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THE MACROECONOMIC EFFECTS OF QUANTITATIVE EASING POLICIES

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Introduction

One of the effects of the global financial crisis that began in 2007/2008 involved the main interest rates that in many advanced economies reached the zero lower bound (ZLB), while the traditional instruments of monetary policy turned out to be no more effective. As a consequence of the freeze of the conventional monetary policy transmission mechanism, and with the aim of safeguard financial stability, price stability and economic growth, central banks around the world began to introduce unconventional monetary policies (UMPs) that were exceptional in magnitude, scope and nature. The main purpose for the use of non-standard monetary instruments was to boost economic recovery, until the time when financial stability as well as price stability could be jointly attained by the traditional and the unconventional macroeconomics tools.

Among these manoeuvres, the most important is Quantitative Easing (QE), well represented by an increase of domestic assets in the balance sheets of central banks. Overall, QE polices were implemented to support economic growth trying to affect the short-term official rates. Moreover, one of the main purposes of QE is to bring inflation and inflation expectations in the direction indicated by central banks, in addition to boosting economic activity and raising the employment rate.

Today, the effects of UMP instruments are the main objects of different studies. However, it is not completely agreed on how non-standard monetary policies affect the economy, given their recent introduction and considering that their framework is a response to concrete developments rather than driven by empirical analysis. Since QE is an exceptional monetary policy instrument, it has not been frequently adopted in the past and, thus, its previous state of knowledge is limited. Therefore, central banks may consider the last evidence after the start of the global crisis and evaluate if the differences in application of these policies involving them can suggest the optimal set-up for the implementation of unconventional instruments in the future.

Then, non-standard policies are more difficult to implement compared to traditional ones, given their exceptional and limited evidence. In addition, results of estimates regarding the effectiveness of unconventional instruments are relatively uncertain, considering the costs associated to their use in comparison to those related to standard policies. Consequently, the responsibility of central banks for the adoption of exceptional policies can be more complex compared to the use of traditional instruments.

The first chapter presents an overview of the existing literature on QE policies. The classification is performed reflecting the overall impact of this instrument, on financial markets or the macro economy, considering also the other different forms of UMPs implemented in the last few years by the four central banks under examination (the Federal Reserve (FED), the Bank of England (BoE), the Bank of Japan (BoJ) and the European Central Bank (ECB)).

Since the present literature is more focused towards the study of the effects of these non-standard measures on financial variables, I therefore decide to link my empirical research to the macroeconomic framework, as it is an innovative, less explored area. Moreover, to the best of my knowledge, the macroeconomic analyses carried out to now have stressed the impact of QE only on real GDP and on inflation; for this reason my purpose is to contribute to literature with an empirical study on the effects of these asset purchases on the potential output growth for the Eurozone and the United States (US) economies.

Given that QE is generally identified as an increase of domestic assets in the balance sheets of central banks, in the second chapter I assess the effect of this policy on the potential (or natural) growth rate of the US and the Eurozone. After producing quarterly and annual estimates of the natural growth rate for these two economic areas using an AS state-space model with time-varying parameters and a Kalman filter methodology, I performed an ordinary least squares (OLS) estimation to detect the impact of QE on the estimated potential output growth rates. The results of this evaluation show a positive impact of QE on potential output growth, demonstrating that a 1% increase in domestic assets corresponds to an effect on natural GDP growth of 0.95% for the US and 0.20% for the Eurozone. Therefore, the results are in line with the positive increment in real GDP detected by findings in literature (even though, as mentioned, is not possible to make a comparison with previous studies on potential growth).

Finally, the third chapter specifically evaluates the macroeconomic effects of QE in the Euro Area. I selected some macro and monetary variables that are in turn influenced through the transmission channels mechanism of the asset acquisitions of the ECB that started in 2015. Regressions are performed through a difference-in-differences (DID) methodology, which considers a policy shift across groups produced by a 'natural occurring event', providing a time series comparison between them. In this analysis the 'treated' group is represented by the Eurozone countries, while the remainder of the European Union (EU) states that are not part of the Euro Area are the 'control' group. The DID methodology is generally used in micro studies; nonetheless, I decide to use it in my empirical analysis to provide an original contribution within literature that quantifies the macroeconomic effects of QE in the Euro Area. This framework is therefore intended to assess what the effectiveness of QE in the Eurozone is, providing a comparison with the other European countries that were not involved in this policy. In this case, the results are also in line with findings in literature, providing a positive increment of CPI inflation in the Eurozone of around 0.33% after the introduction of QE.

Moreover, at the end of *Chapter 3* an *Appendix Section* is proposed that contains a supplemental analysis for the study of the effects of QE in the Eurozone. In this section, the potential output growth of the single 19 Member States of the Euro Area was estimated, using an AS state-space model and a Kalman filter methodology, and then, the impact of QE on that series through an OLS regression (i.e. the same approach as *Chapter 2*) was investigated. Also in this case results suggest an overall positive impact of QE policies on the natural growth rates estimated. For 9 countries (Austria, Belgium, Finland, France, Germany, Italy, Portugal, Slovenia and Spain) the coefficient for *qe* indicates that a 1% increase in net domestic assets correspond to an impact on potential GDP growth of 0.19% on average, a result in line with findings of *Chapter 2*, where QE positively affected the potential output growth of the Eurozone with an impact of 0.20%. Nonetheless, for the remaining countries, the *qe* coefficient has either a negative sign (Cyprus, Estonia, Latvia and Slovakia), or does not reply with a statistically significant effect (Greece, Ireland, Lithuania, Luxemburg, Malta and the Netherlands).

The Effects of Quantitative Easing Policies: a Literature Review

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Chapter 1

Considering the existing literature on Quantitative Easing policies, the first chapter of my thesis is centred on its revision and systematization. My purpose is to schematize the literature according to the effects studied, on financial variables or macro variables, distinguishing the different types of unconventional monetary policies adopted in recent times by the four central banks under consideration (the Federal Reserve, the Bank of England, the Bank of Japan and the European Central Bank).

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1. Introduction

A substantial amount of literature exists on the effects of unconventional monetary policies (UMPs) adopted following the global crisis in the Euro Area, the United States (US), the United Kingdom (UK), and Japan. Generally, empirical literature that regards the central banks' large-scale assets acquisition is primarily focused on its impact on financial markets rather than on public bond markets or an interest rates framework. Nonetheless, in spite of the fact that assessing the general macro impact of non-traditional monetary policy is not an easy task, empirical research is increasingly found in literature on this field. There are also some authors that take into consideration the consequences of theory based models for the efficacy of Quantitative Easing (QE) and other extraordinary monetary policies, looking at the suggestions from growing empirical estimates.

Therefore, the main purpose of this paper is to present a complete framework regarding existing literature on UMPs. With a particular emphasis on QE, a general description of the economic context in this last decade is proposed, along with the economic tools used by the central banks under scrutiny, evaluating at the same time the transmission channels through which QE is supposed to work.

The remainder of the paper is organized as follows. *Section 2* provides a brief presentation of the economic context in which QE moves, such as its monetary policy transmission channels mechanism; *Section 3* focuses on literature regarding the theoretical rationale for asset purchases and on the evidence from surveys of empirical studies; *Section 4* concerns the UMPs and the QE effects on financial markets, covered bond markets and interest rates; *Section 5* continues with an overview of the macroeconomic effects of UMPs and QE policies; finally, *Section 6* concludes with

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two synoptic tables in which the main outcomes from literature studies are resumed, and with the identification of the missing points that clarify where the contribution of my work lies.

2. The economic context

After the global financial crisis of 2007/08, the collapse of international trade, the dramatic decline in short-term loans and the freeze in interbank markets showed rapidly that significant consequences would also be suffered by the broad economy. When the main interest rates in many countries reached the zero lower bound (ZLB), the traditional instruments of monetary policy started to be ineffective.

At first, however, the theory forming the empirical basis of traditional monetary policy seemed to be as robust as its application. One of the main purposes of monetary policy is to reach a small, stable level of inflation, while inflation targeting is the policy framework. Central banks usually manage monetary policy by affecting short-term nominal interest rates, which possibly may impact the economy throughout the transmission channels, so that the influence of these main rates on market rates and the macroeconomy is easily measurable. Given that inflation expectations cannot react as soon as modifications are made to the nominal interest rates, central banks can additionally regulate real interest rates, at least over the short to medium term. Then, to impact economic choices through their influence on asset prices, monetary policies usually modify real (inflation-adjusted) short-term rates. Considering that traditional monetary policy attains low, steady inflation, it cannot avoid the formation of securities market bubbles.

For these reasons, in the global context of the past years, traditional monetary policy stops working because the usual official rate did not operate on the market rates as was expected, and the conventional monetary transmission mechanism was not effective, due to the problems with financial intermediation.

To ensure financial stability, price stability and economic growth, central banks started to use UMPs. The reason why they turned to extraordinary monetary instruments was to support economic recovery, until the moment when traditional and non-traditional monetary policy tools could reach financial and price stability by working together. Several different UMP instruments exist; the most common procedure includes massive expansion of central bank balance sheets, trying to affect the usual short-term official rates.

Overall, the high-profile form has been the so-called Quantitative Easing. This instrument, through different monetary policy transmission channels (see detailed description in the following paragraph), may have an impact on economic behaviour. Usually, it is classified as a non-standard monetary policy programme that is intended to raise the monetary base using huge open market operations, such as large-scale asset acquisitions. "The term 'quantitative easing' nowadays has become almost synonymous with 'domestic' balance sheet policies in general, i.e. with those that exclude foreign exchange intervention, not least large-scale asset purchases. Instead, the term 'credit easing' is typically restricted to those domestic balance sheet policies that target the asset side of the balance sheet and ignore what happens on the liability side" (Borio and Zabai 2016).

It was applied for the first time in Japan as a consequence to the 1990s' crisis that involved a real estate market bubble and the risk of deflation. As mentioned before, traditional monetary policy is used to impact the main interest rates through open market procedures. Indeed, purchasing or selling assets in the banking system has an impact on the amount of bank reserves. During non-

crisis periods, these variations in the level of reserves are not a scope of monetary policy itself. On the contrary, they are useful for obtaining favoured alterations in interest rates. Therefore, the notion 'Quantitative Easing' began to denote changes concerning targeting quantity variables. When the interest rates reached their ZLB, the Bank of Japan (BoJ) began to buy public assets from the banking sector and thus started to alter the size of bank cash reserves in the system. The scope was to raise the magnitude of reserves sufficiently, facilitating upward movement of securities prices to remove the risk of deflation.

In *Table1* a taxonomy of both the conventional and UMP implementation measures described above is presented; as mentioned, the two main ways are the interest rate policy and the balance sheet policy.

Table 1. **Monetary Policy implementation measures**

Policy	Description
Conventional	
Interest rate policy	Setting the policy rate and influencing expectations about its future path
Forward guidance on interest rates	Communication about the future policy rate path
Negative interest rates	Setting the policy rate below zero
Unconventional	
Balance sheet policies	Adjusting the size/composition of the central bank balance sheet and influencing expectations about its future path to influence financial conditions beyond the policy rate
Exchange rate policy	Interventions in the foreign exchange market
Quantitative easing policy	Operations that target the market for public sector debt buying longer term government bonds from banks
Credit policy	Operations that target private debt and securities markets (including banks); (e.g. modifying the discount window facility/adjusting the maturity/collateral/counterparties for central bank operations/purchasing commercial paper, ABS and corporate bonds)
Indirect quantitative/credit easing	Increase the size of the balance sheet by lending to banks at longer maturities, against collateral which includes assets whose markets are temporarily impaired (e.g. fixed-rate full-allotment procedure)
Bank reserves policy	Operations that target bank reserves (e.g. money market operations)
Forward guidance on the balance sheet	Communication about the future balance sheet path (composition/size)

Source: Author; Reference: Borio and Zabai (2016).

Recently, the Federal Reserve (FED), the European Central Bank (ECB) and the Bank of England (BoE), have all imitated the BoJ by putting in place manoeuvres intended to raise their balance sheets. Even though the final targets of monetary policy were basically the same, there were substantial dissimilarities in the approaches followed by the four central banks.

While the first policies of the US and UK central banks were directed completely on securities purchases (first-round QE programmes), the central banks of the Eurozone and Japan in the first phase focused their plans on direct lending to banks. This divergence was driven by the circumstance that the UK and US are prevalently bond markets, whereas in Japan and the Eurozone the prime financing source is bank lending. Therefore, the operations adopted by the ECB diverged

from the central bank purchases adopted by the FED and BoE, because they responded to different situations.

In 2011-2012, pressures in the Euro Area led to a persistent and substantial outflow of euro deposits from peripheral states. This condition brought a bigger imbalance in the Euro Area's banking sector, given the appearance of a particular form of contemporary bank run in many countries. Differently, the FED and the BoE asset purchase operations were planned to affect the yields on a broad range of assets, in particular on bonds issued to finance lending to households and firms, but not to solve a liquidity problem of the banking system.

In *Table 2* the main stages of the UMPs implemented by the four central banks under examination in the wake of the global financial crisis are reported.

Table 2. **Unconventional monetary policies: a timeline**

Date	Programme	Description
European Central Bank		
First Phase		"In the first phase of the financial crisis, the primary aim of the ECB's non-standard measures was to provide liquidity to banks and to keep financial markets functioning".
Autumn 2008	Fixed-rate full allotment	"As the interbank market dried up, and banks could no longer rely on borrowing from each other, the ECB provided unlimited credit to banks at a fixed interest rate".
		"The range of eligible assets that could be used as collateral in refinancing operations was expanded".
July 2009	CBPP1	The ECB launched its first covered bond purchase programme (acquisition of a "broad portfolio of euro-denominated covered bonds").
Second phase		"This phase took the form of a sovereign debt crisis and the ECB's non-standard measures were aimed to address markets' malfunctioning and to reduce differences in financing conditions faced by businesses and households in different euro area countries".
May 2010	SMP	The Eurosystem started purchasing assets in the "private and public debt securities markets".
November 2011	CBPP2	The ECB launched its second covered bond purchase programme.
September 2012	OMT	Countries of the ESM "will be eligible to have their debt purchased in unlimited amounts on the secondary market by the ECB".
July 2013	Forward guidance	The ECB starts to "communicate how expects its policy measures to evolve in the future and what conditions would warrant a change in the policy stance".
Third phase		"In the third phase of the crisis the ECB's non-standard measures addressed the onset of a credit crunch and the risk of deflation. With short-term interest rates already close to zero, the ECB's non-standard measures were intended to influence the whole constellation of interest rates that are relevant for financing conditions in the euro area".

June 2014	$TLTRO_s1$	The ECB announced its first "targeted longer-term refinancing operations (TLTROs) programme; these are Eurosystem operations that provide financing to credit institutions for periods of up to four years".
	Negative interest rate	Negative interest rate on the deposit facility
October 2014	APP/CBPP3	The ECB launched its third covered bond purchase programme.
November 2014	APP/ABSPP	The ECB announced its intention to purchase a "broad portfolio of simple and transparent ABS with underlying assets consisting of claims against the euro area non-financial private sector".
March 2015	APP/PSPP (QE)	The ECB started purchasing "bonds issued by euro area central governments, agencies and European institutions".
March 2016	$TLTRO_s2$	The ECB launched its second targeted longer-term refinancing operations programme.
June 2016	APP/CSPP	The ECB started to purchase corporate sector bonds.
Federal Reserve		
November 2008	QE1	"LSAPs announced: the Fed will purchase $100 billion in GSE debt and $500 billion in MBS".
March 2009	QE1	"LSAPs expanded: the Fed will purchase $300 billion in long-term Treasuries and an additional $750 and $100 billion in MBS and GSE debt, respectively".
	Open-ended guidance	"Fed expects low rates for an extended period".
March 2010	QE2	"QE2 announced: the Fed will purchase $600 billion in Treasuries".
August 2011	Calendar-based guidance	"The Fed expects low rates at least through mid-2013".
September 2011	MEP	"The Fed will buy $400 billion of Treasuries with remaining maturities of 6 to 30 years and sell an equal amount with remaining maturities of 3 years or less".
January 2012	Calendar-based guidance extended to 2014	"The Fed expects low rates at least through late 2014".
September 2012	QE3	"QE3 announced: the Fed will purchase $40 billion of MBS per month as long as the outlook for the labour market does not improve substantially… in the context of price stability".
	Calendar-based guidance extended to mid-2015	"The Fed expects low rates at least through mid-2015".
December 2012	Switch to state-contingent guidance	"The Fed expects low rates to be appropriate while unemployment is above 6.5% and inflation is forecasted below 2.5%".
Mid-2014	End QE3	
Bank of England		
January 2009	APF	"APF established: the BoE will purchase up to £50 billion "high quality private sector assets" financed by Treasury

		issuance".
March 2009	APF/QE1	"QE1 announced: the BoE will purchase up to £75 billion in assets, now financed by reserve issuance; medium- and long-term gilts will comprise the "majority" of new purchases".
October 2011	APF/QE2	"QE2 announced: the BoE will purchase up to £275 billion in assets financed by reserve issuance; the ceiling on private assets held remains at £50 billion".
July 2012	APF/QE3	"QE3 announced: the BoE will purchase up to £375 billion in assets".
August 2013	State-contingent guidance	"The BoE "expects not to raise the Bank Rate from 0.5% at least until unemployment falls below 7%".
February 2014	State-contingent guidance	"The BoE states that "despite the sharp fall in unemployment there remains scope to absorb spare capacity further before raising the Bank Rate" and that the path of the Bank Rate over the next few years will, however, depend on economic developments".
August 2016	QE4	QE4 announced: the BoE will purchase up to £435 billion in assets.
Bank of Japan		
October 2010	CME	"APP established: the BoJ will purchase ¥5 trillion in assets (¥3.5 trillion in JGBs and Treasury discount bills, ¥1 trillion in commercial paper and corporate bonds, and ¥0.5 trillion in ETFs and J-REITs)".
	State-contingent guidance	"The BoJ declares that it will maintain the virtually zero interest rate policy until it judges […] that price stability is in sight".
February 2012	State-contingent guidance	"The BoJ declares that it will conduct its virtually zero interest rate policy and asset purchases until it judges that the 1% goal [y-o-y CPI inflation] is in sight on the condition that the Bank does not identify any significant risk".
January 2013	State-contingent guidance	"The BoJ declares that it will follow a virtually zero interest rate policy aimed at achieving a 2% target for as long as [it] judges it appropriate to continue".
April 2013	QQE	"QQE announced: the BoJ will double the monetary base and the amounts outstanding of JGBs as well as ETFs in two years, and more than double the average remaining maturity of JGB purchases".

Notes:
QE: Quantitative Easing
LSAP: Large-Scale Asset Purchase
MBS: Mortgage-Backed Securities;
MEP: Maturity Extension Program;
SMP: Securities Markets Programme;
OMT: Outright Monetary Transactions;
APP: Asset Purchase Programme;
ABSPP: Asset-Backed Securities Purchase Programme;
ABS : Asset-Backed Securities
CBPP: Covered Bond Purchase Programme
PSPP: Public Sector Purchase Programme
APF: Asset Purchase Facility
CME: Comprehensive Monetary Easing
JGB: Japanese government bond
ETFs: exchange-traded funds
J-REITs: Japanese real estate investment trusts
QQE: Quantitative and Qualitative Easing
TLTRO: Targeted Long-Term Refinancing Operation

Source: Author; References: Borio and Zabai (2016) and www.ecb.europa.eu.

Understandably, the effectiveness of non-standard monetary policies nowadays employs different analyses. Nonetheless, there is still not a definite agreed-upon structure on how UMP affects the

economy. This is due to the fact that it was mainly a reaction to practical developments, rather than motivated by literature studies.
Traditional monetary policy was founded to look after the short-term main rates affecting the economy. Understanding that kind of transmission mechanism signifies that the level of interest rates could be decided with a knowledge of how interest rates move. On the contrary, such empirical evidence has not presented for UMP yet.
The main scope of QE is to drive inflation and inflation expectations in the same direction as central banks targets, raise employment and stimulate economic activity. Thus, QE instruments are constructed to positively stimulate the economy by devaluating the currency and reducing interest rates.
Considering the fact that it is an unconventional instrument, it has not been frequently used, and previous evidence is scant. Thus, central banks have to take into account the last few years' indications since the brunt of the crisis and analyse if the divergences in implementation across them may lead to suggestions about the best set-up of non-traditional monetary policy.
It has to be recognized also that non-standard policies are much more problematic to put in place, given the limited state of knowledge. Estimates of the impact of non-conventional instruments on economic growth and inflation are unsure, given the costs related to their application respect to those associated to traditional policies.
Therefore, responsibility for the implementation of UMPs can be more complex than for the use of traditional instruments. Nonetheless, nowadays, non-standard policies support monetary policy when it cannot achieve itself what a different range of economic instruments might obtain; particularly, it cannot offset by itself the financial and fiscal turmoil that economies face.

