	#N/A	7,3333	#N/A
1995-1	7,7267	#N/A	6,94	#N/A	18,3566667	6,9433	#N/A	7,7267	#N/A
1995-2	7,3733	#N/A	7,14	#N/A	19,3433333	7,1367	#N/A	7,3733	#N/A
1995-3	6,86	#N/A	6,69	#N/A	17,76	6,6933	#N/A	6,86	#N/A
1995-4	6,4667	#N/A	6,51	#N/A	18,1466667	6,5067	#N/A	6,4667	#N/A
1996-1	5,6	#N/A	5,63	#N/A	19,5533333	5,63	#N/A	5,6	#N/A
1996-2	5,1933	#N/A	5,14	#N/A	21,6066667	5,1367	#N/A	5,1933	#N/A
1996-3	5,1	#N/A	5	#N/A	22,3633333	5	#N/A	5,1	#N/A
1996-4	4,5333	#N/A	4,59	#N/A	24,5233333	4,5867	#N/A	4,5333	#N/A
1997-1	4,3733	#N/A	4,44	#N/A	22,7733333	4,44	#N/A	4,3733	#N/A
1997-2	4,3867	#N/A	4,33	#N/A	19,94	4,3267	#N/A	4,3867	#N/A
1997-3	4,41	#N/A	4,32	#N/A	19,7966667	4,3233	#N/A	4,41	#N/A
1997-4	4,5067	#N/A	4,43	#N/A	19,94	4,4333	#N/A	4,5067	#N/A
1998-1	4,1467	#N/A	4,2	#N/A	15,95	4,2033	#N/A	4,1467	#N/A
1998-2	4,11	#N/A	4,06	#N/A	14,6866667	4,0567	#N/A	4,11	#N/A
1998-3	3,8967	#N/A	3,94	#N/A	14,1466667	3,9367	#N/A	3,8967	#N/A
1998-4	3,47	#N/A	3,62	#N/A	12,9233333	3,6233	#N/A	3,47	#N/A
1999-1	3,0459	3	3,09	3	13,0633333	3,0886	3,0537	3,0459	3,0537
1999-2	2,7596	2,5	2,63	2,5	17,6633333	2,6349	2,6086	2,7596	2,6086
1999-3	3,1895	2,5	2,7	2,5	21,7233333	2,6994	2,4658	3,1895	2,4658
1999-4	3,7338	3	3,43	3	24,51	3,4306	2,8314	3,7338	2,8314

2000-1	4,1143	3,5	3,55	3,5	28,7333333	3,5486	3,2835	4,1143	3,2835
2000-2	4,7493	4,25	4,28	4,25	28,6266667	4,2848	3,9847	4,7493	3,9847
2000-3	5,1927	4,5	4,74	4,5	31,5766667	4,7388	4,4425	5,1927	4,4425
2000-4	5,1079	4,75	5,03	4,75	31,8633333	5,0282	4,8052	5,1079	4,8052
2001-1	4,5439	4,75	4,74	4,75	28,7233333	4,7447	4,8387	4,5439	4,8387
2001-2	4,4379	4,5	4,59	4,5	27,9633333	4,5885	4,7408	4,4379	4,7408
2001-3	4,0725	3,75	4,28	3,75	26,49	4,2779	4,3408	4,0725	4,3408
2001-4	3,2891	3,25	3,45	3,75	20,4266667	3,4522	3,6286	3,2891	3,6286
2002-1	3,626	3,25	3,36	3,75	21,6433333	3,3615	3,2806	3,626	3,2806
2002-2	3,8987	3,25	3,45	3,75	26,2533333	3,4461	3,3243	3,8987	3,3243
2002-3	3,4467	3,25	3,36	3,75	28,27	3,3589	3,3041	3,4467	3,3041
2002-4	3,0108	2,75	3,12	2,75	28,1466667	3,1162	3,2373	3,0108	3,2373
2003-1	2,543	2,5	2,69	2,5	33,8633333	2,6854	2,7668	2,543	2,7668
2003-2	2,2342	2	2,36	2	28,91	2,3591	2,4418	2,2342	2,4418
2003-3	2,201	2	2,14	2	30,2033333	2,1391	2,0655	2,201	2,0655
2003-4	2,3619	2	2,15	2	31,1833333	2,1493	2,0155	2,3619	2,0155
2004-1	2,1417	2	2,06	2	35,1466667	2,0618	2,0189	2,1417	2,0189
2004-2	2,292	2	2,08	2	38,3166667	2,0834	2,0395	2,292	2,0395
2004-3	2,3467	2	2,12	2	43,8766667	2,1163	2,0533	2,3467	2,0533
2004-4	2,3149	2	2,16	2	48,2766667	2,164	2,0824	2,3149	2,0824
2005-1	2,3191	2	2,14	2	49,8433333	2,1404	2,0642	2,3191	2,0642
2005-2	2,1859	2	2,12	2	53,17	2,1244	2,0689	2,1859	2,0689
2005-3	2,2043	2	2,13	2	63,19	2,1305	2,0758	2,2043	2,0758
2005-4	2,628	2,25	2,34	2,25	60,02	2,3437	2,142	2,628	2,142
2006-1	2,9545	2,5	2,61	2,5	63,48	2,6136	2,402	2,9545	2,402
2006-2	3,3156	2,75	2,9	2,75	70,6966667	2,8957	2,6347	3,3156	2,6347
2006-3	3,6228	3	3,22	3	70,48	3,2215	2,9418	3,6228	2,9418