2.1 Transmission Channels of QE: Theoretical Rationale for Central Bank Asset Purchases

This section presents the economic framework that underlies a central bank's decisions to put large-scale asset purchases in place. Looking at the theoretical suggestions, generally, this kind of unconventional programme follows the same principles, independently from the economy in which it is performed. The primary scope usually involves the injection of large amounts of money throughout the economy, according to whether the idea is to restore expenditure or to revive particular market sectors. Usually, classifications report four main channels that work for the transmission of an asset purchase policy to the broad economy.

1. Announcement (or Signalling) Channel. The first channel works through the so-called 'announcement effect', in which market participants expectations are affected. When the central bank reveals the path of its future programmes, the signal provides an indication about its purpose of restoring confidence in the markets. Generally, the central bank announces its commitment toward future low and stable interest rates to investors. Lower interest rates mean that market agents seek better yields on public bonds that, in turn, may be devalued by the domestic currency or may be encouraged by exports. The unconventional measures and the QE programme, in particular, applied by the BoJ in 2001, by the FED and the BoE since 2008, and by the ECB from 2015, were all preceded by the announcement of their implementation.

Eggertson and Woodford (2003) suggest, for example, that asset purchases may only have an effect via a signalling channel and affecting markets agents expectations. On the other hand, Joyce et al. (2011) detect that these asset acquisitions can also impact asset prices in incomplete financial market frameworks with imperfect asset substitutability.

2. Portfolio Rebalance Channel. This effect works during the effective period in which acquisitions are made, such as through expectations on the signal of a purchase programme. Tobin (1969) describes this channel as the 'portfolio balance effect', referring to the fact that the central bank' acquisition of assets generates a rise in asset prices as well as a downward pressure on the supply of those assets. Consequently, given that purchases are substituted with riskless short-term reserves, the risk premium on these assets is definitely reduced and the yields start to fall-off.
Therefore, by acquiring a huge amount of assets held by investors through QE, the central bank induces a modification in the supply of the assets being acquired, such as an adjustment in their yields. Given that the assets bought under QE do not present perfect substitutability, sellers are encouraged to rebalance their portfolios by purchasing riskier assets that show similarities to the assets sold. That process brings an upward pressure on the price of the assets acquired with QE, consequently pushing down related yields and term premiums. As a result, expenditure will be encouraged by wealth increase and cheaper loans. Finally, these two effects (increased wealth and reduced borrowing costs) induced by QE, are estimated to improve private nominal spending, such as boosting economic growth and lowering the unemployment rate.

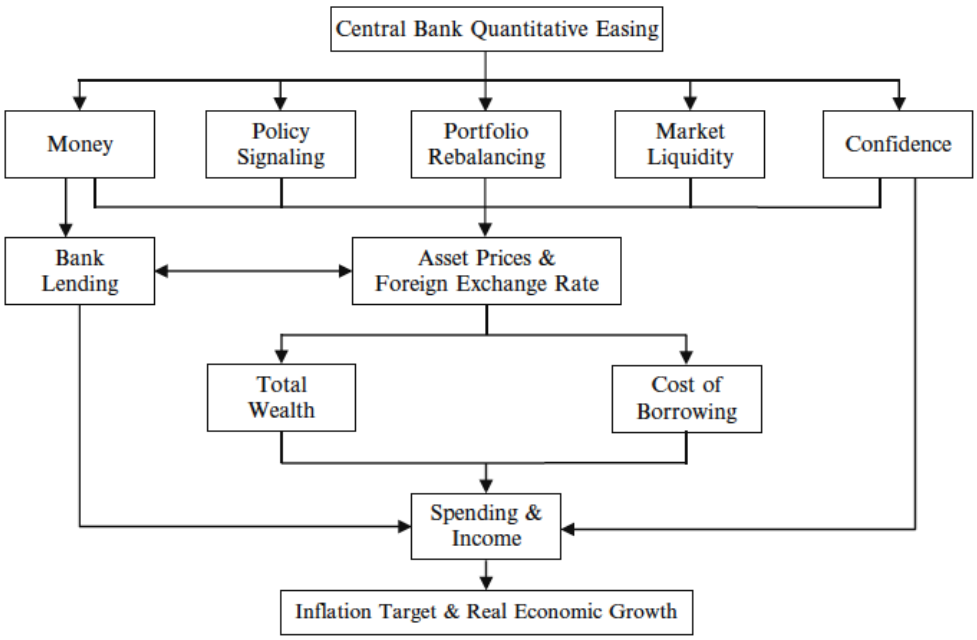
3. Liquidity Premium Channel. This effect appears when central bank assets acquisition rebuilds market liquidity by encouraging two-way market flows; so, it indicates a tightening impact on liquidity premium induced by central bank purchases. Therefore, the investor's liquidity is increased by the central bank acquisition of long-term assets, as well as by the bigger amount of bank reserves issued under QE.
Joyce et al. (2011 a, b) highlight that an improved liquidity and a better market performance, consequent to that securities purchase, will induce a downward pressure on premium for illiquidity, thus raising asset prices. On the other hand, Krishnamurthy and Vissing-Jorgensen (2011) state that an increase in liquidity decreases the price premium on public bonds, compared to different less liquid securities and, thus, raises the yields on these bonds. Nonetheless, the impact of QE within the liquidity premium channel may be visible only during the central banks securities purchases. Moreover, Joyce et al. (2010) stress that the 'portfolio balance channel' on yields is highly persistent as it is conditional over agents' expectations on the amount of assets. On the contrary, the 'liquidity premium channel' is more temporary, given that it is determined by the flow of acquisitions.

4. Real Economy Channel. Thanks to this effect, the returns of a central bank purchase are injected into the broad economy, but the way and the direction differ depending on the type of asset acquired and on the counterpart of the transaction. For example, when the central bank purchases assets from commercial banks, extra monetary flows are provided for them, which, in principle, should be used to finance more loans. Therefore, QE can also have an effect on GDP growth and inflation via the 'bank-lending channel'. Nonetheless, this effect is estimated to have a limited impact considering the tensions in the financial sector after the global crisis.

However, QE may also have a broader 'confidence impact' through improving the general economic outlook. Indeed, the revealed 'confidence' may directly encourage spending and investments, such as increase asset prices thanks to the reduction of risk premiums. The overall effect of the central bank assets acquisition programmes via those channels generally pushes an optimistic market confidence in the assets being purchased. Nevertheless, an open question is whether the securities purchases work more via flows (i.e. the amounts acquired over a determined point in time) or stocks (the amounts held by the central bank at a given period).

Figure 1 summarises the different channels through which this unconventional policy action may give a boost to investments, spending and economic growth.

Figure 1. **Quantitative Easing Transmission Channels**



Source: K. Hausken and M. Ncube, (2013).

3. Evidence from Theory and Surveys of Empirical Studies

This section includes some papers that report and summarize the main findings about the effects of UMPs and QE through a review of other empirical studies. Moreover, some references regarding the theoretical basis for the asset purchases are also reported here.

The theoretical foundations for expectations about variations in securities amounts to impact returns are studied by Vayanos and Vila (2009), which improved a stakeholder's preferred-habitat pattern. However, QE has no larger economic outcomes in most conventional New Keynesian models, except in the case where it modifies investor beliefs regarding the upcoming conduct of interest rates throughout the signalling channel. Eggertsson and Woodford (2003) evaluate that investment balance effects do not exist in those simulations. Given that the riskiness in agent portfolio

decreases after central bank securities purchases, is compensated by a parallel intensification in the risk of governments portfolios (caused by the fundamental insecurity of expectations on taxes and expenditure), QE acquisitions become ineffective within this network. Nonetheless, the models that incorporate the application of non-standard monetary policy into theoretic macro frameworks are gradually developing.

In a later study, Curdia and Woodford (2011) assess that there may be a function for credit conditions, that includes varying the structure of securities of the balance sheet of a central bank, except for QE, that remains unsuccessful at the ZLB. However, if the imperfect securities substitutability is merged with financial disorders and dysfunctional markets, altering also the maturity of assets yields, this could have an effect on securities prices. A solution could be the linkage of Tobin's rule of imperfect securities substitutability with ordinary New Keynesian frameworks.

For example, Andres, Lopez-Salido and Nelson (2004) and Harrison (2012) improve micro fundamentals for "preferred-habitats" and portfolio balance outcomes, which sustain the function of QE inside a dynamic stochastic general equilibrium (DSGE) model. Generally, to describe the macroeconomic impact of QE and other non-conventional monetary instruments, the (modified) DSGE model has to take into account the tensions that create interest rate spreads such as the relationship concerning interest rate spreads with the macroeconomy. An outline approaching similar topics in this developing literature can be found in Christiano (2011).

Considering the review context, Anderson et al. (2010) evaluate a sizeable cross section of central banks that have expanded their monetary base, but their analysis considers only the first stage of the recent unconventional programmes. The examination is constructed over data and surveys derived from central banks databases. The authors study the involvement of selected central banks that have applied large-scale balance-sheet increases as a monetary policy measure. The case studies centre on central banks reacting to the financial turmoil and Nordic central banks following the banking crises of the 1990s; the remainder are specified for comparison scopes.

In conclusion these authors explain that large-scale balance-sheet expansions are a useful monetary policy instrument, if the public realises that the expansion is temporary and if the central bank has particular authority regarding a low and stable inflation rate. For the conduction of monetary policy, this analysis indicates numerous outcomes. For example, a huge expansion in a bank's balance sheet over a brief period can boost the economy. However, motivations for the conduct have to be communicated. Inflation expectations do not change if individuals and enterprises comprehend the causes for policy programs so long as the central bank can reliably commit to relaxing the increase when requested. Furthermore, the nature of assets acquired is not so important as the balance-sheet increase itself. And conclusively, when the recession has ended, the balance sheet has to be reduced quickly.

Among the surveys of empirical researches, one of the most complete studies is that proposed by Joyce et al. (2012), which consider the effects of securities acquisitions describing the empirical literature that studied the impact of these purchases on financial markets, such as on the macro variables. The literature reported in this article is in agreement that non-conventional monetary policies work, asset market acquisitions advantage smaller returns that together with longer-term interest rates positively affect economic recovery. Nonetheless, unsurprisingly, there is insecurity regarding the magnitude and duration of the impact and the particular channel through which QE acts. Even though securities purchases have been successful in terms of supporting the economy,

recovery appears quite unsafe. Thus, the implementation of QE does not completely remedy the difficulty of a slow recovery following an economic turmoil, while it tries to improve it somewhat. This increases the prospect of raising the amount of QE, so that it may afford a wider impact on the real economy. The policy suggestion here concerns central banks governors and economic supervisors that have to expand both the micro and macro programmes, so that in prospect the partial but effective value of non-standard policies does not have to be applied again.

On the other hand, it seems clear for Bernanke (2012), who presents a commentary about the FED involvement with UMPs, that these instruments can be successful, and that, without them, the 2007-2009 crisis would have been even worse and the consequent recovery slower than it actually was. Nonetheless, the author states that extraordinary manoeuvres are quite more problematic to implement compared to traditional ones, because of a lower level of experience. Estimates of the efficacy of non-standard instruments on economic growth and inflation are uncertain, and the use of unconventional instruments involves additional costs beyond those generally associated with standard monetary policy.

Regarding the efficacy of QE in the US, Bluford (2013) focuses on balance sheet activities employed by the FED, taking evidence from systematic reviews of empirical studies. The author separates the initial round of Quantitative Easing (QE1) in late 2008, from other rounds of balance sheet activity to purchase more US Treasury securities or mortgage-backed securities (QE2 and QE3) and to adopt the maturity extension program (i.e., Operation Twist). With regard to some issues presented in the article, in a few cases he also considers ECB activities that are relevant to the discussion.

First of all, Bluford (2013) presents a broad set of theoretical ideas to guide his evaluation of QE and to find the circumstances under which it is likely to achieve the desired economic and financial market results. Therefore, the author links these theoretical ideas with the actual QE has occurred, outlining some conclusions about when it is most appropriate to use QE and, in addition, to evaluate whether future QE policies are likely to achieve their purposes. The conclusions from theoretical considerations and interpretations of FED and ECB actions from 2008 through mid-2012 yield some significant issues. Primarily, QE1 was effective. Central bank purchases of securities held by a weakened or failing banking system may be more effective in encouraging a more rapid return to economic growth than other forms of QE such as outright loans to the banking system. Furthermore, QE impacts rates. QE in the form of purchases of securities with long-term maturities can have a significant effect in terms of lowering long-term interest rates. The opposite effect on rates will occur, however, if and when central banks disentangle their expanded portfolios and return to normal monetary policies.

Despite the development of research on securities acquisition programs, there have been few studies that explain and compare QE policies across central banks. Fawley and Neely (2013) fill that gap by reporting and making a comparison of QE and associated maturity extension plans of the BoJ, the BoE, the FED, and the ECB, referring to a methodical review of empirical studies. The authors highlight, however, that although they report partial results about the direct impact of the manoeuvres on financial markets, they do not assess the effects of the QE policies on the real economy, as that would involve counterfactual framework and empirical analysis well beyond the purpose of the research. The authors report that the QE policies of these four central banks, primarily embraced to moderate financial market disorder, were directed also for other scopes, like achieving inflation targets, stimulating the broad economy, and reducing the European sovereign debt crisis. The FED and the BoE, that manoeuvre in prevalent bond markets, operate with high

amounts of bond acquisitions; on the contrary, the ECB and the BoJ, that move in bank-centric systems, respond mainly through loans to the banking sector. A stable homogeneity among the monetary expansion instruments of all four central banks is that, although all policies led to rises in the monetary base, none drive to expansions in broader monetary aggregates. When the broader aggregates did not rise, they caused banks decision to hold the increased monetary base as bank safe-reserves, given the period of economic instability.

Finally, Gern et al. (2015) report a broad critique of the empirical studies based on the effects of UMPs. According to the authors, the primary task is to isolate empirically the QE-induced consequences from other sources of variations in interest rates. The applied empirical researches in this field mainly use the approaches of the announcement effect and model-based estimations, and almost all studies find that QE will reduce long-term interest rates. Nonetheless, the significance of this reduction broadly differs across studies, so there is a great degree of uncertainty in the outcomes. Moreover, the macro impact of QE is more challenging to examine than the outcomes on interest rates, given the uncertainty of transmission lags, making it problematic to isolate the specific effect of QE from other policies. The conclusion of the authors indicates that the first-stage QE measures implemented in the US and the UK were successful in restoring solidity in the financial markets and in reducing uncertainty and financial turmoil. On the other hand, it is dubious that round two of the QE program had a sizable stimulating impact, as monetary policy is generally less effective following a balance sheet recession.

For a generic discussion about QE and fiscal transfers in the Eurozone see also the study of De Grawe and Ji (2015). Furthermore, Claeys et al. (2015) explain all the ECB QE steps in detail.

4. Effects on Financial Markets, Covered Bond Markets and Interest Rates

Empirical studies on the effects of non-standard monetary policies and QE on the financial sector are growing quickly and are definitely the area of major concern.

4.1 Eurozone

Regarding the Euro Area, the influence of the ECB's exceptional liquidity measures on interbank lending was studied via regression analysis by Abbassi and Linzert (2011), Angelini et al. (2011), Brunetti et al. (2011) and Szczerbowicz (2015). The latter author complemented the previous papers by showing that only stronger liquidity measures (three-year LTROs and 0% deposit rate at the ECB) significantly reduced interbank distress.

Abassi and Linzert (2011) analysed the efficacy of monetary policy in influencing Eurozone main interest rates by exploiting two procedures: firstly, the forecasts of interest rates following the base of monetary policy expectations, secondly, the effect of exceptional central bank manoeuvres on those interest rates. Therefore, the authors examined if money rate expectations are sufficiently replicated in the outline of the money market return curve. Considering that the Eurozone monetary system has a bank-centred configuration, this linkage is important as money rates, and primarily the non-secured interest rate 'Euribor', regulate short-term bank credit conditions and deposit rates, which in turn have an impact on bank loans for individuals and companies.

They then analysed the magnitude to which the ECB's UMPs succeeded in decreasing interest rates. With this scope, they concentrated on the intra-day variations of the 3-month, 6-month and 12-month Euribor, between March 2004 and June 2009.
Their findings suggest that the ECB expansion in extraordinary open market procedures, as in October 2008, caused a decline in Euribor rates of 100 basis points (bps). These outcomes demonstrate that central banks have successful tools to manage monetary policy during periods of crisis. Concerning the phase preceding August 2007, the authors discovered that Euribor rates for up to 12 months were considerably aligned with financial beliefs. Following these findings, an anticipated main rate alteration of 25 bps leads to an increment in the 3, 6 and 12 months Euribor of 17,19 and 23 bps, respectively.

Concerning covered bond markets, Beirne et al. (2011) valued the effectiveness of the first Covered Bond Purchasing Program (CBPP1) by an event study and regression analysis, discovering its success in diminishing covered bond spreads. During the implementation period of the CBPP1, from July 2009 to the end of June 2010, the Euro System made direct acquisitions of covered bonds for the nominal charge of €60 billion. The purpose of the research was a factual evaluation of the effect of the CBPP1 on the primary market, particularly looking for an effect regarding the exceptional size of bonds delivered by banks; therefore, the influence of the CBPP1 through the secondary market was empirically studied, as the investigation looked for the impact of the Sovereign Debt Crisis. The response of the majority of the European 'covered bond markets' after the introduction of the CBPP1 is evident and seems to have started a decreasing movement in covered bond spreads. Conclusively, the analysis conducted on the impact of the CBPP1 on the main and subordinate bond markets indicates that the UMP was a successful monetary policy method. Primarily, it has determined a decline in primary market term rates and a facilitation of credit easing for individuals and firms, encouraging financial intermediaries to preserve and increase their loans to consumers. Secondarily, in central sectors of the 'private debt securities market' it boosted cash fluidity. As a whole, the analysis demonstrates that the CBPP1 exerted a diminishing impact on the Euro Area covered bond returns of around twelve bps. Except for this, the authors did not detect that the acquisitions made by the Euro Area had any relevant effect on prices.

Szczerbowicz (2015) demonstrated this impact for the CBPP1 and additionally for the successive Covered Bond Purchasing Programme (CBPP2). There are also several studies that measure the impact of the first Sovereign-Bond Purchasing Program (SMP) on sovereign bond markets; Eser and Schwaab (2013), Ghysels et al. (2013), and Pattipeilohy et al. (2013) discovered analogous outcomes. In these papers, the SMP proclamation diminished the spreads for the Eurozone members of the periphery considerably.
In addition, De Pooter et al. (2012), Eser and Schwaab (2013), and Ghysels et al. (2013) demonstrated that the effective SMP manoeuvres were additionally successful in dropping sovereign spreads. Szczerbowicz (2015) increments these analyses offering innovations regarding the Second Sovereign Bond Purchase Program (OMT), which was operative in diminishing sovereign market distress in some Euro Area countries.

4.2 United States

For the US, researchers have already carried out considerable studies on UMPs and QE policies. Stroebel and Taylor (2009), Meyer and Bomfim (2010), and Gagnon et al. (2011a,b), for example,

analysed the FED's 2008/2009 QE manoeuvres, while Kohn (2009) offered a summary regarding these programmes.

Gagnon et al. (2011a, b) proposed a study of the first round of Large Scale Asset Purchases guided by the FED following the financial turmoil (usually denoted as LSAP1). Thanks to the utilization of event analysis of the LSAP1 proclamation, the authors indicated that a reduction in returns on Mortgage-Backed Securities (MBS) of around 110 bps and in Treasury yields of 90 bps occurred. They specify how the reduction in longer-term interest rates mostly revealed a decrease in risk premia, produced by those acquisitions, primarily thanks to the decrease of duration risk. The authors also suggest a framework that involves a time series estimation of securities amounts evaluated looking at the before-crisis data, to detect the effect of the LSAPs that indicates a marginally reduced effect.

Implementing a diverse model constructed on panel data investigation, D'Amico and King (2010) discovered that LSAP1 had an effect on long-term Treasury returns of around 30 bps for the five-year to fifteen-year area. Krishnamurthy and Vissing-Jorgensen (2011) assessed LSAP1 and also the subsequent phase of FED acquisitions (LSAP2) using a factual analysis methodology. They detected a huge collapse in interest rates during the prime period, but not during the following one, and indicate many different channels through which QE can operate. Swanson (2011) restudies the Operation Twist implemented in the 1960s applying a factual analysis methodology, discovering that it was approximately similar in volumes to LSAP2. He found that both programmes reduced long-term Treasury returns by about fifteen bps. Hamilton and Wu (2012) indirectly evaluated the effects of the FED's 2008/2009 QE programs with a term structure model.

Szczerbowicz (2011) calculated the impact of unconventional and conventional monetary policies on the Libor-OIS spread, long-term interest rates and long-term inflation expectations. To this purpose, she investigated the behaviour of selected asset yields on the days of monetary policy announcements. The author's results show that QE1 and QE2 had different effects: QE1 reduced long-term interest rates without raising inflation expectations, whereas QE2 raised inflation expectations and did not lower long-term interest rates. In this paper, also the impact of fiscal policy announcements was considered, finding that government bailouts reduced the three-month Libor-OIS spread, while the fiscal stimulus announcements raised long-term inflation expectations. See in this field also Taylor and Williams (2009).

Additionally, Wright (2012) presented an analysis on the persistence of the impact of securities acquisitions. In this study, the author tried to determine the effectiveness of US monetary policy on money markets in the wake of the crisis, implementing a Structural Vector Autoregression (VAR). The key outcome from this evaluation is that even if extraordinary monetary policy has substantial outcomes on money variables over Treasury returns, this impact ends very rapidly, with a limited time of a few months.

Finally, Neely (2012) assessed the effectiveness of the FED's 2008/2009 QE on international long-term bond yields and exchange rates, displaying that the effect is coherent with long-run purchasing power parity and a simple portfolio balance model. The author discovered that the FED LSAPs declaration had considerable effect on worldwide longer-term rates, such as on the significance of the dollar.

4.3 United Kingdom

Similarly, the UK's experience with QE following the global crisis was analysed in different studies. Meier (2009), Dale (2010), Joyce et al (2011) and Bean et al. (2010), for example, examined the operative aspects of large-scale asset purchases implemented by the BoE and evaluated several characteristics of the effects of the non-standard monetary instruments. Meier (2009) and Joyce et al. (2011) discovered that the first phase of the BoE's asset acquisitions had an economically substantial impact on gilt yields.

Meier (2009), implementing an event study methodology, assessed the effect of QE announcements and specified that long-term government bond yields dropped between 40 and 100 bps, after the first announcement of the programme by the BoE in March 2009.

Instead, Joyce et al (2011) offered a broader evaluation adopting factual analysis and 'portfolio balance models'. In this evaluation, the authors supposed that government bonds and money are 'imperfect substitutable assets', and a multiplier detects the effect of changes in the volume of gilts on extra securities yields in a multivariate portfolio. The authors indicate that QE reduced longer-term government bond returns by around 100 bps and that portfolio balance effects produced the greater part of the drop. They discovered that the BoE's QE programme had bond yield impact quantitatively comparable to that described by Gagnon et al. (2011a, b) for the US case.

The majority of these empirical analyses on central bank asset acquisitions detected that these purchases had primarily affected securities returns and different bond prices since they decrease term or risk premium via 'portfolio balance effects'. In this area, Christensen and Rudebisch (2012) determined that the FED's LSAPSs mostly operated within the 'signalling channel', even if their outcomes specify that the 'portfolio balance channel' has been more significant in describing the reduction in UK returns following the introduction of QE.

Finally, among the empirical literature on the effects of QE, only a few studies investigated the role of exchange rates; see for this topic, for instance, C.N. Neely (2015) and Schenkelberg and Watzka (2013). The conclusions of those authors show that the first-round QE programmes applied in the US and the UK were successful in rebuilding reliance in the financial markets and in decreasing uncertainty and financial distresses. On the contrary, it is probable that the second-round QE programmes did not have large stimulating effects, since monetary policy normally is less effective in the aftermath of balance sheet recessions.

4.4 Japan

Finally in Japan, the effectiveness of UMP is controversial. Ueda (2012) reviewed the UMP instruments implemented by the BoJ since the beginning of the global financial crisis. In this study, the impact of the forward direction of future policy rates, the targeted asset acquisitions, and QE is examined. Most of these programmes are revealed to have stimulated asset prices in the expected way, but many of the monetary easing instruments were unsuccessful in devaluating the yen. In general, the author suggests that the measures were not useful to prevent the deflationary trend of the Japanese economy.

Using a dataset from the QE monetary policy phase, Honda (2014) offered an econometric suggestion of the impact of non-traditional monetary policies, demonstrating factually that the QE monetary instruments implemented by the BoJ during the years from March 2001 to March 2006

led to an encouraging boost on the overall Japanese economy. On this topic it is possible to read also the works of Ueda (2013) and Ugai (2006).

5. Effects on Macroeconomic Variables

As underlined before, the investigation on the impact of UMPs and QE commonly states that they had the anticipated result on asset prices, but effectiveness on the broad economy is much more challenging to detect, as it is not an easy task to discover with any sureness how economic activity would have developed without these manoeuvres. Nonetheless, within the UMPs and QE outcome review there is considerable literature on the effects on macroeconomic variables. Therefore, in this section the main findings regarding this sector are reported.

5.1 Eurozone

Regarding the Eurozone, Lenza et al. (2010) defined the approach of the ECB in pursuing monetary policy after the start of the financial recession in August 2007. In particular, the authors reviewed the ECB's introduction of extraordinary monetary policies following the financial crisis, using a quantitative exercise that assessed the impact of the reduction of money market spreads to the broader economy. The ECB started with the "Enhanced Credit Support" program (see also Trichet (2009)), centred on market liquidity, beginning in 2009 and finishing in 2010, together with a set of other policies planned to support market performance. Implementing a sizable Bayesian Vector Autoregression (BVAR) model created on a counterfactual analysis, they postulated evidence that these manoeuvres were helpful in diminishing financial market distress, thanks to the evident reduction in money market spreads. Lastly, they also discovered that these policies had a huge effect on growth and prices (with a lag).

Peersman (2011) too showed that the Euro System can stimulate the economy beyond the policy rate, by increasing the size of its balance sheet or the monetary base. Most of the policy instruments implemented by the ECB in the wake of the recession were focused on increasing the volume of the central bank balance sheet, such as affecting long-term money market and bank credit interest rates. However, even during no-crisis periods, the ECB could have affected interest rates without having changed its main policy rate (for example, by varying the signs in its policy indications). Moreover, it is significant to highlight that the author concentrated only on the impact concerning credit lending or the banking sector, and thus, the methodology did not take into account policy measures that do not regard bank credit directly or indirectly. Differently from countries where securities markets have the main function of supporting the private sector, borrowing and credit in the Euro System are primarily carried out via the mediation of the banking sector. Indeed, the extraordinary policies implemented by the Euro Area as a reaction to the recession were actually directed at improving the banking sector, similar to the previous purchases of covered bonds which were implemented to push credit conditions.

Thus, to measure the macroeconomic impact of conventional interest rate shocks and extraordinary monetary policy measures on the Euro System economy, the author regressed a Structural Vector Autoregressive (SVAR) model using monthly data from 1999m1 to 2009m12. Inside this SVAR, Peersman classified three different types of shocks at the supply side of the credit market: "(1) innovations to credit supply that are independent of a policy action, identified as credit multiplier

shocks; (2) credit supply shocks resulting from a shift in the monetary policy rate; (3) innovations to credit supply caused by monetary policy actions that are orthogonal to the policy rate" (Peersman 2011). The latter shocks are called extraordinary monetary policy disturbances.
Next, Peersman compared the results with conventional interest rate shocks, discovering comparable macroeconomic effects. In particular, both innovations have a positive effect on economic growth and drive a persistent rise in inflation. Considering the transmission mechanism, nonetheless, it is not the same for both policies; while the results on output and inflation obtain the maximum approximately after one year for interest rate shocks, this happens about six months later for shocks to the monetary base. Additionally, bank interest rate spreads rise considerably behind an expansionary interest rate manoeuvre, while spreads significantly slow down following an innovation that increases the volume of the Euro Area's balance sheet.

Apart from Peersman (2011), other analyses proposed by Fahr et al. (2010) and Giannone et al. (2011) suggested that the ECB's measures were successful in boosting the Euro System economic recovery. Moreover, the report by Giannone et al. (2012) investigated the effects of the extraordinary manoeuvres applied by the ECB operating with a different dataset on bank balance sheets that involved also the size of interbank credit and of Euro Area lending to banks.

More recently, the study by Andrade et al. (2016) investigated the impact of the ECB's extended Asset Purchase Programme (APP), indicating that the macroeconomic effect of the instrument can be estimated to be sizable. Using a General Equilibrium Model, their findings imply that QE helped to boost recovery of the level of prices as well as economic growth.
Finally, also Burriel and Galesi (2016), through a Global VAR (GVAR) methodology, found that the recent UMPs implemented by the ECB had a positive effect on output and inflation. Moreover, once they ran a second model where the cross-country spill over effects are taken into account, the results were definitely augmented.

5.2 United States

Inside the group of UMPs, the LSAPs implemented by the FED and the BoE, starting from 2009, involved particular attention. The primary objective of QE policies was to put downward pressure on long-term interest rates, to support private borrowing of households and businesses, thereby driving aggregate demand and real economic activity. In that context, the research by Baumeister and Benati (2010) approached two issues. First of all, the authors investigated how successful central banks' government-bond purchases were in reacting to the recessionary shocks before the financial crisis. The idea for the first hypothesis included a counterfactual model that involves changes in unemployment, inflation and output if the securities acquisition schedules were never implemented.
Generally, estimating the money market effect of securities acquisitions is the prime phase for the evaluation of monetary policy instruments. Nonetheless, the final purpose of a central bank involves a reaction to deflationary forces and a boost for the broad economy. This analysis was centred primarily on this second issue. Therefore, the authors investigated the macroeconomic consequences of a compression in the yield spread when short-term interest rates are at the ZLB, considering as given the estimations of the impact of public asset acquisitions on the spread.
The authors proposed to assess the macroeconomic effects of this compression by regressing a Time-Varying Parameter Structural VAR (TVP-VAR) methodology for the UK and the US markets. With this outline, they indicated a 'pure spread shock' like a disorder that does not affect

the short-term main rate, and that allows them to describe the reactions of macro variables to a drop in longer-term returns produced by central banks' assets purchases, in a situation in which the short rate is fixed, that is, exactly the condition faced at the ZLB. This innovation is characterized by a combination of sign restrictions and a single zero restriction. As a result, they showed that a reduction in the long-term yield spread had a massively strong impact on inflation (1.6 percentage point (pp)) and output growth (2.4 pps) for the US, and 1.8/2.4 pps for the UK respectively, at the moment in which monetary policy arrived at the ZLB.

Agreeing with Gagnon et al. (2011), who evaluated the effects of the FED's asset acquisitions on the 10-year public-security return, the US extraordinary monetary policy programs prevented substantial risks of output deficit and deflationary forces. The authors state that, without the net asset purchase programme, the US markets would have encountered a reduction in inflation, with a level of 1%, as in 2009. Moreover, also real GDP and unemployment would have faced a consistent contraction. Given these outcomes, they determined that large-scale asset acquisitions of government bonds are a solid policy decision to afford further monetary policy manoeuvres in a ZLB case, to permit central banks to attain their prime target of inflation stability.

The impact of the FED's large-scale asset purchases on the US' macroeconomy is also covered in Chung et al. (2012), who affirm that the first LSAPs were successful. These authors clarified that the ZLB possibly had a first-phase effect on macroeconomic variables in the US. Before the start of the recent recession, the general agreement stated that the ZLB maybe would not be a significant issue for monetary policy, depending on the bank's purpose of an inflation rate around 2%. This study assessed this consensus following the financial crisis, which brought policy rates to their actual lower bound in two years in the US and Japan, and close to zero in several other economies. Final results from this analysis report a positive impact on US GDP of about 2.4-3% and an inflation increase of 0.4-1.0 pps.

As anticipated, several studies have investigated the financial market effects of the Federal Open Market Committee's (FOMC) unconventional actions, especially with regard to the FED's asset purchases and found noticeable effects on long-term interest rates. Contrarily, there have been relatively few analyses of the impact of these instruments on real economy and inflation; for this reason, Engen et al. (2015) concentrated completely on the macroeconomic results contingent only with the decreases in term premiums produced by QE policies.

These authors replicated the FRB/US model to quantify the real economic effort provided by non-traditional manoeuvres since early 2009. They implemented an estimate of the variations over time in private expectations for the implicit policy rule, demonstrating that the net incentive to real economy and inflation was decreased by the variations in policy expectations and term premium effects. The methodology is divided into three parts. First of all, they measured shifts in monetary policy rate expectations. Furthermore, the examination also considered the other monetary 'impulse' from non-conventional policies, i.e. the variations in term premiums related with the FED's QE agenda. Finally, having determined the effect of the FED's extraordinary policies on expectations of its implicit policy rule and on term premiums, the last section discussed the impact of these manoeuvres on real economic activity and inflation over recent years. This investigation shows that the incentive to real economy and inflation was reduced by the steady nature of the variations in policy expectations and term premium effects, as well as by the public expectation that the recovery could be much closer than demonstrated. In conclusion, this analysis suggested that the macroeconomic impact of the FOMC's non-traditional policy measures is seen some years after

their implementation; in fact, the peak unemployment effect was not reached until 2015 and the peak inflation effect did not occur until 2016.

5.3 United Kingdom

Regarding the UK, Kapetanios, Mumtaz, Stevens and Theodoris (2012) ran three different methods to assess the effects of QE. Their analysis evaluates the macroeconomic effect of the first stage of QE pursued by the BoE. Starting from March 2009 to January 2010, the BoE purchased 200 billion of assets, mainly consisting of public assets. These purchases were directed mainly to affect economic activity in several ways, predominantly within the 'portfolio balance channel'.
The main scope of this analysis was to assess how the real economy reacted to the incentive from QE by evaluating the impact on inflation and output. Nonetheless, studying this impact is not a simple exercise, as it involves an estimation of what could have occurred to real GDP and consumer price indices (CPI) inflation if the QE manoeuvre had not been executed. The authors simulated how the macro effectiveness of QE arises within the effect on government returns. This framework was afterward compared with a forecast model that involved QE. The discrepancy between the two settings was acquired to quantify the macroeconomic impact.
They create qualified predictions (for real GDP and CPI inflation) using three distinctive factual methodologies that are all modifications of simulations identified as Vector Autoregressions (VARs). The prime simulation is a sizable BVAR. The second is a 'Markov-Switching' or 'Change-Point Structural' VAR (MS-SVAR), while the third is a TVP-SVAR. The factual outcomes indicate that, in the absence of the QE manoeuvre, real GDP would have decreased significantly more during 2009, while inflation would have moved through negative levels. Considering the more careful average results of the three methodologies, it was perceived that QE had the maximum effect on the real GDP level of about 1.5% and a maximum influence on annual CPI inflation of around 1.25 pp. Nonetheless, the size of these effects changes significantly from one model estimation to another, so these results are exposed to substantial uncertainty.
A research outcome close to this one is proposed by Gambacorta, Hoffman and Peersman (2013) who assessed the macro effect of central bank asset purchases in eight economies during the phase from 2008m1 to 2011m6. Their analysis regards the effect of every kind of central bank manoeuvre that involves a balance sheet increase, assessing how these instruments affect output and prices.

Also Bridges and Thomas (2012) examined the impact of the BoE QE on the money supply and used their estimates in two econometric methodologies. The first is an aggregate SVAR model, while the second is a connected set of sectorial money demand schemes, which allow them to determine how securities prices and expenditures have to be modified to support money demand so as to be constant with an intensification in the broad money supply. Their results suggest a GDP increase of around 1.5-2% and a positive impact on inflation of about 1-2 pps.

In that context, also Weale and Wieladek (2014) investigated the effect of securities acquisitions on the UK and US markets. Differently from previous analyses, these authors use only data series starting from the beginning of the purchases in 2009, using also identification schemes that do not involve preceding considerations on the effect of this instrument on inflation and growth. The main issue of this study contemplated whether securities acquisitions have an effect or not on inflation and real GDP. This estimation was performed using monthly data from 2009m3 to 2013m5. The short time series related to the phase under examination is one of the reasons why there are few studies on this topic. The authors solved the problem of the sample period construction by using

Bayesian methodologies of inference and adopting two priors: the 'Litterman prior' (1986) that involves persistent parameters with a random walk, and the 'hierarchical panel VAR prior', that simulates that each economy shows a uniform mean in their autoregressive variables.
Their findings suggest that, at the median level, a bond acquisition policy that is preceded by announcement values 1% for nominal GDP, led to an increase of around 0.36% (0.18%) of real GDP and 0.38% (0.3%) in inflation CPI in the US and UK economies respectively. For the UK, bond purchase proclamations had an effect on interest rates, implying that the 'signalling' is the transmission channel that works in this case. On the contrary, for the US the 'portfolio rebalancing channel' had the prime function, given that the longer-term returns and the real exchange rate showed a reaction to securities acquisition innovations.

6. Conclusions

This concluding section reports two tables in which the main literature findings with respect to the effects of UMPs and particularly QE on the financial sector (*Table 3*) and on the macroeconomy (*Table 4*) are summarized, followed by a brief commentary on these outcomes.

Table 3. **Literature findings: UMPs and QE effects on Financial Markets**

Author(s)	Method	Event(s)/Period	Main Channel(s)	Main Findings
EURO AREA				
Abbassi and Linzert (2011)	Regression Analysis	MROs/LTROs 2004/09	Signalling/Interest Rate	Reduction in Euribor rates more than 100 bps
Angelini et al. (2011)	Regression Analysis	LTROs 2007/08	Bank-lending	Rise in interbank spreads after Lehman Brothers failure
Brunetti et al (2011)	Regression Analysis	3-month LTROs	Portfolio Rebalancing/Liquidity Premium	Rise in the level and volatility of the bid-ask spread
Beirne et al. (2011)	Event Study-Regression Analysis	CBPP1 2009/10	Portfolio Rebalancing/Liquidity Premium	Reduction in Covered Bond spreads of 12 bps
De Pooter et al. (2012)	Regression Analysis	SMP 2010/11	Portfolio Rebalancing/Liquidity Premium	Actual SMP operations reduced sovereign spreads
Eser and Schwaab (2013)	Regression Analysis	SMP 2010/11	Signalling	The announcement reduced sovereign spreads in peripheral EZ countries
Ghysels et al. (2013)	Regression Analysis	SMP 2010/11	Signalling	The announcement reduced sovereign spreads in peripheral EZ countries
Pattipeilohy et al. (2013)	Regression Analysis	SMP 2010/11	Signalling	The announcement reduced sovereign spreads in peripheral EZ countries
Szczerbowicz (2015)	Event-based Regressions	SMP/OMT/CBPP1 /CBPP2/LTROs 2009/12	Portfolio Rebalancing/Liquidity Premium	LTROs effective in lowering long term risk premia/ SMP, OMT and CBPP reduced sovereign spreads

US				
D'Amico and King (2010)	Panel data Analysis	LSAP1 2008/09	Portfolio Rebalancing	30 bps on long-term Treasury returns
Gagnon et al. (2011a,b)	Model-based Event Study/Regression Analysis	LSAP1 2008/09	Portfolio Rebalancing	50-100 bps on 10-yr Treasury yield /110 bps on MBS
Hamilton and Wu (2012)	Model-based	LSAP1/LSAP2	-	32 bps on 10-yr Treasury yield
Krishnamurthy and Vissing-Jorgensen (2011)	Event Study	LSAP1	Signalling/ Risk Channel	20 bps (10-yr)
Neely (2012)	Event Study	LSAP1	Signalling/ Portfolio Rebalancing	Effect on long-term bond rates and exchange rates
Stroebel and Taylor (2009)	Regression Analysis	MBS Purchase Program	-	Impact on mortgage interest rates not significant in the primary market; 30-60 bps on the secondary market
Swanson (2011)	Factual Analysis	LSAP2	-	15 bps on long-term Treasury returns
Szczerbowicz (2011)	Regression-based Event Study	LSAP1/LSAP2	Signalling	LSAP1 reduced long-term interest rates/ LSAP2 raised inflation expectations
Wright (2012)	Structural VAR	LSAP1	Signalling	Impact on 10-yr yields and covered bond yields
UK				
Joyce et al. (2011)	Event Study	APP1	Portfolio Rebalancing	Decrease around 100 bps in Gilt spread
Meier (2009)	Event Study	APP1	Signalling	Decrease between 40 and 100 bps in long-term Gilt spread
JAPAN				
Ueda (2012)	Event Study	CME/ABS	-	10 bps on JGB/little impact on JGB
Ugai (2006)	Survey	CME/ABS	Signalling/Portfolio Rebalancing	0-50 bps (3-5 yr) bond yields/ little evidence