2006-4	3,8584	3,5	3,59	3,5	60,21	3,5902	3,3627	3,8584	3,3627
2007-1	4,0877	3,75	3,82	3,75	58,16	3,8204	3,6091	4,0877	3,6091

2007-2	4,381	4	4,07	4	65,0333333	4,0678	3,8553	4,381	3,8553
2007-3	4,6495	4	4,49	4	75,38	4,4937	4,0469	4,6495	4,0469
2007-4	4,6765	4	4,72	4	90,6766667	4,7184	3,9507	4,6765	3,9507
2008-1	4,4757	4	4,48	4	97,9	4,4763	4,0451	4,4757	4,0451
2008-2	5,0545	4	4,86	4	123,98	4,8593	4,0008	5,0545	4,0008
2008-3	5,3678	4,25	4,98	4,25	117,976667	4,9817	4,2527	5,3678	4,2527
2008-4	4,3781	2,5	4,03	4,3	58,7333333	4,62333333	3,175	5,06666667	6
2009-1	2,2184	1,5	3,03	3,3	43,08	3,77	1,50779257	3,35	4,1
2009-2	1,6732	1,25	2,78	3,05	59,62	2,88333333	1,25649381	2,48333333	3,4
2009-3	1,3369	1,25	2,78	3,05	68,3	3,08	1,25649381	2,47	3,3
2009-4	1,2387	1,25	2,78	3,05	76,19	#N/A	1,25649381	#N/A	2,85
2010-1	1,2237	1,25	2,78	3,05	78,7133333	#N/A	1,25649381	#N/A	3
2010-2	1,2528	1,25	2,78	3,05	78,0366667	#N/A	1,25649381	#N/A	3,4
2010-3	1,405	1,25	2,78	3,05	76,2	#N/A	1,25649381	#N/A	#N/A
2010-4	1,5211	1,25	2,78	3,05	85,1666667	#N/A	1,25649381	#N/A	#N/A
2011-1	1,7357	1,25	2,78	3,05	94,1	#N/A	1,25649381	#N/A	#N/A
2011-2	2,1275	1,25	2,78	3,05	102,563333	#N/A	1,25649381	#N/A	#N/A
2011-3	2,1142	1,5	3,03	3,3	89,7633333	#N/A	1,50779257	#N/A	#N/A
2011-4	2,0524	1	2,53	2,8	94,0566667	#N/A	1,00519505	#N/A	#N/A
2012-1	1,671	1	2,53	2,8	102,93	#N/A	1,00519505	#N/A	#N/A
2012-2	1,2813	1	2,53	2,8	93,4933333	#N/A	1,00519505	#N/A	#N/A
2012-3	0,8969	0,75	2,28	2,55	92,2166667	#N/A	0,75389629	#N/A	#N/A
2012-4	0,5996	0,75	2,28	2,55	88,1833333	#N/A	0,75389629	#N/A	#N/A
2013-1	#N/A	#N/A	#N/A	#N/A	47,415	#N/A	#N/A	#N/A	#N/A

9.4 Appendix IV: Batch files

9.4.1 Replication of results by P&S

This batch file replicates the estimations from the article by P&S.

```
loaddata("Country_Data_(1979Q4-2011Q2)edite.xls");
usedata("Country_Data_(1979Q4-2011Q2)edite.xls");

algebra{
                                                                   // Producing the GDP growth rates
dlogGDPUK=dlog(GDPUK);
dlogGDPUSA=dlog(GDPUSA);
dlogGDPEA=dlog(GDPEA);

                                                                   // log of policy rates
lRshortUK=0.25*log(1+RshortUK/100);
lRlongUK=0.25*log(1+RlongUK/100);
lSpreadUK=lRlongUK-lRshortUK;
                                                                 // Counterfactual rates, Var14 is a scaling variable
CounterRlongUK=RlongUK+Var14;
lCounterSpreadUK=0.25*log(1+CounterRlongUK/100)-0.25*log(1+RshortUK/100);
}
                                                                   // Replicating M1
module("PcGive");
package("PcGive", "Single-equation ");

system
{
    Y = dlogGDPUK;
    Z = Constant, dlogGDPUK_1, lSpreadUK, lSpreadUK_1;

}

estimate("OLS", 1980, 3, 2011, 3);
testlinres{
1 5
0 0 1 -1 0
}
estimate("OLS", 1980, 3, 2008, 4);
testlinres{
1 5
0 0 1 -1 0
}
```

```
forecast(11, 0, 0);
store ("forecast", "Forcast:dlogGDP");


module("PcGive");
package("PcGive", "Single-equation ");

system
{
    Y = dlogGDPUK;
    Z = Constant, dlogGDPUK_1, lCounterSpreadUK, lCounterSpreadUK_1;

}

estimate("OLS", 1980, 3, 2008, 4);
forecast(11, 0, 0);
store ("forecast", "Forcast:CounterdlogGDP");

                                                                              // Imposing the zero long-run condition
algebra{

dlSpreadUK=diff(lSpreadUK, 1);
dlCounterSpreadUK=diff(lCounterSpreadUK, 1);

}
                                                                              // restricted M1
module("PcGive");
package("PcGive", "Single-equation ");

system
{
    Y = dlogGDPUK;
    Z = Constant, dlogGDPUK_1, dlSpreadUK;

}

estimate("OLS", 1980, 3, 2008, 4);
forecast(11, 0, 0);
store ("forecast", "rForcast:dlogGDP");

module("PcGive");
package("PcGive", "Single-equation ");

system
{
```

```
    Y = dlogGDPUK;
    Z = Constant, dlogGDPUK_1, dlCounterSpreadUK;

}

estimate("OLS", 1980, 3, 2008, 4);
forecast(11, 0, 0);
store ("forecast", "rForcast:CounterdlogGDP");

algebra{

DForecast_u="Forcast:dlogGDP"-"Forcast:CounterdlogGDP";            // delta forecast unrestricted
DForecast_r="rForcast:dlogGDP"-"rForcast:CounterdlogGDP";          //   delta forecast restricted

}
//break;

                                                                   //including US and EA GDP: M2
                                                                   // Unrestricted M2
module("PcGive");
package("PcGive", "Single-equation ");

system
{
    Y = dlogGDPUK;
    Z = Constant, dlogGDPUK_1, lSpreadUK, lSpreadUK_1, dlogGDPUSA, dlogGDPEA;

}

estimate("OLS", 1980, 3, 2011, 2);
testlinres{
1 7
0 0 1 -1 0 0 0
}
estimate("OLS", 1980, 3, 2008, 4);
testlinres{
1 7
0 0 1 -1 0 0 0
}
forecast(11, 0, 0);
store ("forecast", "ForcastM2:dlogGDP");

module("PcGive");
package("PcGive", "Single-equation ");
```

```
system
{
    Y = dlogGDPUK;
    Z = Constant, dlogGDPUK_1, lCounterSpreadUK, lCounterSpreadUK_1, dlogGDPUSA, dlogGDPEA;

}

estimate("OLS", 1980, 3, 2008, 4);
forecast(11, 0, 0);
store ("forecast", "ForcastM2:CounterdlogGDP");

module("PcGive");                                                          // Restricted M2
package("PcGive", "Single-equation ");

system
{
    Y = dlogGDPUK;
    Z = Constant, dlogGDPUK_1, dlSpreadUK, dlogGDPUSA, dlogGDPEA;

}

estimate("OLS", 1980, 3, 2008, 4);
forecast(11, 0, 0);
store ("forecast", "rForcastM2:dlogGDP");

module("PcGive");
package("PcGive", "Single-equation ");

system
{
    Y = dlogGDPUK;
    Z = Constant, dlogGDPUK_1, dlCounterSpreadUK, dlogGDPUSA, dlogGDPEA;

}

estimate("OLS", 1980, 3, 2008, 4);
forecast(11, 0, 0); store ("forecast", "rForcastM2:CounterdlogGDP");

algebra{

DForecastM2_u="ForcastM2:dlogGDP"-"ForcastM2:CounterdlogGDP";           // delta forecast unrestricted
DForecastM2_r="rForcastM2:dlogGDP"-"rForcastM2:CounterdlogGDP";         // delta forecast restricted

}
```

9.4.2 Algebra

This batch file is the first one to run. It calculates and creates all the needed variables from the ones in the data set.