Notes:
Bps denotes basis points
MRO: Main Refinancing Operation
LTRO: Long-Term Refinancing Operation
CBPP: Covered Bond Purchase Programme
SMP: Securities Market Programme
OMT: Outright Monetary Transactions
LSAP: Large-Scale Asset Purchase
MBS: Mortgage-Backed Security
APP: Asset Purchase Programme
CME: Comprehensive Monetary Easing
ABS: Asset-Backed Securities
JGB: Japanese Government Bond
VAR: Vector Autoregression

Source: Author

Table 4. **Literature findings: UMPs and QE effects on Macroeconomy**

Author(s)	Methodology	Sample Period/Frequency	Size of the Shock	Main Findings
EURO AREA				
Andrade et al. (2016)	General Equilibrium Model	2015/16	APP programme	Without the APP, the shock would have reduced the inflation rate by more than 2% and output by around 7%
Baumeister and Benati (2010)	TVP SVAR	1981q1-2009q3	100 bps negative shock to the 10-yr Treasury bond yield spread	GDP growth increases by 1 pp /Inflation increases by 0.8 pps
Burriel and Galesi (2016)	GVAR	Jan.2007-Sep.2015	UMP shocks	Output and inflation response with a peak effect of about 4 and 3 bps respectively. The impact is augmented when the spillover effects are considered
Giannone et al. (2012)	BVAR/Counterfactual Analysis	1999m1-2011m4	Counterfactual IP is calculated by predicting the level of CB intermediation between 2007 and 2011 without policy intervention	IP increases by 2%
Lenza et al. (2010)	BVAR/Counterfactual Analysis	1991m1-2007m12	Counterfactual inflation and industrial production are calculated by assuming the reduction in money market spreads	IP growth increases by 1.5-2.5 pps / Inflation increases by 0.1-0.2 pps
Peersman (2011)	SVAR	1999m9-2009m12	8% increase in the monetary base	IP and CPI price level both increases
US				
Baumeister and Benati (2010)	TVP SVAR	1965q4-2009q4	100 bps negative shock to the 10-yr Treasury bond yield spread	GDP growth increases by 2.4 pps / Inflation increases by 1.6 pp
Chung et al. (2012)	FED FRB/US Macro Model	2007-2010	FED purchases $2.6 trillion of long-term securities	GDP increases by 2.4-3% / Inflation increases by 0.4-1.0 pps
Engen et al. (2015)	FED FRB/US Macro Model	2009q1-2013q3	-	Peak unemployment effect in 2015 / Peak inflation effect in 2016
Weale and Wieladek (2014)	BVAR	2009m3-2013m5	-	Real GDP increases by 0.36% / Inflation increases by 0.38%
UK				
Baumeister and Benati (2010)	TVP SVAR	1965q4-2009q4	100 bps negative shock to the 10-yr Treasury bond yield spread	GDP growth increases by 2.4 pps / Inflation increases by 1.8 pp
Bridges and Thomas (2012)	Money Accounting/SVAR	1964q1-2007q3	£122 billion of increase in money supply	GDP increases by 1.5-2% / Inflation increases by1-2 pps
Kapetanios et al. (2012)	BVAR/MS-SVAR/TVP-SVAR	1963m2-2011m3	100 bps negative shock on the 10-yr Treasury bond yield spread	On average: Real GDP increases by 1.5% / Inflation increases by 1.25 pp
Weale and Wieladek (2014)	BVAR	2009m3-2013m5	-	Real GDP increases by 0.18% / Inflation increases

	by 0.3%

Notes:
Bps denotes basis points / pps denotes percentage points
IP denotes Industrial Production
CB denotes Central Bank
SVAR: Structural Vector Autoregression
TVP SVAR: Time-Varying Parameter Vector Autoregression
BVAR: Bayesian Vector Autoregression
MS-SVAR: Marcov-Switching VAR
GVAR: Global Vector Autoregression

Source: Author

The results of the previous four major UMP programs reported in these analyses have been mixed. Regarding the financial markets' impact of asset purchases policies, positive conclusions have been found in the Eurozone in favour of a reduction in the *Euribor* rates, covered bond spreads and sovereign spreads, mainly through the portfolio rebalancing and the signalling channels. For the US case, researchers agree on the impact on long-term (10-years) Treasury spreads of around 30 bps, via the portfolio and the signalling channels. Moreover, in the UK literature reports a general consensus of a reduction between 40 and 100 bps on long-term Gilt spreads (also in this case portfolio and signalling are the main channels). Finally, in Japan, the average of the impact is between 10 and 50 bps on the 3-5 years Japanese government bond (JGB) spreads, mainly through the same channels as above.

On the other hand, considering the effects of UMPs and QE on the macroeconomic variables, in the Euro Area output and prices showed both a positive increment. In the US, researchers report an increase of real GDP of around 0.36-3%, and an inflation increment between 0.4-1.6 pps. Lastly, also for the UK, the outcomes are quite divergent given that the estimation results are between 0.18-1.5% for output and 1-2 pps for the inflation rate.

Finally, it is important to underline also that the majority of literature studies have been focused on the financial market's effects of UMPs and QE policies, and very few studies have concentrated on the macroeconomic impact. Moreover, within the macro framework, the studies only report the effects of asset purchases on real GDP and inflation; in fact, to the best of my knowledge, there are no previous studies examining the impact of QE on potential output growth for the US and the Eurozone economies.

Therefore, this research relates to the macro framework and contributes to literature providing quarterly estimates of the long run potential growth for the US and the Euro Area, evaluating the effects of QE policies on that estimated series of potential output growth. Furthermore, the second part of the empirical research provides an original framework for the evaluation of the effects of QE in the Eurozone, considering a comparison with the other European countries that are not part of the monetary area through a DID methodology. Also in this case, to the best of my knowledge, there are no previous studies that compare the European effects of QE using a DID methodology; nonetheless, it should be stressed that the DID is used mainly in microeconomics and thus, it is quite risky to use this methodology in macro studies.

The Effects of Quantitative Easing on Potential Output Growth: Evidence from the US and the Eurozone

VERONICA BONANNO·*

Chapter 2

In this paper, I assess the impact of an increase of domestic assets in the balance sheets of the Federal Reserve and the European Central Bank following the global financial crisis that started in 2007. This asset increase is well represented by the so-called Quantitative Easing (QE) policy. Overall, this unconventional monetary policy was implemented to positively influence, among other things, the labour productivity growth rate and the natural or potential growth rate. I provide quarterly and annual estimates of potential growth for the United States (US) and Eurozone economies using an AS state-space model with time-varying parameters and a Kalman filtering methodology. Next, I select the best time series estimates for each area and I run different linear regression models, using one proxy for QE, one proxy for labour force, and three proxies for labour productivity, to detect the impact of this policy on the estimated potential growth rates of the US and the Euro Area.

Keywords: quantitative easing, unconventional monetary policy, potential output, United States, Eurozone.
JEL Codes: C13, C32, E52, E58
Supervisor: Professor Matteo Lanzafame

1. Introduction

After the global financial crisis that started in 2007, severe consequences spread toward most economies, due to the collapse of international trade, the decline in short-term loans and the freeze in interbank markets. Moreover, the traditional instruments of monetary policy became ineffective when policy interest rates in many countries reached the zero lower bound (ZLB).
Nonetheless, to ensure economic growth, financial stability and price stability, central banks in many advanced economies started to use unconventional monetary policies (UMPs). Several different UMPs instruments exist; overall, the high-profile form has been the so-called Quantitative Easing (QE), whose aim is to support the economy in its recovery, avoiding deflation and economic recession. Therefore, the efficacy of this new instrument nowadays is the object of different studies. Given that QE was recently introduced and its foundation was driven by the necessity to respond faster to the crisis, rather than determined by relevant research, even today the effects of this policy on the economy are not clear.
One of the main scopes of QE is to drive inflation and inflation expectations toward the central bank's target, to boost economic growth and raise employment. Therefore, lowering interest rates and devaluing the currency, QE policies are created to positively stimulate the economy.
This paper proposes an empirical analysis of the issues discussed above. The research question investigates the QE programmes adopted by the European Central Bank (ECB) and the Federal

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Reserve (FED), which are two of the central banks recently engaged in these policies in the aftermath of the global financial crisis. Evaluating the transmission channels of monetary policy, my purpose is to study the effects of these new instruments on a macroeconomic framework. Will this instrument in the future be considered as "conventional" instead of "unconventional"?
Considering that QE targets are long-term economic growth prospects, I decided to investigate if this policy affects the potential (or natural) growth rate, instead of the actual growth rate, given that it is the level of GDP where the economy tends to operate over the long run.

To estimate the potential growth rates of the United States (US) and Eurozone economies, I rely on annual and quarterly data over the periods 1960–2017 (for the US) and 1995-2017 (for the Eurozone). My approach is based on a time-varying parameter Aggregate Supply (AS) model that is consistent with the concept of the natural growth rate proposed by Harrod (1939) and its relation to Okun's Law (Okun 1962) and the Phillips curve. To obtain time-series estimates of the US and Eurozone economies potential growth rates, I use the methodology proposed by Lanzafame (2016) and Felipe et al. (2016), that consider different versions of the AS model and estimate it via a Kalman filtering methodology. Similarly, Anand et al. (2014) and Blagrave et al. (2015) are references for estimating the potential growth rate, as are Beffy et al. (2006) and Furceri and Mourougane (2012).

Next, I turn to the question if, and in what measure, QE policies impact potential output estimates, bearing in mind that what marks these programmes as non-standard is the size of the resulting increases in official balance sheets. Thus, I study the domestic spill over effects of UMPs, represented by QE in their most representative form.
Therefore, I empirically explore the impact on the potential growth rate estimates of the US and the Eurozone, running an ordinary least squares (OLS) regression and using the increase in net domestic assets as proxy of QE, as proposed by Gagnon et al. (2017).
So, the main question of this research investigates if QE policies had a positive impact on the potential output growth rate of these two economies. Accordingly, the contribution of this paper to literature is original in the sense that, to the best of my knowledge, there are no previous studies that have analysed the effects of QE on potential output growth for the US and Eurozone economies. Moreover, this is one of the first studies that has produced an estimate of the natural output growth rate of the Euro Area using a multivariate approach and a Kalman filter methodology. Looking at the existing literature, most of the studies focus on the impact of QE (and UMPs in general) on real GDP and inflation (as reported in *Section 2*) but there are not references about potential output growth for both economies.

The remainder of the paper is organized as follows. The next section reports a brief review of the literature that focuses on the macroeconomic effects of UMPs and QE policies. *Section 3* describes the model and the empirical methodology used to estimate the potential growth rates of the US and Eurozone economies. *Section 4* considers the linear regression model used to assess the impact of QE instrument on the natural growth rate estimates. *Section 5* includes the robustness checks, while *Section 6* concludes the study.

2. Literature

Literature on the effects of UMPs and QE policies generally reports positive feedback regarding their impact on asset prices. Nonetheless, is much more difficult to assess their influence on the broader economy, given that is not an easy task to discern how economic conditions would have evolved without their introduction. However, an increasing amount of empirical analyses focus on the effects of UMPs and QE on macro-variables.

Therefore, this paper links to recent literature dealing with the quantification of the macro impact of UMPs, and particularly QE, in the US and the Eurozone, on real GDP and inflation. Andrade et al. (2016), Baumeister and Benati (2010), Burriel and Galesi (2016), Giannone et al. (2012), Lenza et al. (2010) and Peersman (2011) show that recent UMPs and QE policies had positive and significant effects on output and inflation in the Euro Area. Regarding the US, Baumeister and Benati (2010), Chung et al. (2012), Engen et al. (2015) and Weale et al. (2014) also report a confident impact on real GDP and prices for this economy. Nonetheless, the size and persistence of the impact vary across these studies. The majority of the estimates show that UMPs and QE led to a total increase of real output in the US of around 0.36-3%. Regarding the inflation rate, estimates for the US are assessed between 0.4-1.6 percentage points (pps). *Table 1* collects the literature papers concerning this argument.

Secondarily, this paper contributes to recent literature as, to the best of my knowledge, there are no previous works that analyse the structural impact of QE on long-run potential growth for the US and Eurozone economies.

Table 1. **Literature findings: UMPs and QE effects on Macroeconomy (Eurozone/US)**

Author(s)	Methodology	Sample Period/Frequency	Size of the Shock	Main Findings
EURO AREA				
Andrade et al. (2016)	General Equilibrium Model	2015/16	APP programme	Without the APP, the shock would have reduced the inflation rate by more than 2% and the output by around 7%
Baumeister and Benati (2010)	TVP SVAR	1981q1-2009q3	100 bps negative shock to the 10-yr Treasury bond yield spread	GDP growth increases by 1 pp / Inflation increases by 0.8 pps
Burriel and Galesi (2016)	GVAR	January 2007-September 2015	UMP shocks	Output and inflation response with a peak effect of about 4 and 3 bps respectively. The impact is augmented when the spillover effects are considered
Giannone et al. (2012)	BVAR/Counterfactual Analysis	1999m1-2011m4	Counterfactual IP is calculated by predicting the level of CB intermediation between 2007 and 2011 without policy intervention	IP increases by 2%
Lenza et al. (2010)	BVAR/Counterfactual Analysis	1991m1-2007m12	Counterfactual inflation and industrial production are calculated by assuming	IP growth increases by 1.5-2.5 pps / Inflation increases by 0.1-0.2 pps

			the reduction in money market spreads	
Peersman (2011)	SVAR	1999m9-2009m12	8% increase in the monetary base	IP and CPI price level both increases
US				
Baumeister and Benati (2010)	TVP SVAR	1965q4-2009q4	100 bps negative shock to the 10-yr Treasury bond yield spread	GDP growth increases by 2.4 pps / Inflation increases by 1.6 pp
Chung et al. (2012)	FED FRB/US Macro Model	2007-2010	FED purchases of $2.6 trillion of long-term securities	GDP increases by 2.4-3% / Inflation increases by 0.4-1.0 pps
Engen et al. (2015)	FED FRB/US Macro Model	2009q1-2013q3	-	Peak unemployment effect in 2015 / Peak inflation effect in 2016
Weale and Wieladek (2014)	BVAR	2009m3-2013m5	-	Real GDP increases by 0.36% / Inflation increases by 0.38%

Notes:
Bps denotes basis points / pps denotes percentage points
IP denotes Industrial Production
CB denotes Central Bank
SVAR: Structural Vector Autoregression
TVP SVAR: Time-Varying Parameter Vector Autoregression
BVAR: Bayesian Vector Autoregression
GVAR: Global Vector Autoregression

Source: Author

3. Model and Empirical Methodology

The approach implemented in my analysis will be primarily empirical, focusing on the effects of QE policies on the natural output growth rate. First of all, I estimate different time series of the rate of growth of potential output for the US and the Eurozone, using both annual and quarterly data; then, I assess the impact of QE policies on the most significant potential output series obtained by running an OLS regression.

3.1 Potential Growth Definitions

"Potential", "trend" or "natural" growth can be broadly defined in a number of ways. The macroeconomic definition of the natural rate of growth was formally introduced into growth theory by Harrod (1939), who defined it as "the sum of the growth rates of the labour force and labour productivity, both of which were assumed to be exogenous". Hence, potential output growth is defined as the maximum rate of growth that an economy can achieve consistent with macroeconomic stability (e.g. consistent with the natural rate of unemployment and stable inflation), in which there are neither inflationary nor deflationary pressures.
Moreover, as reported by Felipe et al. (2016), the notion of potential output was initially formulated to quantify the ability of an economy to produce output, i.e., its productive capacity. "Potential output" is therefore the highest level of real GDP that can be attained over the long term. By translating levels to growth rates, it is possible to obtain the rate of growth of potential output. A limit to output growth exists because of technical, natural, and institutional constraints on the ability to produce. Therefore, the notions of potential GDP and potential growth, which are supported by a viewpoint of an economy's productive capability based on the statements of stable inflation and full

employment, may be displayed to characterize short-term deviations from the main trend in actual GDP growth (Felipe et al. 2016).
During the short term, actual output will diverge momentarily from potential as shocks stress the economy. Those deviations reveal the gradual adjustment in wages and prices to crisis periods, which indicates that the return of GDP to its potential level is slow.
Instead, as explained by Lanzafame (2016), the role played by the natural growth rate is twofold: it is both the "trend growth rate of the economy and the short-term upward limit to (noninflationary) growth that turns cyclical expansions into recessions". In this context, trend growth is usually estimated by using the link between inflation and output gaps.
Blagrave et al. (2015), for example, explain that "the economic definition of 'potential output' differs from the concept of 'trend output'; the former relies on an explicit framework based on economic theory, while the latter derives from statistical data filtering using various forms of moving averages or deterministic trends. This is the same as smoothing actual GDP over time, based on the implicit assumption that an economy is, on average, in a state of full capacity, without incorporating information from variables such as inflation or unemployment" (Blagrave et al. 2015).
In conclusion, as reported by Anand et al. (2014), given that potential output growth is unobservable, there are various approaches to estimate it that are conceptually different and could yield different results. Consequently, the valuations could be exposed to statistical and model uncertainty; thus, the results can differ depending on the methodology used.

3.2 Potential Growth Estimation Methods

There are different methodologies to estimate the potential growth rate. Felipe et al. (2016), for example, report four main methods.

1. Univariate filters. This is a statistical approach that is not based on any underlying economic theory and uses information only on GDP. Following this method, 'potential growth' can indicate a merely statistical estimation of the tendencies in GDP data. Therefore, this procedure is developed by decomposing or filtering GDP data into a cyclical/noise component and a trend component using various statistical specifications. Its main scope is to statistically eliminate the cyclical component of a series from the raw data. An example is the peak-to-peak analysis of GDP trend growth specified in Beffy et al. (2006). The most widely used of these univariate filters is the Hodrick-Prescott (HP), but other filters include the Beveridge–Nelson, Christiano–Fitzgerald, Corbae–Ouliaris, and Baxter–King.

2. Multivariate estimates. To obtain estimates of potential output this second category involves different economic series. This methodology is usually linked to a structural theory and estimates, for example, the rate of growth coherent with 'macroeconomic stability'. Therefore, a basic model could be a bivariate structural time series that links inflation to temporary fluctuations in output and assumes that there is a positive relation between output gap and inflationary pressures. In addition, an extensive procedure can consider also Okun's Law that relates output growth and unemployment.

3. Growth accounting approach. Also this approach can be considered a multivariate approach. Generally, it uses information regarding variables that are related with the aggregate production function, such as output, employment, capital and total factor productivity. Usually a Cobb-Douglas Production Function $[Y_t = A_t K_t^{\alpha}(L_t H_t)^{(1-\alpha)}]$ is used to obtain a decomposition of the different elements of growth. Generally, it is not econometrically estimated; "factor markets are assumed to be competitive, so the labour and capital elasticities equal the factor shares in national income, and these are imposed to derive total factor productivity growth" (Felipe et al. 2016).

4. Output identity. The last procedure involves the decomposition of output, and considers it as the product of different terms: labour productivity in hours (Y/H), the employment rate (L/P), hours per employee (H/L) and working-age population (P), such that $Y_t = \left(\frac{Y}{H}\right) * \left(\frac{H}{L}\right) * \left(\frac{L}{P}\right) * P$. It is also possible to filter these series to calculate their trend, which is considered as the potential level. In line with the third approach, this methodology does not take into account the link between the estimation of trend growth, output gap and inflation.

As stressed by Beffy et al. (2006), an important reason for using more structural economic methods is that "whereas statistical measures may appear to be 'judgement free', they are nonetheless sensitive to the choice of arbitrary non-economic assumptions, including those about sample length, smoothness properties, end-points and out-of sample restrictions. Although also making use of statistical filtering methods, the production function/growth accounting approach provides a simple but economically meaningful decomposition of growth potential into underlying supply-side factors and thereby makes the relevant assumptions more transparent in economic terms".
Moreover, the methodology presented in Beffy et al. (2006) is also used by Furceri and Mourougane (2012) and is defined as a 'hybrid' approach in the sense that it relies on economic relationships (to estimate structural unemployment) but also on univariate filters (like the HP filter) to calculate trend participation rates or trend total factor productivity.