```
loaddata("Allgiveeditshort.xls");
usedata("Allgiveeditshort.xls");

algebra{
                                                                  // GDP growth rates
GDPGrowthRateEA=("GDP_EA17_SA_Q_1970_RCL_MEuro_ECB+OECD"-lag("GDP_EA17_SA_Q_1970_RCL_MEuro_ECB+OECD", 1))/
(lag("GDP_EA17_SA_Q_1970_RCL_MEuro_ECB+OECD", 1));
GDPGrowthRateUSA=("GDP_USA_SA_Q_1971_RCL_MEuro_Eurostat"-lag("GDP_USA_SA_Q_1971_RCL_MEuro_Eurostat", 1))/
(lag("GDP_USA_SA_Q_1971_RCL_MEuro_Eurostat", 1));
GDPGrowthRateJapan=("GDP_Ja_SA_Q_1980_RCL_MEuro_Eurostat"-lag("GDP_Ja_SA_Q_1980_RCL_MEuro_Eurostat", 1))/
(lag("GDP_Ja_SA_Q_1980_RCL_MEuro_Eurostat", 1));
GDPGrowthRateUK=("GDP_UK_SA_Q_1971_RCL_MEuro_Eurostat"-lag("GDP_UK_SA_Q_1971_RCL_MEuro_Eurostat", 1))/
(lag("GDP_UK_SA_Q_1971_RCL_MEuro_Eurostat", 1));


                                                                  // log of policy variables
lMRO=0.25*log(1+"MRO_end of period"/100);
lEONIA=0.25*log(1+"Eonia_rate_Q_Aobsperiod_ECB"/100);
lR3MEA=0.25*log(1+"EURIBOR_3M_rate_Q_Aobsperiod_ECB"/100);
lR12MEA=0.25*log(1+"EURIBOR_1Y_rate_Q_Aobsperiod_ECB"/100);
lR10YEA=0.25*log(1+"Gbenhmarkbond_Q_10y_EA_ECB"/100);

                                                                  //log of counterfactual policy variables
lCounterEONIA_MROratio=0.25*log(1+"CounterEonia_MROratio"/100);
lCounterEONIA_pap2=0.25*log(1+"CounterEonia_pap2"/100);
lCounterEURIBOR3M=0.25*log(1+"CounterEURIBOR3M"/100);
lCounterEURIBOR3Mpapergrapg=0.25*log(1+"CounterEURIBOR3M_paper3periods"/100);
lCounterR12MEA=0.25*log(1+"CounterEURIBOR1Y"/100);
lCounterEURIBOR12Mpapergrapg=0.25*log(1+"CounterEURIBOR12M_paper3periods"/100);

                                                                  // spreads of logs
lSpreadEONIAMRO=lEONIA-lMRO;
lSpread3MMRO=lR3MEA-lMRO;
lSpread3MEONIA=lR3MEA-lEONIA;
lSpread12MMRO=lR12MEA-lMRO;
lSpread12M3M=lR12MEA-lR3MEA;
lSpread10Y3MEA=lR10YEA-lR3MEA;


                                                                  // spreads of log counterfactuals
```

```
lSpreadCounterEONIAMROratio=lCounterEONIA_MROratio-lMRO;
lSpreadCounterEONIAMROpap2=lCounterEONIA_pap2-lMRO;
lSpreadCounter3MMRO=lCounterEURIBOR3M-lMRO;
lSpreadCounter3MMROpap=lCounterEURIBOR3Mpapergrapg-lMRO;
lSpreadCounter3MEONIApap2=lCounterEURIBOR3M-lCounterEONIA_pap2;
lSpreadCounter3MEONIApap=lCounterEURIBOR3Mpapergrapg-lCounterEONIA_MROratio;
lSpreadCounter12M3Mpap=lCounterEURIBOR12Mpapergrapg-lCounterEURIBOR3Mpapergrapg;


                                                                    // imposing no long-run effect
dlSpreadEONIAMRO=diff(lSpreadEONIAMRO, 1);
dlSpread3MMRO=diff(lSpread3MMRO, 1);
dlSpread3MEONIA=diff(lSpread3MEONIA, 1);
dlSpread12MMRO=diff(lSpread12MMRO, 1);
dlSpread12M3M=diff(lSpread12M3M, 1);
dlSpreadCounterEONIAMROratio=diff(lSpreadCounterEONIAMROratio, 1);
dlSpreadCounterEONIAMROpap2=diff(lSpreadCounterEONIAMROpap2, 1);
dlSpreadCounter3MMRO=diff(lSpreadCounter3MMRO, 1);
dlSpreadCounter3MMROpap=diff(lSpreadCounter3MMROpap, 1);
dlSpreadCounter3MEONIApap=diff(lSpreadCounter3MEONIApap, 1);
dlSpreadCounter3MEONIApap2=diff(lSpreadCounter3MEONIApap2, 1);
dlSpreadCounter12M3Mpap=diff(lSpreadCounter12M3Mpap, 1);

}
```

9.4.3 Unrestricted and restricted estimations and tests of the zero long-run restriction on the simplest set-up

This batch file estimates the unrestricted models and runs tests for the validity of the zero long-run restriction. Then estimates and forecasts the restricted version.

```
loaddata("Allgiveeditshort.xls");
usedata("Allgiveeditshort.xls");

////////////////////////////////////// adding conditioning variables to the models using spreads


                                                                              //EONIA over MRO
module("PcGive");
package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", lSpreadEONIAMRO, lSpreadEONIAMRO_1, "GDPGrowthRateUSA", "GDPGrowthRateJapan", Constant;
}
//estimate("OLS", 1979, 3, 2012, 3, 0, 1);
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "uForecastM2:EONIAMRO");
testlinres{
1 7
0 1 -1 0 0 0 0
}

                                                                              //3 month EURIBOR over MRO
module("PcGive");
package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", lSpread3MMRO, lSpread3MMRO_1, "GDPGrowthRateUSA", "GDPGrowthRateJapan", Constant;
}
//estimate("OLS", 1979, 3, 2012, 3, 0, 1);
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "uForecastM2:3MMRO");
```

```
testlinres{
1 7
0 1 -1 0 0 0 0
}

                                                            //3 month EURIBOR over EONIA
module("PcGive");
package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", lSpread3MEONIA, lSpread3MEONIA_1,"GDPGrowthRateUSA", "GDPGrowthRateJapan",Constant;
}
//estimate("OLS", 1979, 3, 2012, 3, 0, 1);
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "uForecastM2:3MEONIA");
testlinres{
1 7
0 1 -1 0 0 0 0
}

                                                         // 12 month EURIBOR over 3 month EURIBOR
module("PcGive");

package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", lSpread12M3M, lSpread12M3M_1, "GDPGrowthRateUSA", "GDPGrowthRateJapan", Constant;
}
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "uForecastM2:12M3M");
testlinres{
1 7
0 1 -1 0 0 0 0
}

//////////////////////////////////////////////////////////////////      new model using Autometrics

                                                         // EONIA/MRO
```

```
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "GDPGrowthRateEA_1", "GDPGrowthRateEA_3",
            "lSpreadEONIAMRO_1", "lSpreadEONIAMRO_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1",
            "GDPGrowthRateUK", "GDPGrowthRateUK_3",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "uForecastM3:EONIAMRO");
testgenres{
&3+&4=0;
}

                                                        //3M/MRO
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "lSpread3MMRO", "lSpread3MMRO_1", "lSpread3MMRO_2", "lSpread3MMRO_3",
            "GDPGrowthRateEA_1", "GDPGrowthRateEA_2", "GDPGrowthRateEA_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1",
            "GDPGrowthRateUK_2",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "uForecastM3:3MMRO");
testgenres{
&1&2&3&4=0;
}

                                                        //3M/EONIA
```

```
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "lSpread3MEONIA", "lSpread3MEONIA_2", "lSpread3MEONIA_3",
            "GDPGrowthRateEA_1",
            "GDPGrowthRateUSA_1", "GDPGrowthRateUSA_2", "GDPGrowthRateUSA_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1", "GDPGrowthRateJapan_4",
            "GDPGrowthRateUK", "GDPGrowthRateUK_3",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "uForecastM3:3MEONIA");
testgenres{
&1&2&3=0;
}


                                                                          //3M/12M
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "lSpread12M3M", "lSpread12M3M_1", "lSpread12M3M_3",
            "GDPGrowthRateEA_1",
            "GDPGrowthRateUSA_1", "GDPGrowthRateUSA_3", "GDPGrowthRateUSA_4",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_4",
            "GDPGrowthRateUK", "GDPGrowthRateUK_1", "GDPGrowthRateUK_3", "GDPGrowthRateUK_4",
            "Constant";
}
estimate("OLS", 1994, 4, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "uForecastM3:12M3M");
testgenres{
&1&2&3=0;
}
```

9.4.4 Imposing the zero long-run restriction and forecasting

This batch file imposes the zero long-run restriction and forecasts

```
loaddata("Allgiveeditshort.xls");
usedata("Allgiveeditshort.xls");

///////////////////////////////////////////////////////// running the regression after imposing zero long-run effect

                                                                  //EONIA over MRO
module("PcGive");
package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", dlSpreadEONIAMRO, "GDPGrowthRateUSA", "GDPGrowthRateJapan", Constant;
}
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM2:EONIAMRO");

                                                                  //3 month EURIBOR over MRO
module("PcGive");
package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", dlSpread3MMRO, "GDPGrowthRateUSA", "GDPGrowthRateJapan", Constant;
}
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM2:3MMRO");

                                                                  //3 month EURIBOR over EONIA
module("PcGive");
package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", dlSpread3MEONIA, "GDPGrowthRateUSA", "GDPGrowthRateJapan",Constant;