To obtain time-series estimates of the US and Eurozone economies potential growth rates I decided to follow the methodology described in Lanzafame (2016) and Felipe et al. (2016). This procedure relies on the multivariate estimation category and applies statistically based filtering methods, as well as univariate and bivariate state-space models with the Kalman filter. This approach is in line with the definition of trend growth described above, and the bivariate state-space model also partly relies on the link between output gap and inflation. As referred by Anand et al. (2014), an important advantage of this class of approaches is that it is simple and transparent.
It is important to underline that, as purely statistical techniques, these filter estimates of trend growth need a strong relation to economic theory such as the Phillips curve and Okun's law, with the partial exception of the bivariate state-space model. Moreover, the filtering approach can be sensitive to the specific choice of smoothing parameters and, basically, it is often described as a backward-looking technique that ultimately tracks actual output developments.
In summary, the multivariate filtering framework, as specified by Blagrave et al. (2015), proposes an equilibrium between statistical filters, which are valid for numbers of economies but are a-theoretical, and structural models of potential output, which instead propose larger theoretical consistency but are more problematic to create and apply broadly.

The next section explains, in detail, the methodology proposed by Lanzafame (2016) and Felipe et al. (2016) that I used to estimate the potential growth rate for the Eurozone and US economies.

3.3 Potential Growth Rate Estimation

As the natural growth rate is the particular growth rate consistent with a non-changing unemployment rate, and represents the sum of the growth rates of labour productivity and labour force, this implies that unemployment will rise when the actual rate of growth (g_t) falls below the natural rate (g^N), and it will fall when g_t rises above g^N; therefore, the following specification of Okun's Law is a clear estimation framework to fix the value of g^N:

$$\Delta U_t = \sigma - \varsigma g_t \quad (1)$$

where ΔU_t is the percentage change in the unemployment rate U_t, and g_t is the growth rate of output.

Since I am interested in studying the evolution over time of the natural (or potential) growth rate for the time period under analysis (1960-2017 for the US, 1995-2017 for Eurozone), I use a time-varying parameter approach to estimate a time series for g_t^N, because the specification in *Equation (1)* produces a single estimate. Furthermore, linking Harrod's definition of g^N to the relationship between unemployment and growth, it is possible to estimate the natural growth rate of the US and Eurozone economies relying on an AS model.

Since, in the long run, unemployment will be constant when it is equal to the nonaccelerating inflation rate of unemployment, the natural growth rate can be defined as the growth rate consistent with $U_t = U_t^N$ and, thus, $\Delta U_t = 0$. This can be formalized in Okun's relation as

$$U_t = U_t^N - \beta_t (g_t - g_t^N) \quad (2)$$

where the Okun coefficient (β_t) and the nonaccelerating inflation rate of unemployment (U_t^N) are assumed to be time varying. The relationship between inflation and unemployment is given by the following Phillips curve in which

$$\pi_t = \pi_t^e - \gamma_t (U_t - U_t^N) \quad (3)$$

where π_t and π_t^e are, respectively, the actual and expected inflation rates, while γ_t is a time-varying parameter. Combining *Equations (2)* and *(3),* the following equation is obtained:

$$\pi_t = \pi_t^e + \varphi_t (g_t - g_t^N) \quad (4)$$

where $\varphi_t = \beta_t \gamma_t$. The specification in *Equation (4)* formalizes an AS model with time-varying parameters.

To estimate the model in *Equation (4),* I need an estimate of the expected inflation rate, π_t^e. Since there is very limited availability of time-series data for expected inflation of Asian economies, Lanzafame (2016) and Felipe et al. (2016) decided to model π_t^e as a function of the actual inflation rate (π_t), assuming two possible specifications.

The first is in *Equation (5),* where expected inflation in time *t* is a time-varying function of actual inflation in *t*:

$$\pi_t^e = \alpha_t \pi_t + \varepsilon_t \quad (5)$$

where α_t is a time-varying parameter reflecting the public's degree of accuracy in forecasting inflation and ε_t is an independent normally distributed error term, with zero mean and constant variance. The estimated model (*Model 1*) in this case is

$$g_t = g_t^N + \frac{(1-\alpha_t)}{\varphi_t} \pi_t + \varepsilon_t \quad (6)$$

The second specification assumes an extreme form of adaptive expectations in which expected inflation in *t* is equal to actual inflation in $t-1$ plus a random error term:

$$\pi_t^e = \pi_{t-1} + \varepsilon_t \quad (7)$$

and the relative model (*Model 2*) is

$$g_t = g_t^N + \frac{1}{\varphi_t} \Delta\pi_t + \varepsilon_t \quad (8)$$

Equations (6) and *(8)* can both be specified in state-space form. Specifically, the measurement equations are

$$g_t = \mu_t + \beta_t \pi_t + \varepsilon_t \quad (6')$$
$$g_t = \mu_t + \beta_t \Delta\pi_t + \varepsilon_t \quad (8')$$

with $\mu_t = g_t^N$. Following standard practice in literature (see, for example, Harvey 1989), to capture possible level breaks or trend patterns, the transition equations are assumed to follow a unit root:

$$\mu_t = \mu_{t-1} + \upsilon_t \quad (9)$$
$$\beta_t = \beta_{t-1} + \upsilon_t \quad (10)$$

However, in the case of the US and Eurozone economies, time-series data for expected inflation are accessible; therefore, in my work I decided to estimate g^N modelling π_t^e as a function of π_t (using both specifications reported above) and without modelling π_t^e, thanks to the availability of data. In this case the relative model (*Model 3*) is

$$g_t = g_t^N + \frac{1}{\varphi_t} (\pi_t - \pi_t^e) + \varepsilon_t \quad (11)$$

Since *Equation (11)* can be specified in a state-space form, the measurement equation is

$$g_t = \mu_t + \beta_t (\pi_t - \pi_t^e) + \varepsilon_t \quad (11')$$

where $\mu_t = g_t^N$.

Following Romer (1993), I take account also of the possible effects of the degree of openness on the slope of the Phillips curve, and thus of the AS models in *Equations (6')* and *(8'),* considering the following transition equations for β_t:

$$\beta_t = \beta_{t-1} + \kappa m_t + \upsilon_t \quad (12)$$
$$\beta_t = \beta_{t-1} + \kappa m x_t + \nu_t \quad (13)$$

where m_t is the share of imports in gross domestic product (GDP) and mx_t is the sum of the share of imports and exports in GDP.

For each economy, I produce estimates of the potential output growth using both annual and quarterly data over the period 1960–2017 (for the US) and 1995-2017 (for Eurozone). My estimations are carried out relying on the Kalman filter recursive algorithm, which is commonly used in literature to obtain optimal estimates for state variables in models with time-varying parameters (see, for example, Lanzafame and Nogueira 2011). More specifically, to obtain a time series for the potential growth rate g_t^N, I applied the Kalman smoothing procedure, which uses all the information in the sample to provide smoothed-state estimates. This procedure differs from Kalman filtering in the construction of the state series, as this technique uses only the information available up to the beginning of the estimation period. Smoothed series tend to produce more gradual changes than filtered ones and, as discussed by Sims (2001), they provide more precise estimates of the actual time variation in the data.

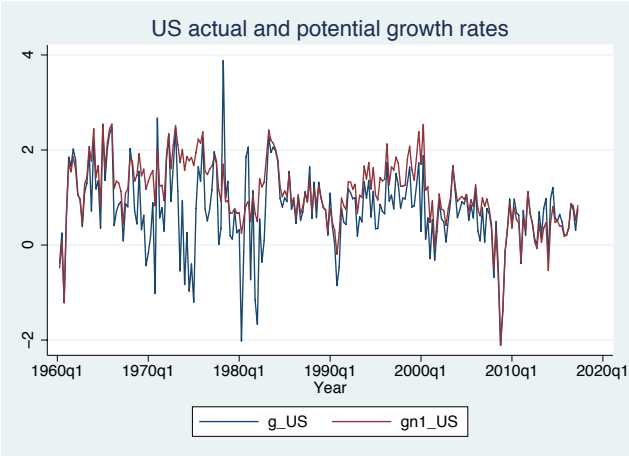
Then, I selected the most appropriate version of the model according to the significance of the estimated parameters relying on the Akaike Information Criterion (AIC)[1]. However, I decided to test the effectiveness of QE only using the quarterly estimates of g_t^N, due to the availability of the largest series in this case.

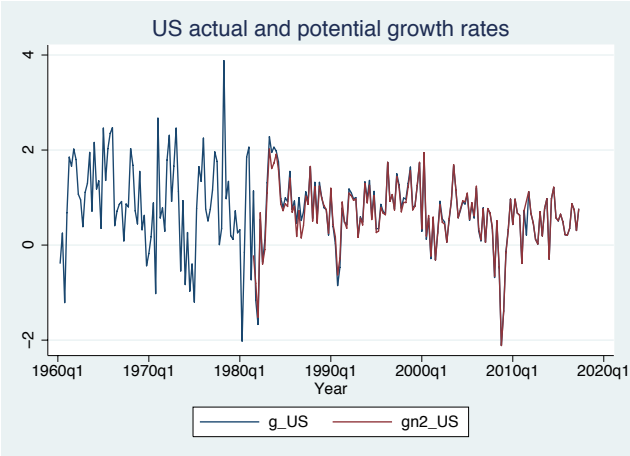
Regarding the results of quarterly estimations for the US, the most significant model is the one represented in *Equation (6),* where expected inflation in time *t* is a time-varying function of actual inflation in *t* (named *gn1_US*); estimates in this case show the best Akaike criteria and a collinearity between g and g_t^N during the crisis period (*Figure1 Panel (a)*). Nonetheless, I also selected the estimate produced by *Equation (11)*, where expected inflation is not modelled (named *gn2_US*); the estimate in this case is significant but produces a series of g_t^N which is almost convergent with g for all the time (*Figure1 Panel (b)*).

Moreover, for the US, the models representing the degree of openness to international trade (*Equations (12)* and *(13)*) do not produce significant results. The selected estimation series of the natural growth rate (*gn1_US* and *gn2_US*) and the actual growth rate (*g_US*) are reported in *Figure 1*.

[1] The remainder estimated series of potential output growth (both annual and quarterly) that I did not select given the higher AIC and considering also the significance of the parameters, are available in Sections A1, A2, A3 and A4 in the Appendix, such as the relative models used to produce these series, which are specified in Table A1 (Appendix).

Figure 1. **United States actual and potential growth rates**

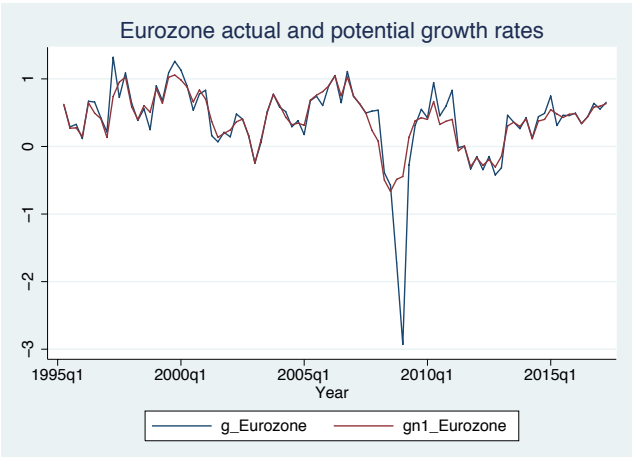


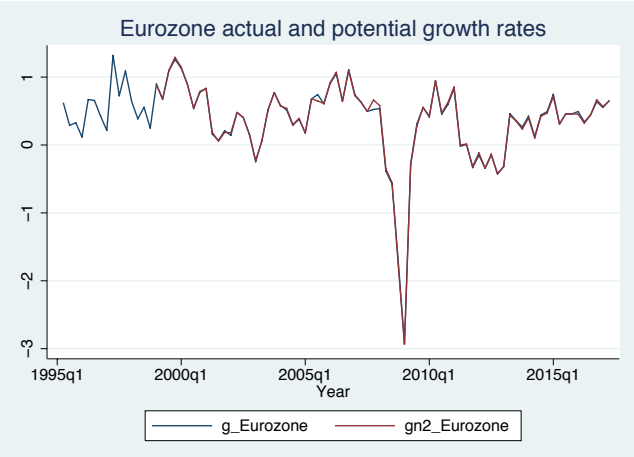


Source: Author's calculations Panel (a) Panel (b)

On the other hand, for the Eurozone, the strongest results are reached using the extension proposed by Romer (1993) i.e. adding the share of imports in gross domestic product to the original model (*Equation (12)*) (*Figure 2 Panel (a)*); the estimated series in this case is called *gn1_Eurozone*. Also for the Euro Area, I selected the estimate produced by *Equation (11)* as the second preferable model (named *gn2_Eurozone*), even if the convergence between g and g_t^N series is also present here (*Figure 2 Panel (b)*). The difference between these two estimates is that the second one presents the deepest values during the crisis period compared to the model with the imports share. *Figure 2* shows, for the Euro Area, the selected estimation results of the natural growth rate (*gn1_Eurozone* and *gn2_Eurozone*) and the actual growth rate (*g_Eurozone*).

Figure 2. **Eurozone actual and potential growth rates**





Source: Author's calculations Panel (a) Panel (b)

4. Linear Regression Model and Results

Having selected the best time-series estimates of g_t^N for the US and Eurozone economies, in this section I turn to the investigation of the impact (or not) of QE policies on the potential output growth; the regressions are performed using the estimated series *gn1_US* and *gn1_Eurozone*. These results are obtained through the OLS methodology and using the central bank acquisitions of domestic assets (*qe*), as proxy for QE, as proposed by Gagnon et al. (2017). "For the major advanced economies, this proxy corresponds well with the unconventional policy known as Quantitative Easing. This definition measures the extent to which the central bank expands its balance sheet to take risk off the balance sheets of domestic market participants, thus potentially easing financing conditions. Indeed, the measure looks broadly as expected in known QE cases following the Global Financial Crisis" (Gagnon et al. 2017).

Given that potential output growth is defined as the sum of the growth rates of labour force and labour productivity, in the regression I also considered potential determinants of g_t^N. These potential determinants and their definitions and data sources are presented in *Table 2*. Since the potential growth rate is the particular rate that actual growth tends to in the long run, the set of determinants of potential growth I took into account reflects a set of variables typically considered to affect actual growth in the long run. Therefore, I introduce the labour force trend (*g_lf_tr*) and, as proxies of labour productivity, the degree of openness to international trade (*openness*), the expenditure in R&D (*exp_rd*), and the gross enrolment tertiary ratio (*ger t*).

Table 2. **Variables specification**

Variable	Description	Source
qe	Net domestic assets (% nominal GDP)	IFS dataset /Author's calculation
g_lf_tr	Labour force growth trend	OECD dataset /Author's calculation
openness	Imports + Exports shares (%nominal GDP)	IFS dataset /Author's calculation
exp_rd	Total R&D expenditure (%nominal GDP)	FRED dataset /Eurostat
ger_s	Gross enrolment ratio, secondary, both sexes (%total enrolment)	World Bank dataset
qe_openness	Interaction term (*qe* × *openness*)	Author's calculation
gdev	Average deviation of actual growth from the potential growth rate ($g_t - g_t^N$)	Author's calculation

Source: Author

In the succeeding step of my empirical investigation, I estimate the following dynamic *Model (1)* for both areas under analysis:

$$g_{it}^{N} = \text{l}.qe_{it} + \text{l}.openness_{it} + l.g\_lf\_tr_{it} + l.\exp\_rd_{it} + l.ger\_s_{it} + \varepsilon_{it} \quad (14)$$

Trying to assess the possibility of endogeneity, the regressors are instrumented with first lag. The results from *Equation (14),* reported in the second columns of *Table 3* (US) and *Table 4* (Eurozone), are not so much in line with expectations. In particular, the coefficient on *qe*, which represents the elasticity of natural output with respect to an increase in net domestic assets, is positive for the US, representing a small but not significant impact on potential output growth; on the other hand, for the Eurozone the coefficient of *qe* is not significant, demonstrating the absence of an impact on potential growth rate.
Moreover, the coefficient of *g_lf_tr*, which represents the elasticity of potential output with respect to the labour force growth trend, is positive and significant in both cases, but is not as close to 1 as expected. Given that suggestions from theory report that a 1% increase in the labour force growth leads to a 1% increase in potential output growth, and this is consistent with the definition of the natural growth rate used in this paper, these results indicate that *g_lf_tr* is probably a proxy that does not work well for the potential long-run growth rate of the labour force.
All other variables turn out to be not significant for the US and enter with a negative sign, while for the Eurozone the coefficient on the secondary enrolment (*ger_s*) is significant and positive, and the coefficient of the degree of openness in international trade (*openness*) is significant but negative. However, considering that potential output growth rate is an estimation result, it is difficult to check for measurement errors.

Given that QE has a different impact on potential output depending on the degree of openness to international trade, I performed a second regression model, represented by *Equation (15),* adding the new proxy *qe_openness* that represents the interaction term between *qe* and *openness.* The interaction term is constructed as simple product of QE with openness (*qe_openness*= *qe*×*openness*).

$$g_{it}^{N} = \text{l}.qe_{it} + \text{l2}.qe_{it} + openness_{it} + \text{l}.qe\_openness_{it} + \text{l2}.qe\_openness_{it} + g\_lf\_tr_{it} + \exp\_rd_{it} + ger\_s_{it} + \varepsilon_{it} \quad (15)$$

This extension of the benchmark model is tested with the addition of a second lag for the *qe* and *qe_openness* regressors, given that expectations are in line with a delayed effect of these variables on potential output. Moreover, the first lag for the variables *openness, g_lf_tr, exp_rd* and *ger_s* it is also dropped here. For the US, *Model (2)* does not show any significance on the coefficients, while in the Eurozone case the second lags of these regressors are significant and, overall, a better performance of the model is shown.

In the third columns of *Table 3* and *Table 4* the results coming from *Model (3)* are reported, a variation of the previous model that contains only the first lag on *qe* and *qe_openness* regressors *(Equation (16)).*

$$g_{it}^{N} = \text{l}.qe_{it} + openness_{it} + \text{l}.qe\_openness_{it} + g\_lf\_tr_{it} + \exp\_rd_{it} + ger\_s_{it} + \varepsilon_{it} \quad (16)$$

Model (3) shows better results for both economies: the coefficient on QE *(qe)* displays a positive and statistically significant effect on g_t^N, expressing that a 1% increase in net domestic assets corresponds to an impact on potential output growth of 0.90% for the US and 0.20% for the Eurozone. Regarding the new proxy *qe_openness,* with *qe* being equal, the greater the openness of an economy to international trade, the smaller the coefficient of the interaction term will be. Looking at the other results, the coefficient of *g_lf_tr* is always greater than 1, leaving this outcome still puzzling, while the coefficient of *ger_s,* the human capital proxy, is always statistically significant.