}
```

```
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM2:3MEONIA");

                                                                  // 12 month EURIBOR over 3 month EURIBOR
module("PcGive");

package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", dlSpread12M3M, "GDPGrowthRateUSA", "GDPGrowthRateJapan", Constant;
}
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM2:12M3M");


//////////////////////////////////////////////////////////////////////      new model using Autometrics

algebra{

d2lSpreadEONIAMRO = diff(lSpreadEONIAMRO, 2);
d2lSpread3MEONIA = diff(lSpread3MEONIA, 2);
d2lSpread12M3M = diff(lSpread12M3M, 2);

}

                                                                  // EONIA/MRO
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "GDPGrowthRateEA_1",
            "d2lSpreadEONIAMRO_1", "lSpreadEONIAMRO_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1",
            "GDPGrowthRateUK", "GDPGrowthRateUK_3",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
```

```
forecast(11, 0, 0);
store("forecast", "rForecastM3:EONIAMRO");

                                                                  //3M/MRO
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "dlSpread3MMRO", "dlSpread3MMRO_1", "dlSpread3MMRO_2",
            "GDPGrowthRateEA_1", "GDPGrowthRateEA_2", "GDPGrowthRateEA_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1",
            "GDPGrowthRateUK_2",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM3:3MMRO");


                                                                  //3M/EONIA
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "d2lSpread3MEONIA", "dlSpread3MEONIA_2",
            "GDPGrowthRateEA_1",
            "GDPGrowthRateUSA_1", "GDPGrowthRateUSA_2", "GDPGrowthRateUSA_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1", "GDPGrowthRateJapan_4",
            "GDPGrowthRateUK", "GDPGrowthRateUK_3",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM3:3MEONIA");
```

//3M/12M

```
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "dlSpread12M3M", "d2lSpread12M3M_1",
            "GDPGrowthRateEA_1",
            "GDPGrowthRateUSA_1", "GDPGrowthRateUSA_3", "GDPGrowthRateUSA_4",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_4",
            "GDPGrowthRateUK", "GDPGrowthRateUK_1", "GDPGrowthRateUK_3", "GDPGrowthRateUK_4",
            "Constant";
}
estimate("OLS", 1994, 4, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM3:12M3M");
```

9.4.5 Counterfactual forecasting and calculation of effect

```
loaddata("Allgiveeditshort.xls");
usedata("Allgiveeditshort.xls");

/////////////////////////////////////////////////////// running the regressions for the counterfactuals

//lCounterEONIA_followMRO : is the actual EONIA rate until 2008Q4 when it followes the MRO which it did in normal circumstances
//lEONIA2: is the EONIA from the last section of the thesis
//lCounterEURIBOR3M : is apprximately the one given in Lenza
//lCounterR12MEA : is approximately the one given in Lenza


                                                                  //Counter EONIA over MRO
module("PcGive");

package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", dlSpreadCounterEONIAMROratio, "GDPGrowthRateUSA", "GDPGrowthRateJapan", Constant;
}
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM2:CounterEONIAMRO");

                                                                  //Counter 3 month EURIBOR over MRO
module("PcGive");
package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", dlSpreadCounter3MMROpap, "GDPGrowthRateUSA", "GDPGrowthRateJapan", Constant;
}
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM2:Counter3MMROpap");
```

```
                                                                   //Counter 3 month EURIBOR over EONIA
module("PcGive");
package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", dlSpreadCounter3MEONIApap, "GDPGrowthRateUSA", "GDPGrowthRateJapan",Constant;
}
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM2:Counter3MEONIApap");


                                                                   //Counter 12 month EURIBOR over 3 month EURIBOR
module("PcGive");

package("PcGive", "Single-equation");

system
{
    Y = "GDPGrowthRateEA";
    Z = "GDPGrowthRateEA_1", dlSpreadCounter12M3Mpap, "GDPGrowthRateUSA", "GDPGrowthRateJapan", Constant;
}
estimate("OLS", 1979, 3, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM2:Counter12M3Mpap");

algebra {
"DForecast:EONIAMRO"="rForecastM2:EONIAMRO"-"rForecastM2:CounterEONIAMRO";
"DForecast:3MMROpap"="rForecastM2:3MMRO"-"rForecastM2:Counter3MMROpap";
"DForecast:3MEONIApap"="rForecastM2:3MEONIA"-"rForecastM2:Counter3MEONIApap";
"DForecast:12M3Mpap"="rForecastM2:12M3M"-"rForecastM2:Counter12M3Mpap";

}

/////////////////////////////////////////////////////////////////// new model using Autometrics

algebra{

d2lSpreadCounterEONIAMROratio = diff(lSpreadCounterEONIAMROratio, 2);
d2lSpreadCounterEONIAMROpap2 = diff(lSpreadCounterEONIAMROpap2, 2);
d2lSpreadCounter3MEONIApap = diff(lSpreadCounter3MEONIApap, 2);
d2lSpreadCounter3MEONIApap2 = diff(lSpreadCounter3MEONIApap2, 2);
```

```
d2lSpreadCounter12M3Mpap = diff(lSpreadCounter12M3Mpap, 2);
}



                                                                               // EONIA/MRO
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "GDPGrowthRateEA_1",
            "d2lSpreadCounterEONIAMROratio_1", "lSpreadCounterEONIAMROratio_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1",
            "GDPGrowthRateUK", "GDPGrowthRateUK_3",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM3:CounterEONIAMRO");

                                                                               // EONIA2/MRO
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "GDPGrowthRateEA_1",
            "d2lSpreadCounterEONIAMROpap2_1", "lSpreadCounterEONIAMROpap2_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1",
            "GDPGrowthRateUK", "GDPGrowthRateUK_3",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM3:CounterEONIA2MRO");

                                                                               //3M/MRO
```

```
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "dlSpreadCounter3MMROpap", "dlSpreadCounter3MMROpap_1", "dlSpreadCounter3MMROpap_2",
            "GDPGrowthRateEA_1", "GDPGrowthRateEA_2", "GDPGrowthRateEA_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1",
            "GDPGrowthRateUK_2",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM3:Counter3MMROpap");


                                                                        //3M/EONIA
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "d2lSpreadCounter3MEONIApap", "dlSpreadCounter3MEONIApap_2",
            "GDPGrowthRateEA_1",
            "GDPGrowthRateUSA_1", "GDPGrowthRateUSA_2", "GDPGrowthRateUSA_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1", "GDPGrowthRateJapan_4",
            "GDPGrowthRateUK", "GDPGrowthRateUK_3",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM3:Counter3MEONIApap");

                                                                        //3M/EONIA2
module("PcGive");

package("PcGive", "Single-equation");

system
```

```
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "d2lSpreadCounter3MEONIApap2", "dlSpreadCounter3MEONIApap2_2",
            "GDPGrowthRateEA_1",
            "GDPGrowthRateUSA_1", "GDPGrowthRateUSA_2", "GDPGrowthRateUSA_3",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_1", "GDPGrowthRateJapan_4",
            "GDPGrowthRateUK", "GDPGrowthRateUK_3",
            "Constant";
}
estimate("OLS", 2000, 1, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM3:Counter3MEONIA2");


                                                                  //3M/12M
module("PcGive");

package("PcGive", "Single-equation");

system
{
      "Y" = "GDPGrowthRateEA";
      "Z" =
            "dlSpreadCounter12M3Mpap", "d2lSpreadCounter12M3Mpap_1",
            "GDPGrowthRateEA_1",
            "GDPGrowthRateUSA_1", "GDPGrowthRateUSA_3", "GDPGrowthRateUSA_4",
            "GDPGrowthRateJapan", "GDPGrowthRateJapan_4",
            "GDPGrowthRateUK", "GDPGrowthRateUK_1", "GDPGrowthRateUK_3", "GDPGrowthRateUK_4",
            "Constant";
}
estimate("OLS", 1994, 4, 2008, 4, 0, 1);
forecast(11, 0, 0);
store("forecast", "rForecastM3:Counter12M3Mpap");



algebra {
"DrForecastM3:EONIAMRO"="rForecastM3:EONIAMRO"-"rForecastM3:CounterEONIAMRO";
"DrForecastM3:EONIAMRO"="rForecastM3:EONIAMRO"-"rForecastM3:CounterEONIA2MRO";
"DrForecastM3:3MMROpap"="rForecastM3:3MMRO"-"rForecastM3:Counter3MMROpap";
"DrForecastM3:3MEONIApap"="rForecastM3:3MEONIA"-"rForecastM3:Counter3MEONIApap";
"DrForecastM3:3MEONIApap"="rForecastM3:3MEONIA"-"rForecastM3:Counter3MEONIA2";
"DrForecastM3:12M3Mpap"="rForecastM3:12M3M"-"rForecastM3:Counter12M3Mpap";
}
```

9.4.6 Testing for the invariance of the conditioning variables to the policy variable

```
                                                                  // P&S data
module("PcGive");
package("PcGive", "Single-equation");
usedata("Country_Data_(1979Q4-2011Q2)edite.xls");
system
{
    Y = dlogGDPUSA;
    Z = Constant, dlogGDPUSA_1, dlogGDPEA, dlogGDPEA_1, lSpreadLoverSUK,
        lSpreadLoverSUK_1, SP_EURO, SP_EURO_1, SP_USA, SP_USA_1;
}
estimate("OLS", 1979, 4, 2011, 2, 0, 1);

                                                                  // my data
//////////////////////////////////////// EONIA/MRO
module("PcGive");
package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateUSA;
    Z = GDPGrowthRateUSA_1,
//          SP_USA, SP_USA_1,
            lSpreadEONIAMRO,
            lSpreadEONIAMRO_1, lSpreadEONIAMRO_2, lSpreadEONIAMRO_3, lSpreadEONIAMRO_4, GDPGrowthRateJapan,
        GDPGrowthRateJapan_1, GDPGrowthRateUK, GDPGrowthRateUK_1,
//          lSpreadLoverSUK, lSpreadLoverSUK_1,
//          GDPGrowthRateEA, GDPGrowthRateEA_1,
//      CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateJapan;
    Z = GDPGrowthRateJapan_1,
//          SP_USA, SP_USA_1,
            lSpreadEONIAMRO,