I also explored the possibility that other business cycle features may play a role by including the variable *gdev* as an additional regressor in the model, which expresses the average deviation of actual growth rate from potential growth rate ($gdev = g_t - g_t^N$). The last columns of *Tables 3* and *Table 4* show the results of *Equation (17),* the model (*Model (4)*) that contains the new proxy, *gdev*. With *Model (4)* the overall best performance for both areas is reached: the *qe* coefficient shows a positive and statistically significant effect on potential output growth, demonstrating that a 1% increase in domestic assets corresponds to an effect on g_t^N of 0.95% for the US and 0.20% for the Eurozone. Regarding the other proxies, results in this case do not add relevant information compared to *Model (3)*. Moreover, in the Eurozone case there is no statistical evidence that deviations of the actual from the potential growth rate (proxied by *gdev*) play a significant role. Thus, this outcome suggests that the decline in actual growth associated with the 2008/09 global financial crisis can be expected not to leave permanent signs on long-term growth. However, the proxy *gdev* for the US shows a negative and significant effect, demonstrating in this case that the deviation of the actual from the potential growth rate may have a negative effect of 1.35% on long-term US growth.

$$g_{it}^N = \mathrm{l}.qe_{it} + openness_{it} + \mathrm{l}.qe\_openness_{it} + g\_lf\_tr_{it} + \exp\_\mathrm{rd}_{it}. + ger\_s_{it} + l.gdev_{it} + \varepsilon_{it} \qquad (17)$$

Table 3. **Determinants of US g_t^N: OLS Estimations**

Variable	Model (1)	Model (2)	Model (3)	Model (4)
qe	-	-	-	-
L1.	0.040*	0.183	0.905***	**0.957*** **
L2.	-	0.523	-	-
openness	-	0.130	0.250**	**0.242*** **
L1.	-0.090	-	-	-
qe_openness	-	-	-	-
L1.	-	-0.007	-0.028***	**-0.029*** **
L2.	-	-0.014	-	-
g_lf_tr	-	8.387*	10.114***	**9.239*** **
L1.	3.801**	-	-	-
exp_rd	-	-1.000	-0.796	**-0.698**
L1.	-0.470	-	-	-
ger_s	-	-0.256	-0.310**	**-0.245** **
L1.	-0.098	-	-	-
gdev	-	-	-	-
L1.	-	-	-	**-1.356*** **

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

Table 4. **Determinants of Eurozone g_t^N: OLS Estimations**

Variable	Model (1)	Model (2)	Model (3)	Model (4)
qe	-	-	-	-
L1.	-0.008	0.085	0.207***	**0.204*** **
L2.	-	0.137***	-	-
openness	-	0.045*	0.058**	**0.056**
L1.	-0.056***	-	-	-
qe_openness	-	-	-	-
L1.	-	-0.001	-0.002***	**-0.002*** **
L2.	-	-0.001***	-	-
g_lf_tr	-	5.891***	4.738***	**4.765*** **
L1	2.875**	-	-	-
exp_rd	-	-0.430	-0.590	**-0.505**
L1.	-0.259	-	-	-
ger_s	-	0.178***	0.156***	**0.155*** **
L1.	0.199***	-	-	-
gdev	-	-	-	-
L1.	-	-	-	**0.018**

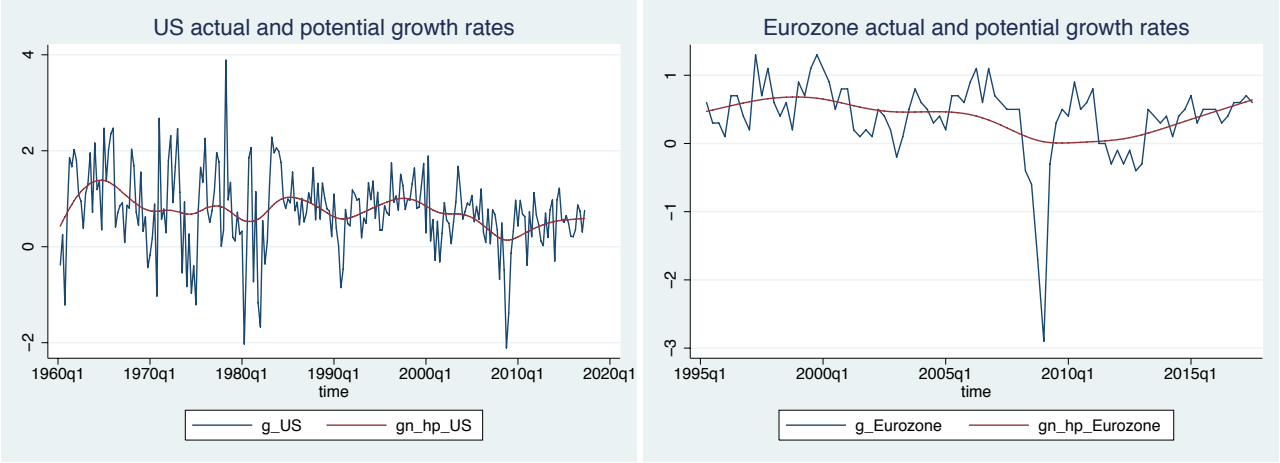
Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

5. Robustness Checks

In this section, an alternative way to estimate the potential output growth rate of the US and Eurozone economies is presented. Thus, this robustness check allows to compare findings on the growth potential rates estimated in *Section 3* with one of the other possible computation approaches existing in literature and presented in *paragraph 3.2.* Successively, I performed the four regression models highlighted in *Section 4*, to detect the impact of QE on the 'new' natural growth rates obtained.

The methodology used for the estimation of potential growth rates in the main analysis was the multivariate approach, which links statistical filters with a structural economic theory. The basic model generally involves a bivariate structural time series that relates fluctuations in output with inflation. Instead, in this section the estimations of the natural growth rates are performed with the univariate filters procedure. As underlined, this is a statistical approach that is not based on any underlying economic theory and uses information only on GDP. Therefore, this methodology is developed by filtering GDP data into a cyclical/noise component and a trend component, using various statistical specifications. In this case, I decided to use the Hodrick-Prescott (HP) filter. The estimation results are reported in *Figure 3*.

Figure 3. **United States and Eurozone 'HP' potential growth rates**



Source: Author's calculations Panel (a) Panel (b)

With respect to the previous potential output growth estimates (*gn1_US* and *gn1_Eurozone*), here only the 'trend' component of the series (*gn_hp_US* and *gn_hp_Eurozone*) is observable as the cyclical component from the raw data is statistically dropped; the series now presents more 'smoothness' in both cases. As before, the blue line represents the actual growth rate (*g_US* and *g_Eurozone*).

In the next step, I estimated for both areas, the four dynamic models presented in the previous section. The results for both economies are presented in *Table 5*, where only the most significant model, i.e. *Model (2)* in this case is reported.

Table 5. **Determinants of g_t^N: OLS Estimations on 'HP' potential growth rates**

Variable	Model (2) US	Model (2) Eurozone
qe	-	-
L1.	-0.151***	-0.003
L2.	0.112***	0.007**
openness	-0.034***	0.002
L1.	-	-
qe_openness	-	-
L1.	0.005***	0.000
L2.	-0.003***	-0.000**
g_lf_tr	2.261***	2.473***
L1.	-	-
exp_rd	-0.143**	0.589***
L1.	-	-
ger_s	-0.059***	0.022***
L1.	-	-
gdev	-	-
L1.	-	-

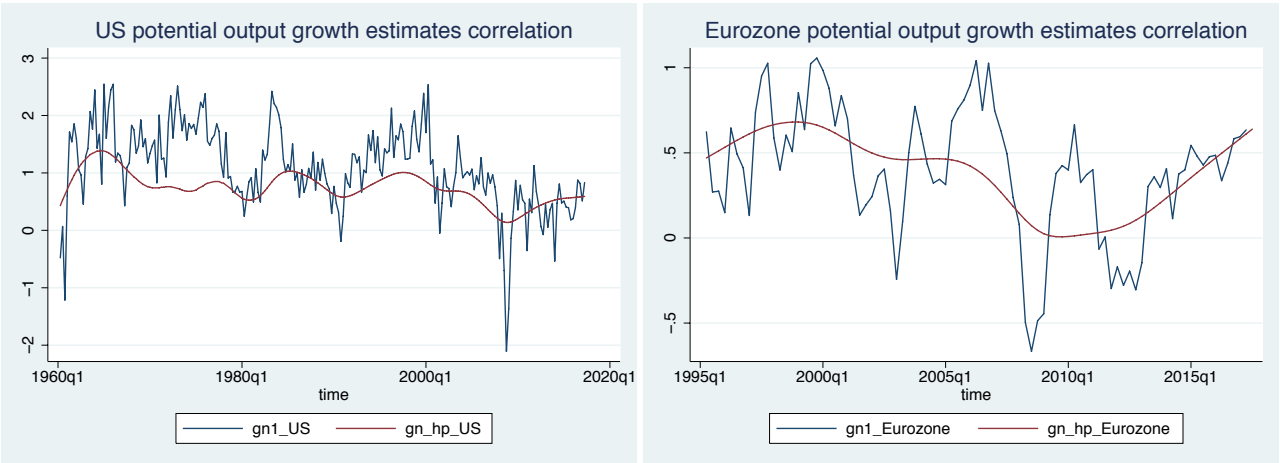
Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

The results of these two new regressions show that, in the US case, the *qe* coefficient (first lag) has a negative and statistically significant sign (-0.15%) (even if the percentage is very small), while in the main regression the result showed a positive impact of QE on the potential output growth of 0.95%. However, the *qe* coefficient of the second lag presents a positive and statistically significant sign (0.11%), representing that, even if in the first period the effect of central bank asset acquisitions may be negative, in the long run it tends to become positive. Has expected, given the smoothness of the potential output series obtained with the HP filter, with respect to the previous g^N series, the effects are visible more gradually and are positive in the long run. Also the *openness* coefficient now shows a negative sign, while in the previous regression it was positive (0.24%). Instead, the *qe_openess* (first lag) coefficient now is positive and not negative as before (-0.02%). The results remain invariant in the case of the *g_lf_tr* coefficient, still positive and statistically significant, and *exp_rd* and *ger_s,* still negative in their signs.

On the other hand, also for the Eurozone the *qe* coefficient is negative in the first lag (-0.003%) but not statistically significant, and positive and significant in the second lag, even if the impact of the asset purchases is very small in this case (0.007%) compared to the previous regression (0.20% of positive impact). Regarding the other coefficients, *qe_openess* remains negative (even if the impact is practically null), *g_lf_tr* is also here positive (with an impact of 2.47% instead of 4.76%), *exp_rd* is now positive and significant, and *ger_s* remains positive.

The divergent results of these last regressions, compared to the main models, can be explained by the visible difference in the estimated series of potential output growth, produced following two different methodologies. In *Figure 4* the correlation between the potential output growths estimated following the multivariate approach (*gn1_US* and *gn1_Eurozone*) and the natural growth rates estimated with the Hodrick-Prescott filter methodology (*gn_hp_US* and *gn_hp_Eurozone*) is reported, which present smallest values.

Figure 4. **US and Eurozone g_t^N estimates correlation**



Source: Author's calculations Panel (a) Panel (b)

The estimated series of potential output growth show few correlation points because, as underlined in *paragraph 3.2*, the HP procedure is a statistical approach that is not based on any economic theory and indicates a merely statistical estimation of the tendencies in GDP data. On the contrary,

the multivariate approach involves a linkage with structural economic theory and the rate of growth obtained is coherent with the concept of 'macroeconomic stability'. As specified by Blagrave et al. (2015), the multivariate methodology represents the optimal equilibrium between the statistical filters (such as the HP) and the models that propose larger theoretical consistency but are more problematic to apply broadly.

6. Conclusions

The focus of this research was to assess the impact of an increase of domestic assets in the balance sheets of the FED and the ECB following the global financial crisis that started in 2007/08. Overall, QE polices were introduced to boost the economy in its recovery. Acting through the monetary policy transmission channels, these unconventional monetary programmes were implemented to positively influence also the labour productivity growth rate and the potential growth rate. I provided quarterly and annual estimates of potential growth for the US and Eurozone economies by using an AS state-space model with time-varying parameters and a Kalman filtering methodology.
Next, I selected the best time series estimates for each area and I regressed a dynamic model where variables are instrumented with first lag, using a proxy for QE policies, and four proxies for labour force and labour productivity. Later, three different variations of the initial model were proposed. The strongest results are reached with *Model (4),* where the coefficient of QE shows a positive and statistically significant effect on g_t^N, expressing that a 1% increase in domestic assets corresponds to an impact on potential output of 0.95% for the US and 0.20% for the Eurozone. Therefore, these results are in line with one of the main objectives of central banks in the wake of the financial crisis, i.e. to help the economy in its recovery, facilitating an increment of the long-run growth rate.
Thus, this analysis links to literature findings regarding the effects of QE, and UMPs in general, on the macro framework; the majority of estimates show that the acquisition of domestic assets, such as the other UMPs, led to an increase of real output in the Euro Area, as well as for the US the increment is assessed of around 0.36-3%. Moreover, the contribution of the work is innovative as the estimates are produced using the potential output growth rate instead of the real GDP.

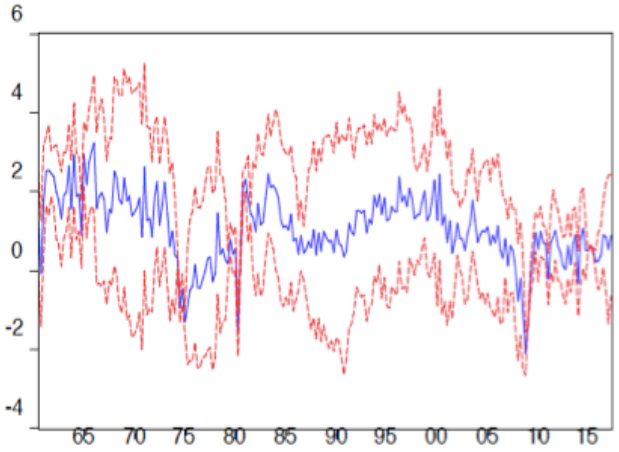
Appendix. Supplemental results and analysis

Table A1. **Potential output estimation models (Annual and Quarterly)**

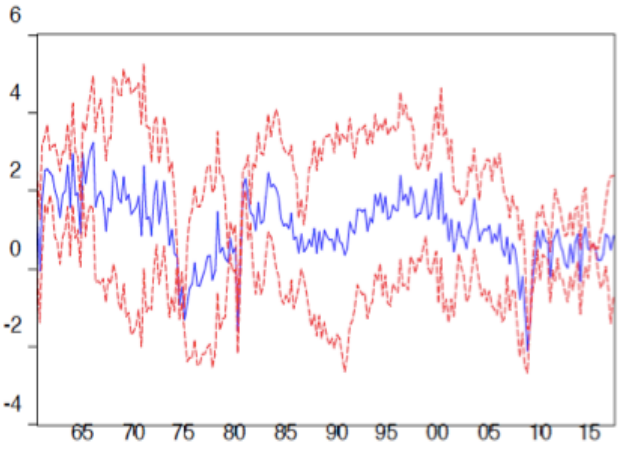
Model 1	Model 2	Model 3
$g_t = g_t^N + \frac{(1-\alpha_t)}{\varphi_t}\pi_t + \varepsilon_t$	$g_t = g_t^N + \frac{1}{\varphi_t}\Delta\pi_t + \varepsilon_t$	$g_t = g_t^N + \frac{1}{\varphi_t}(\pi_t - \pi_t^e) + \varepsilon_t$
Model 1_infl (Inflation CPI)	*Model 2_infl* (Inflation CPI)	*Model 3_infl* (Expected inflation)
Model 1_m.infl (Inflation CPI + share of imports in GDP)	*Model 2_m.infl* (Inflation CPI + share of imports in GDP)	*Model 3_m.infl* (Expected inflation + share of imports in GDP)
Model 1_mx.infl (Inflation CPI + share of imports and exports in GDP)	*Model 2_mx.infl* (Inflation CPI + share of imports and exports in GDP)	*Model 3_mx.infl* (Expected inflation + share of imports and exports in GDP)
Model 1_defl (GDP deflator)	*Model 2_defl* (GDP deflator)	—
Model 1_m.defl (GDP deflator + share of imports in GDP)	*Model 2_m.defl* (GDP deflator + share of imports in GDP)	—
Model 1_mx.defl (GDP deflator + share of imports and exports in GDP)	*Model 2_mx.defl* (GDP deflator + share of imports and exports in GDP)	—

Source: Author

Section A1. **Potential output graphics and AIC:**
US_Quarterly



Model 1_infl *AIC: 2.88*



Model 1_m.infl *AIC: 2.89*

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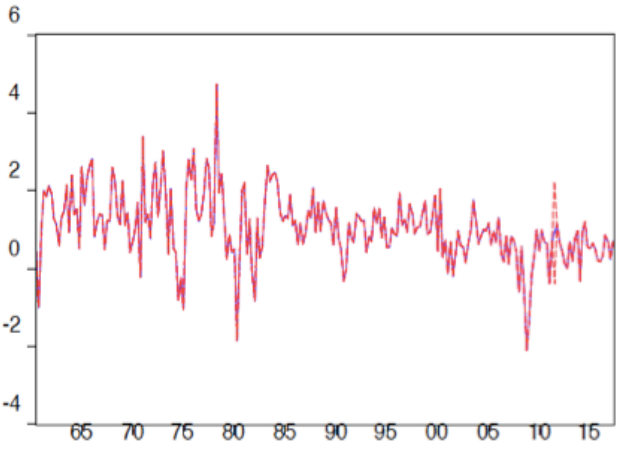
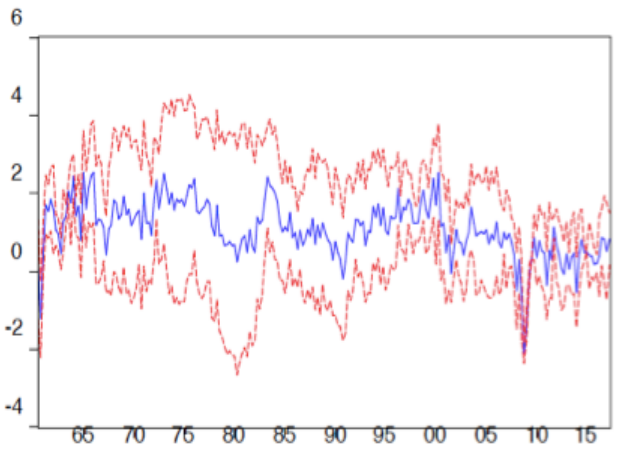


Model 1_mx.infl *AIC: 2.96*



Model 1_defl *AIC: 2.75*

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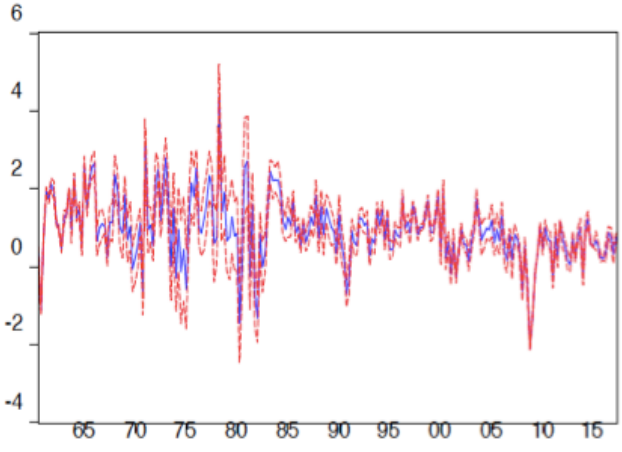
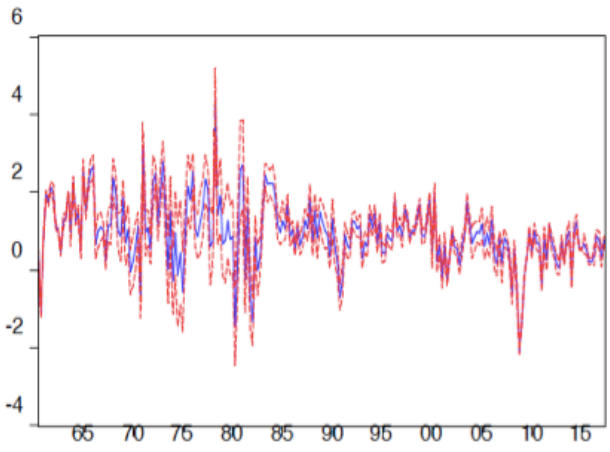


Model 1_m.defl *AIC: 2.88*



Model 1_mx.defl *AIC: 2.88*

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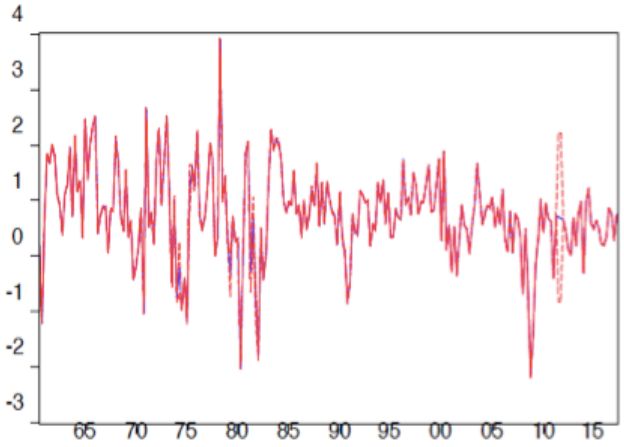
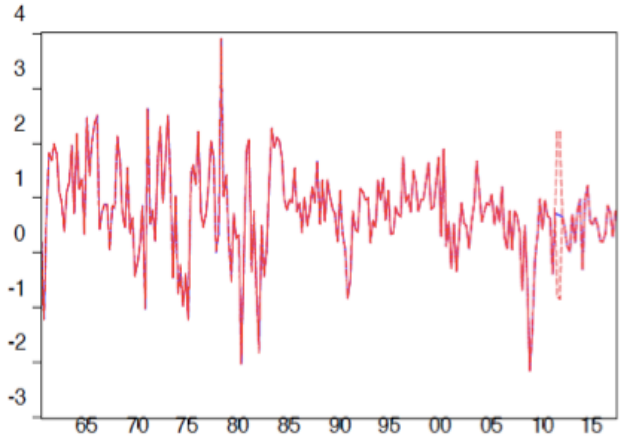