            lSpreadEONIAMRO_1, lSpreadEONIAMRO_2, lSpreadEONIAMRO_3, lSpreadEONIAMRO_4, GDPGrowthRateUSA,
```

```
        GDPGrowthRateUSA_1, GDPGrowthRateUK, GDPGrowthRateUK_1,
//          lSpreadLoverSUK, lSpreadLoverSUK_1,
            GDPGrowthRateEA, GDPGrowthRateEA_1,
//          CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateUK;
    Z = GDPGrowthRateUK_1,
//          SP_USA, SP_USA_1,
            lSpreadEONIAMRO,
            lSpreadEONIAMRO_1, lSpreadEONIAMRO_2, lSpreadEONIAMRO_3, lSpreadEONIAMRO_4, GDPGrowthRateUSA,
        GDPGrowthRateUSA_1, GDPGrowthRateJapan, GDPGrowthRateJapan_1,
//          lSpreadLoverSUK, lSpreadLoverSUK_1,
//          GDPGrowthRateEA, GDPGrowthRateEA_1,
//      CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

// 3M/MRO
package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateUSA;
    Z = GDPGrowthRateUSA_1,
            SP_USA, SP_USA_1,
            lSpread3MMRO,
            lSpread3MMRO_1, lSpread3MMRO_2, lSpread3MMRO_3, lSpread3MMRO_4, GDPGrowthRateUK,
        GDPGrowthRateUK_1, GDPGrowthRateJapan, GDPGrowthRateJapan_1,
//          lSpreadLoverSUK, lSpreadLoverSUK_1,
//          GDPGrowthRateEA, GDPGrowthRateEA_1,
            CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

package("PcGive", "Single-equation");
```

```
system
{
    Y = GDPGrowthRateJapan;
    Z = GDPGrowthRateJapan_1,
//          SP_USA, SP_USA_1,
            lSpread3MMRO,
            lSpread3MMRO_1, lSpread3MMRO_2, lSpread3MMRO_3, lSpread3MMRO_4, GDPGrowthRateUSA,
        GDPGrowthRateUSA_1, GDPGrowthRateUK, GDPGrowthRateUK_1,
//          lSpreadLoverSUK, lSpreadLoverSUK_1,
            GDPGrowthRateEA, GDPGrowthRateEA_1,
//      CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateUK;
    Z = GDPGrowthRateUK_1,
//          SP_USA, SP_USA_1,
            lSpread3MMRO,
            lSpread3MMRO_1, lSpread3MMRO_2, lSpread3MMRO_3, lSpread3MMRO_4, GDPGrowthRateUSA,
        GDPGrowthRateUSA_1, GDPGrowthRateJapan, GDPGrowthRateJapan_1,
            lSpreadLoverSUK, lSpreadLoverSUK_1,
//          GDPGrowthRateEA, GDPGrowthRateEA_1,
//      CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

///////////////////////////////////// 3M/EONIA
package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateUSA;
    Z = GDPGrowthRateUSA_1,
//          SP_USA, SP_USA_1,
            lSpread3MEONIA,
            lSpread3MEONIA_1, lSpread3MEONIA_2, lSpread3MEONIA_3, lSpread3MEONIA_4, GDPGrowthRateUK,
        GDPGrowthRateUK_1, GDPGrowthRateJapan, GDPGrowthRateJapan_1,
//          lSpreadLoverSUK, lSpreadLoverSUK_1,
//          GDPGrowthRateEA, GDPGrowthRateEA_1,
```

```
//      CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateJapan;
    Z = GDPGrowthRateJapan_1,
//          SP_USA, SP_USA_1,
            lSpread3MEONIA,
            lSpread3MEONIA_1, lSpread3MEONIA_2, lSpread3MEONIA_3, lSpread3MEONIA_4, GDPGrowthRateUSA,
        GDPGrowthRateUSA_1, GDPGrowthRateUK, GDPGrowthRateUK_1,
//          lSpreadLoverSUK, lSpreadLoverSUK_1,
            GDPGrowthRateEA, GDPGrowthRateEA_1,
//      CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateUK;
    Z = GDPGrowthRateUK_1,
//          SP_USA, SP_USA_1,
            lSpread3MEONIA,
            lSpread3MEONIA_1, lSpread3MEONIA_2, lSpread3MEONIA_3, lSpread3MEONIA_4, GDPGrowthRateUSA,
        GDPGrowthRateUSA_1, GDPGrowthRateJapan, GDPGrowthRateJapan_1,
            lSpreadLoverSUK, lSpreadLoverSUK_1,
//          GDPGrowthRateEA, GDPGrowthRateEA_1,
//      CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

////////////////////////////////////////////////// 12M/3M
package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateUSA;
```

```
    Z = GDPGrowthRateUSA_1,
            SP_USA, SP_USA_1,
            lSpread12M3M,
            lSpread12M3M_1, lSpread12M3M_2, lSpread12M3M_3, lSpread12M3M_4, GDPGrowthRateUK,
        GDPGrowthRateUK_1, GDPGrowthRateJapan, GDPGrowthRateJapan_1,
//          lSpreadLoverSUK, lSpreadLoverSUK_1,
            GDPGrowthRateEA, GDPGrowthRateEA_1,
      CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateJapan;
    Z = GDPGrowthRateJapan_1,
//          SP_USA, SP_USA_1,
            lSpread12M3M,
            lSpread12M3M_1, lSpread12M3M_2, lSpread12M3M_3, lSpread12M3M_4, GDPGrowthRateUSA,
        GDPGrowthRateUSA_1, GDPGrowthRateUK, GDPGrowthRateUK_1,
//          lSpreadLoverSUK, lSpreadLoverSUK_1,
//          GDPGrowthRateEA, GDPGrowthRateEA_1,
//      CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1);

package("PcGive", "Single-equation");
usedata("Allgiveeditshort.xls");
system
{
    Y = GDPGrowthRateUK;
    Z = GDPGrowthRateUK_1,
//          SP_USA, SP_USA_1,
            lSpread12M3M,
            lSpread12M3M_1, lSpread12M3M_2, lSpread12M3M_3, lSpread12M3M_4, GDPGrowthRateUSA,
        GDPGrowthRateUSA_1, GDPGrowthRateJapan, GDPGrowthRateJapan_1,
//          lSpreadLoverSUK, lSpreadLoverSUK_1,
//          GDPGrowthRateEA, GDPGrowthRateEA_1,
//      CrudeOil_Ft_CushingOK, CrudeOil_Ft_CushingOK_1,
            Constant;
}
estimate("OLS", 1999, 2, 2012, 3, 0, 1
```