Model 2_infl *AIC: 3.05*



Model 2_m.infl *AIC: 3.03*

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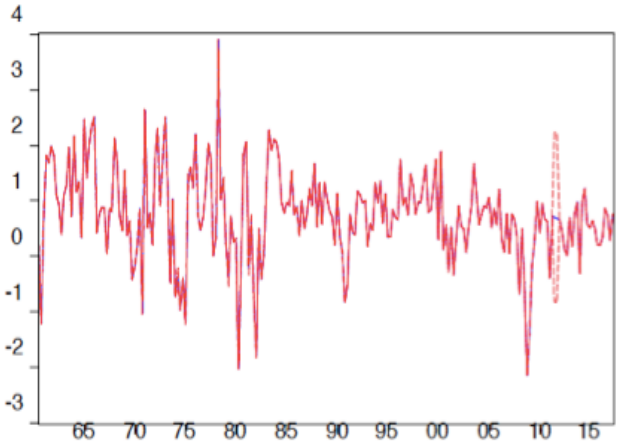
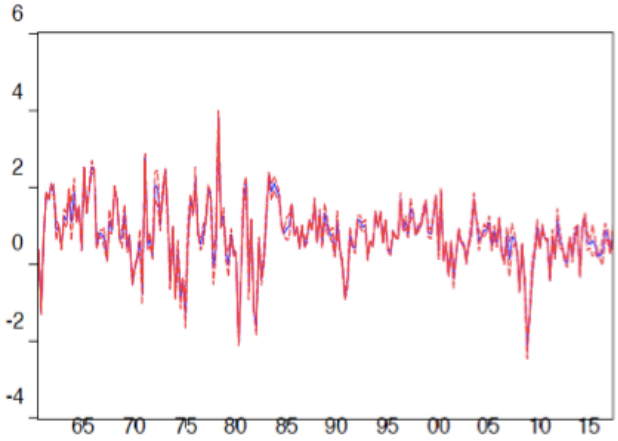


Model 2_mx.infl *AIC: 3.00*



Model 2_defl *AIC: 2.87*

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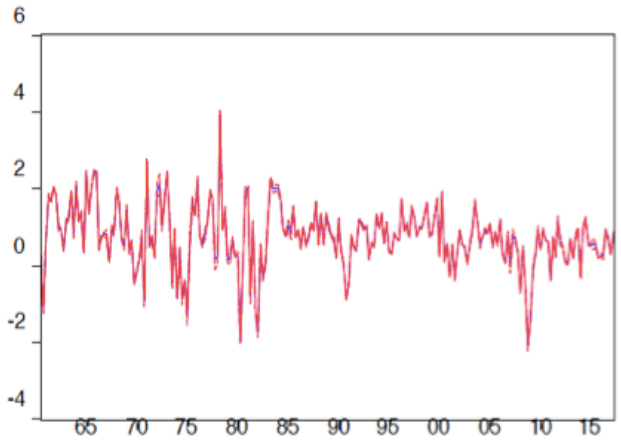
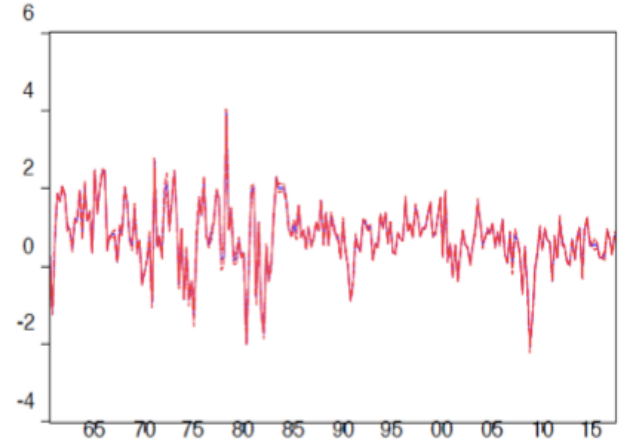


Model 2_m.defl *AIC: 2.89*



Model 2_mx.defl *AIC: 2.89*

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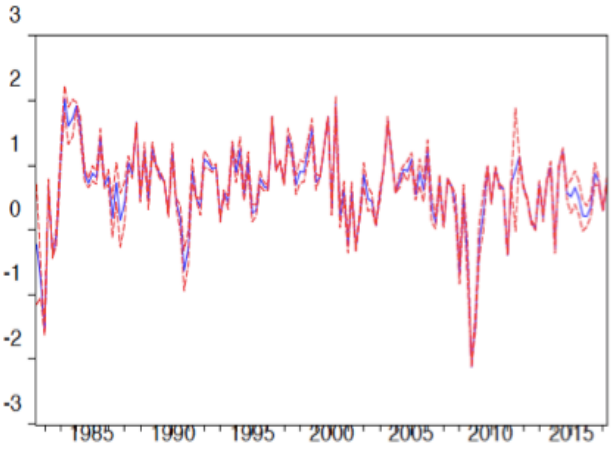
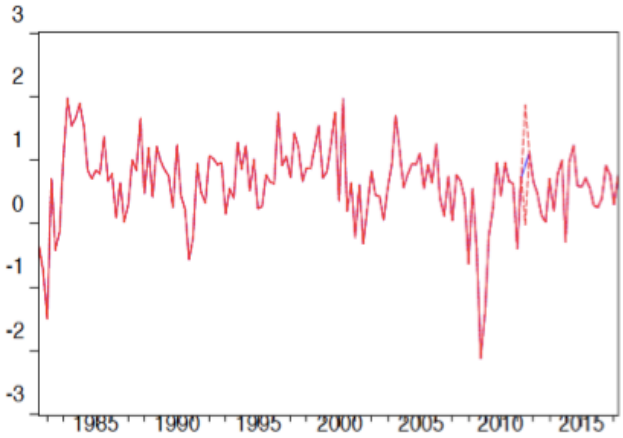
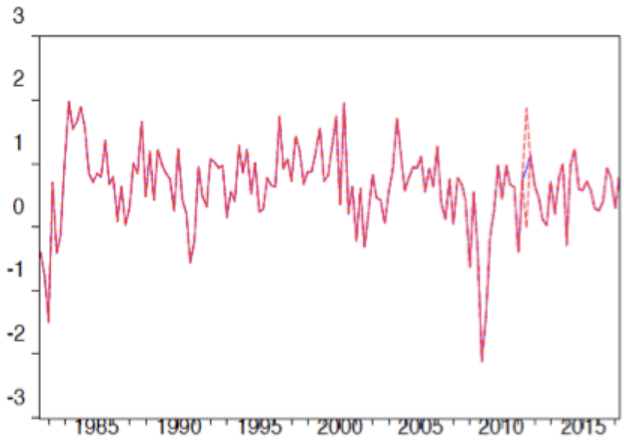


Model 3_infl *AIC: 2.47*



Model 3_m.infl *AIC: 2.46*

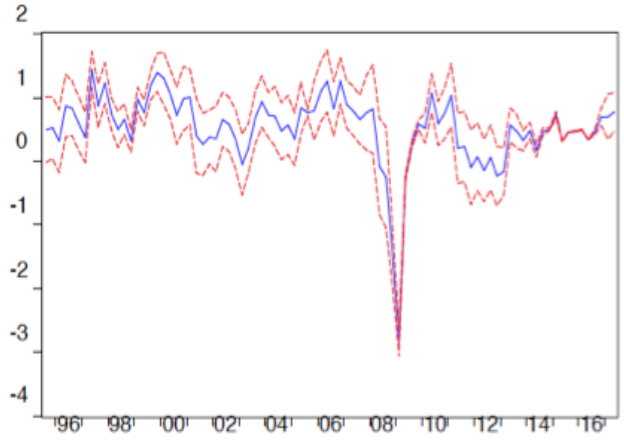
—TR - - - -2MRSE



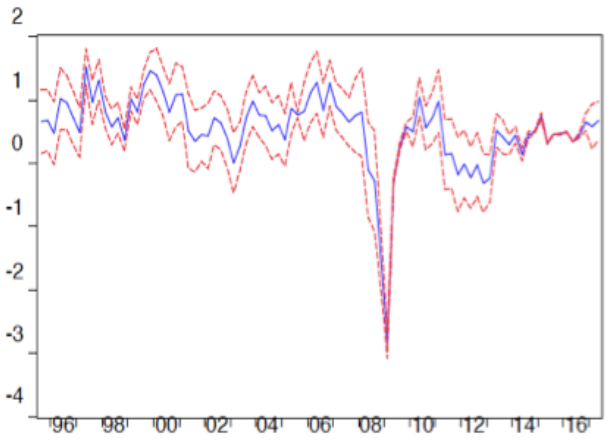
Model 3_mx.infl *AIC: 2.46*

—TR - - - -2MRSE

Section A2. **Potential output graphics and AIC:**
Eurozone_Quarterly

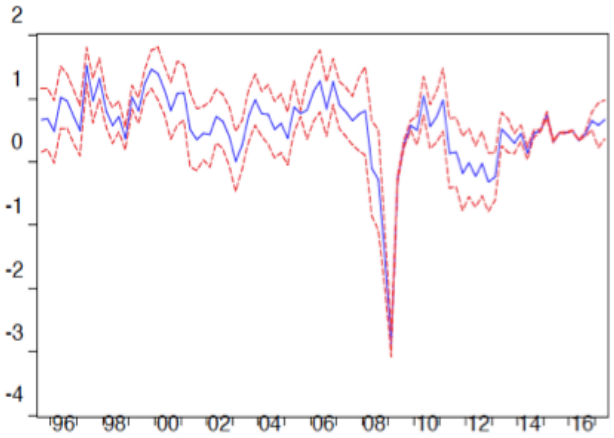


Model 1_infl *AIC: 1.75*

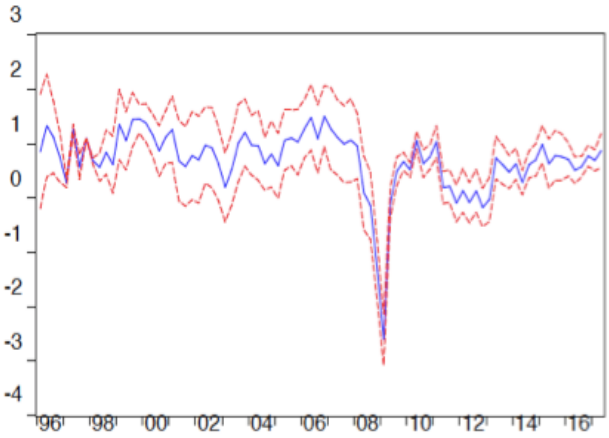


Model 1_m.infl *AIC: 1.77*

—TR - - - -2MRSE

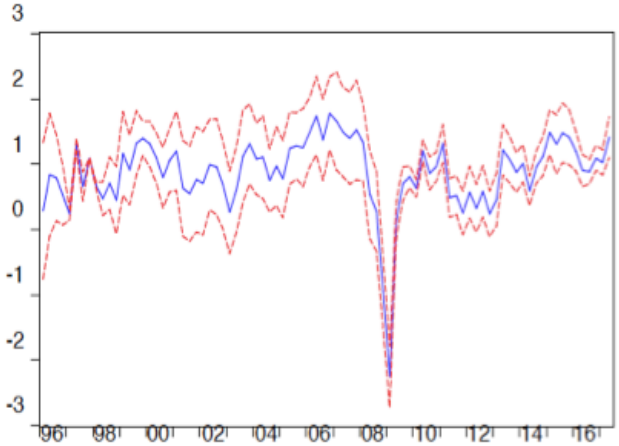


Model 1_mx.infl *AIC: 1.77*

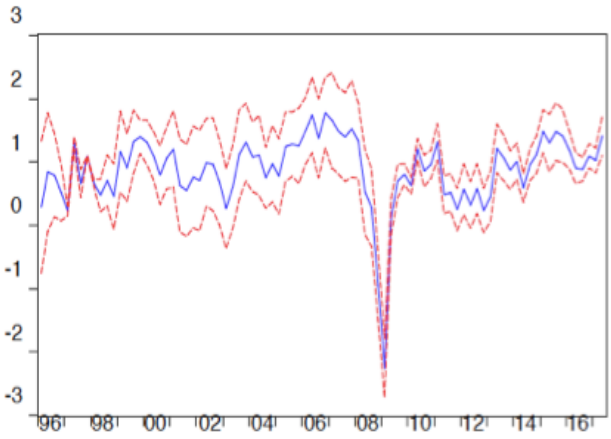


Model 1_defl *AIC: 1.77*

—TR - - - -2MRSE

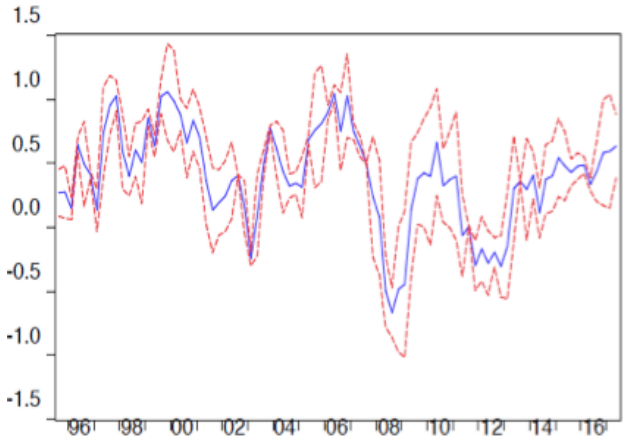


Model 1_m.defl *AIC: 1.78*

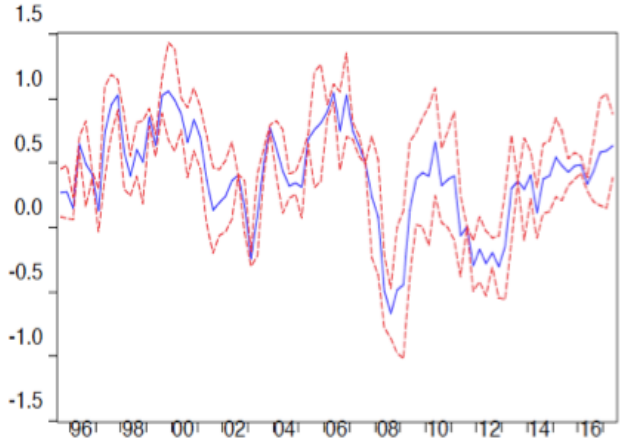


Model 1_mx.defl *AIC: 1.78*

—TR - - - -2MRSE

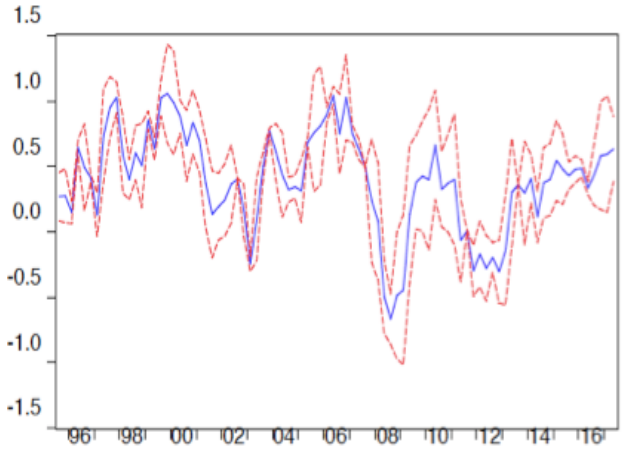


Model 2_infl *AIC: 1.52*

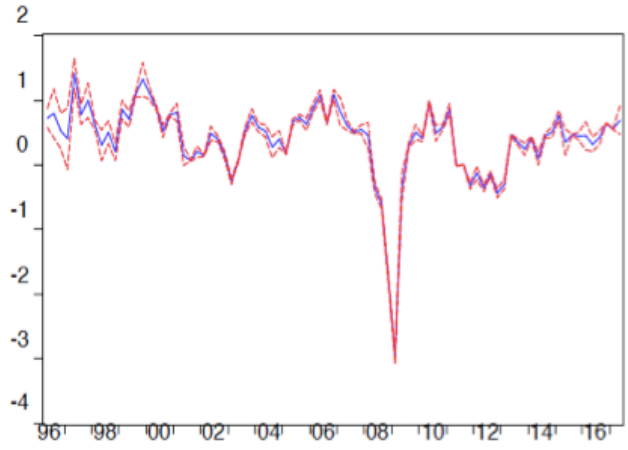


Model 2_m.infl *AIC: 1.54*

—TR - - - -2MRSE

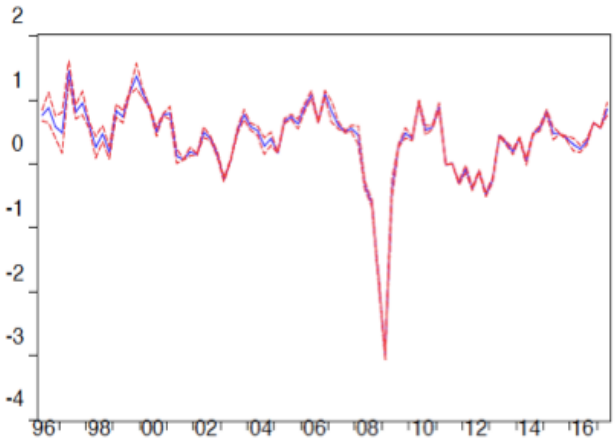


Model 2_mx.infl *AIC: 1.54*

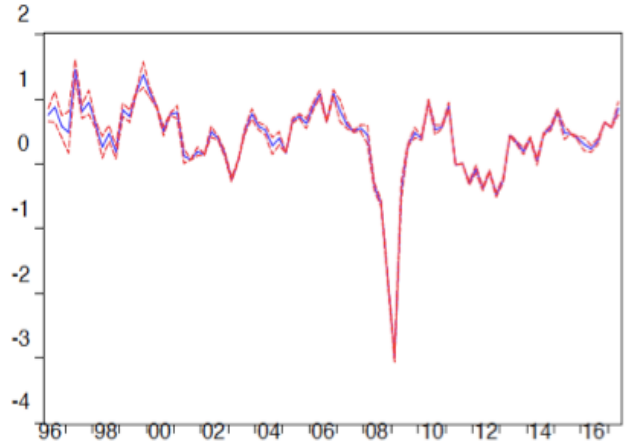


Model 2_defl *AIC: 1.79*

—TR - - - -2MRSE

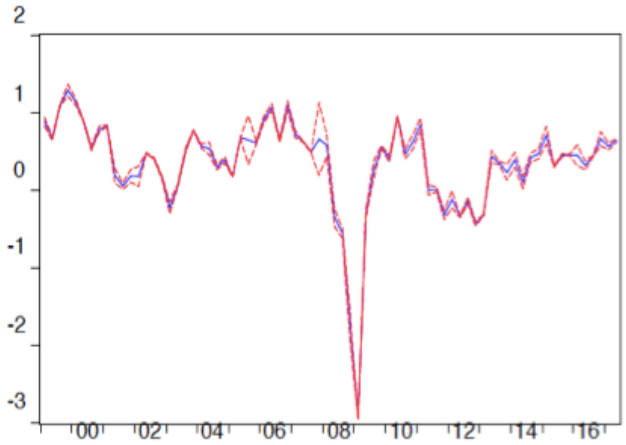


Model 2_m.defl *AIC: 1.80*

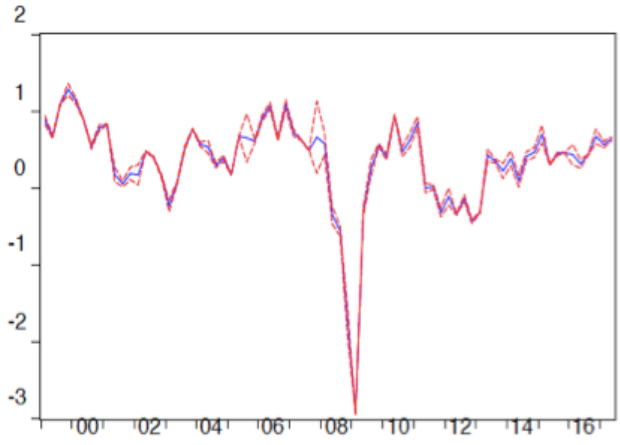


Model 2_mx.defl *AIC: 1.80*

—TR - - - -2MRSE

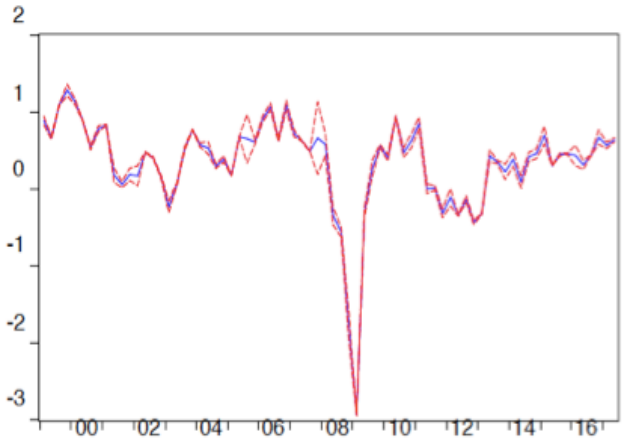


Model 3_infl *AIC: 1.86*



Model 3_m.infl *AIC: 1.89*

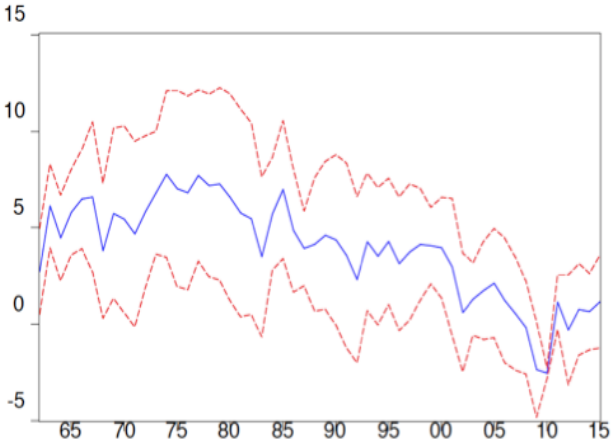
—TR - - - -2MRSE



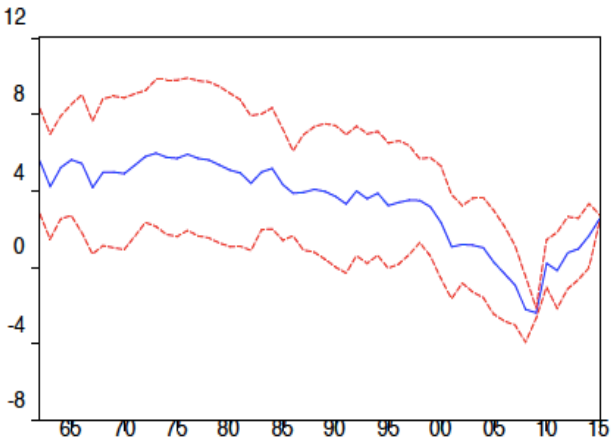
Model 3_mx.infl *AIC: 1.89*

—TR - - - -2MRSE

Section A3. **Potential output graphics and AIC:**
US_Annual

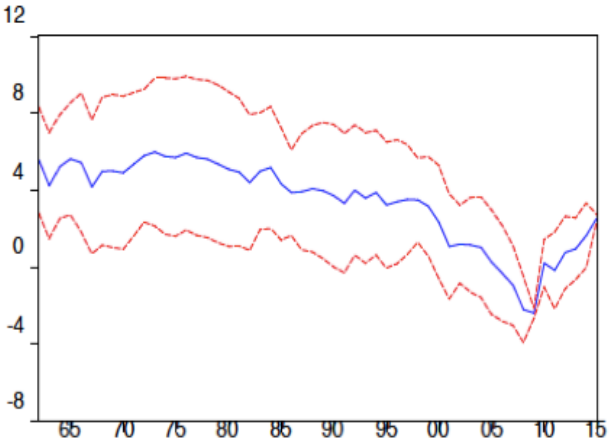


Model 1_infl *AIC: 5.08*

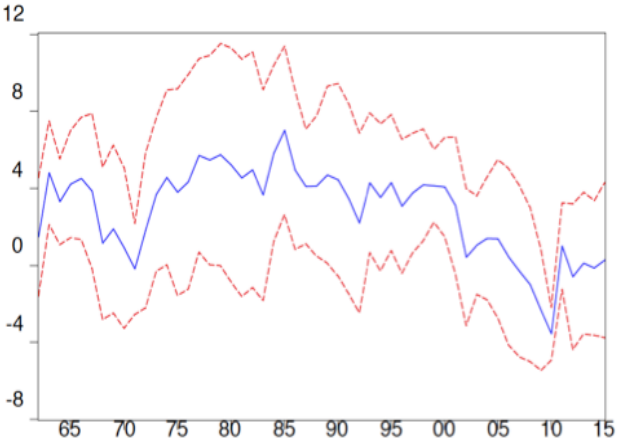


Model1_m.infl *AIC: 5.19*

TR - - - -2MRSE

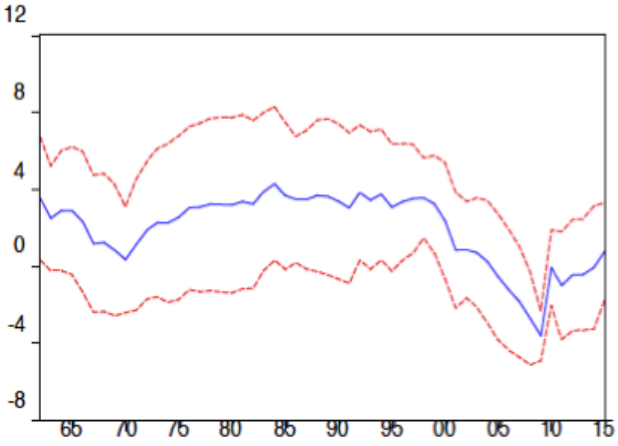


Model 1_mx.infl *AIC: 5.19*

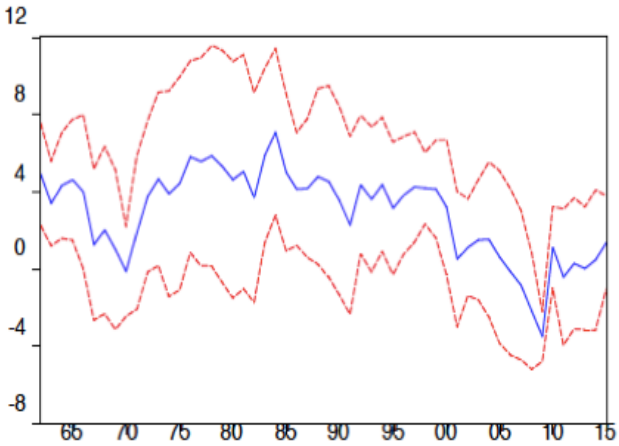


Model 1_defl *AIC: 5.09*

TR - - - -2MRSE

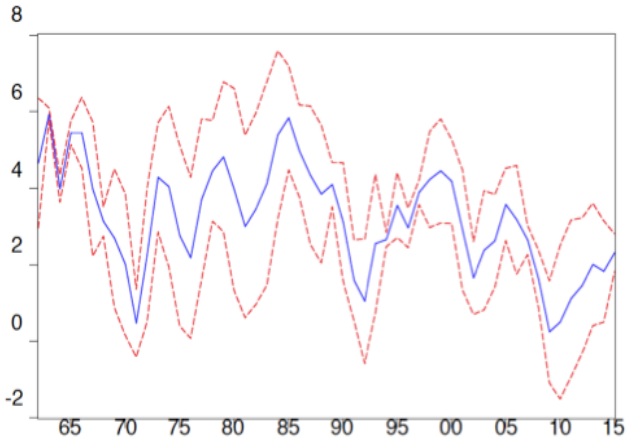


Model 1_m.defl *AIC: 5.26*

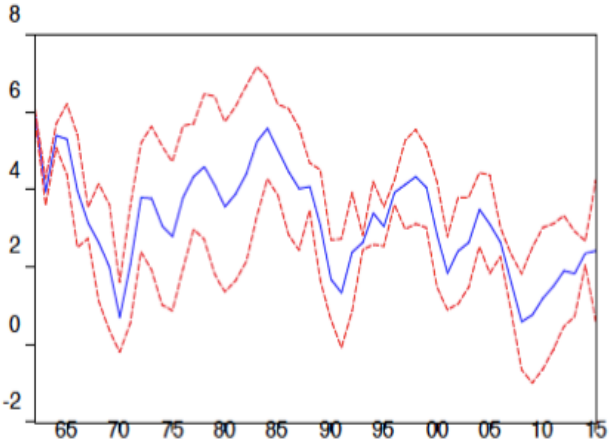


Mode 1_mx.defl *AIC: 5.10*

TR - - - -2MRSE

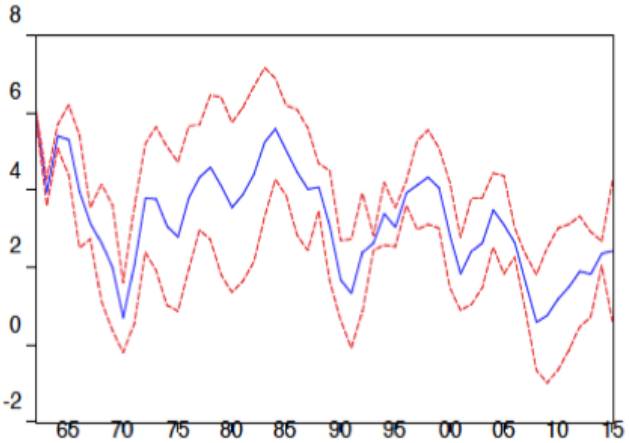


Model 2_infl *AIC: 5.15*

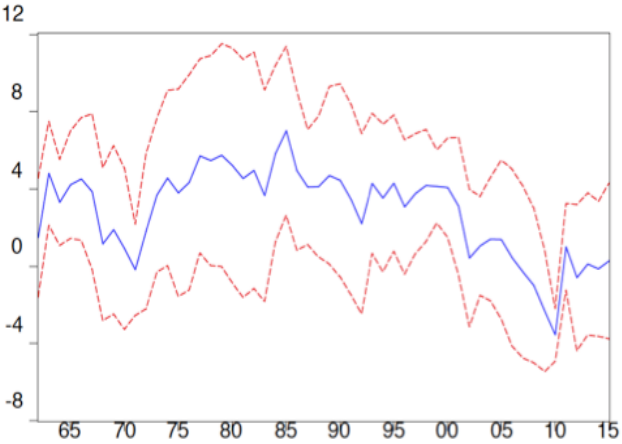


Model 2_m.infl *AIC: 5.22*

—TR - - - -2MRSE

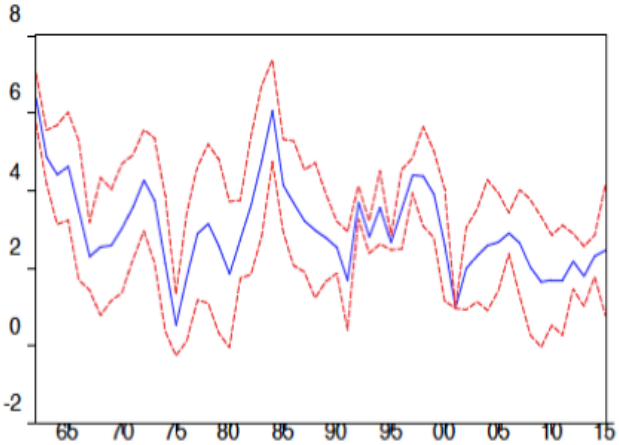


Model 2_mx.infl *AIC: 5.22*

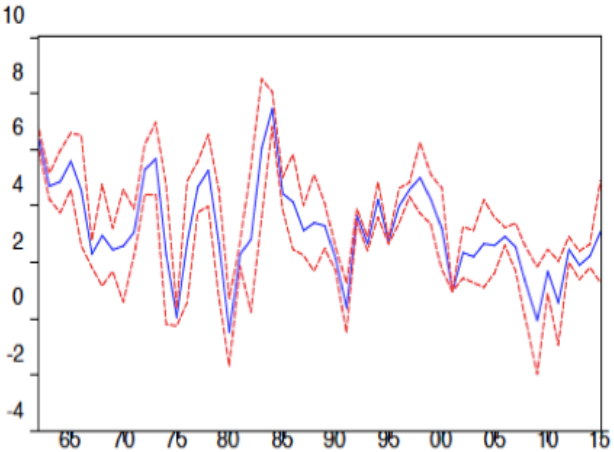


Model 2_defl *AIC: 5.09*

—TR - - - -2MRSE

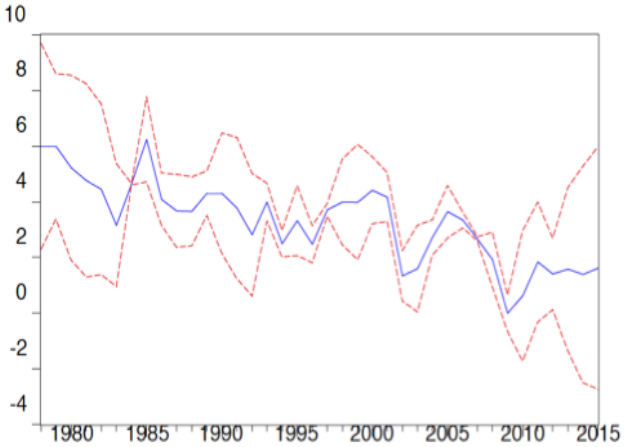


Model 2_m.defl *AIC: 5.24*

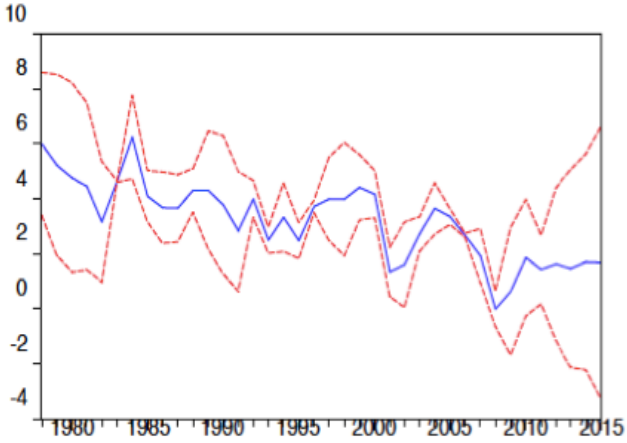


Model 2_mx.defl *AIC: 4.98*

—TR - - - -2MRSE

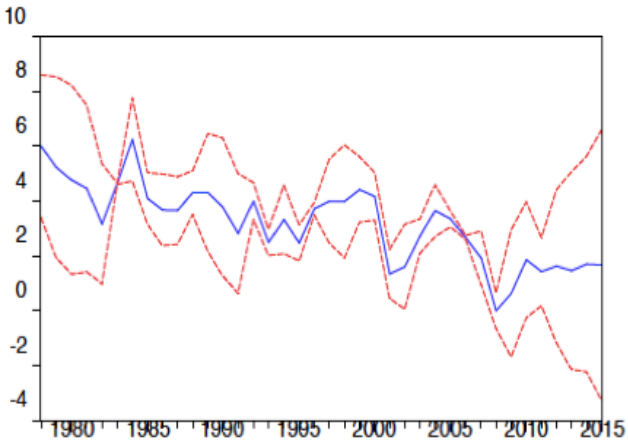


Model 3_infl *AIC: 5.13*



Model 3_m.infl *AIC: 5.16*

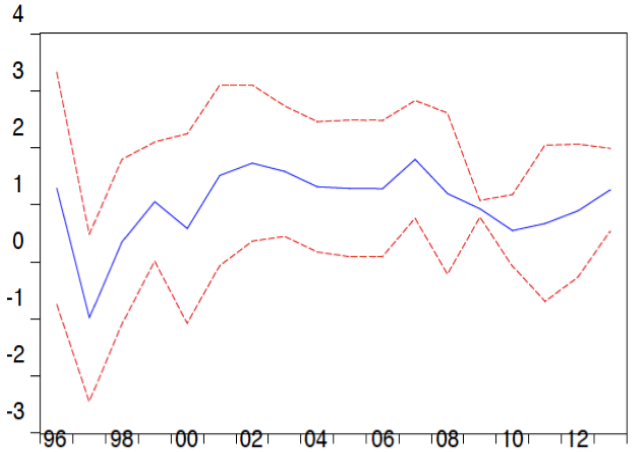
—TR - - - -2MRSE



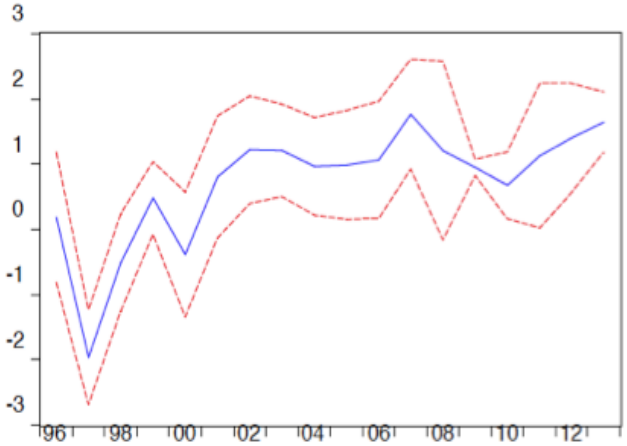
Model 3_mx.infl *AIC: 5.16*

—TR - - - -2MRSE

Section A4. **Potential output graphics and AIC:**
Eurozone_Annual

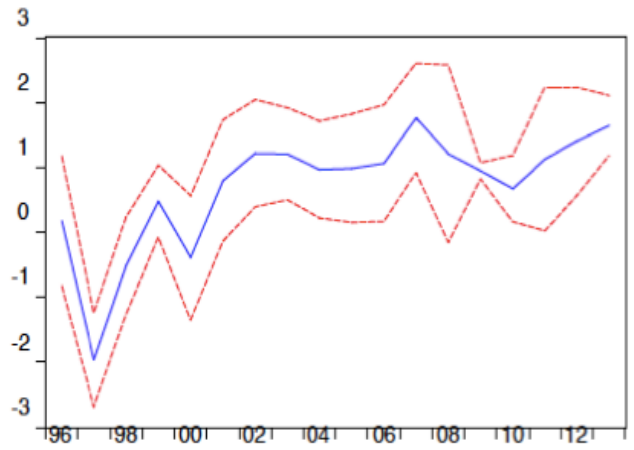


Model 1_infl *AIC: 4.43*



Model 1_m.infl *AIC: 4.47*

—TR - - - -2MRSE



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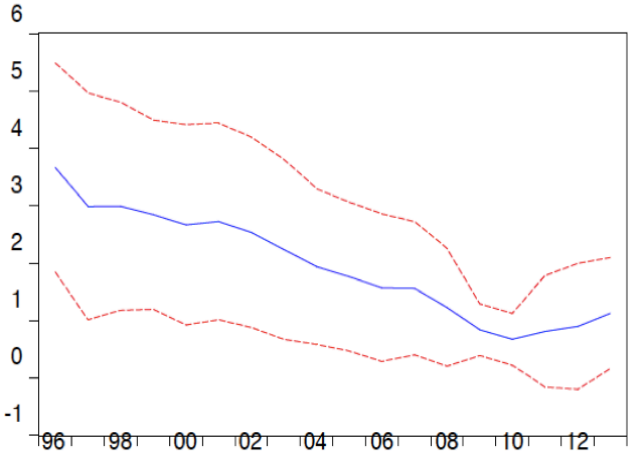
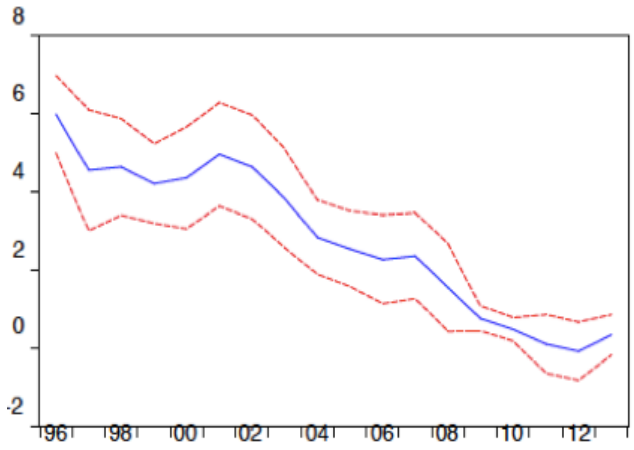
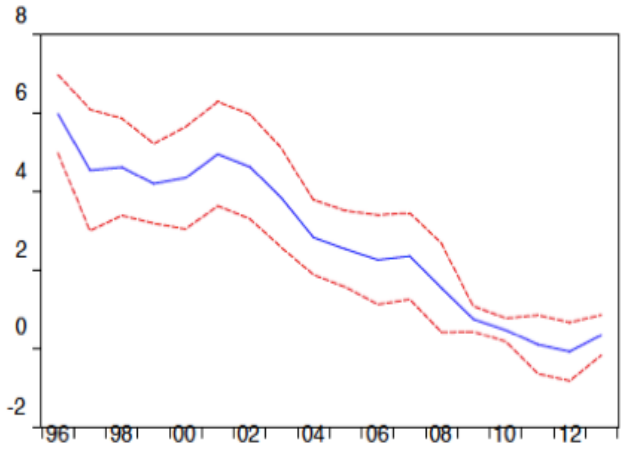


Model 1_defl *AIC: 3.95*

—TR - - - -2MRSE

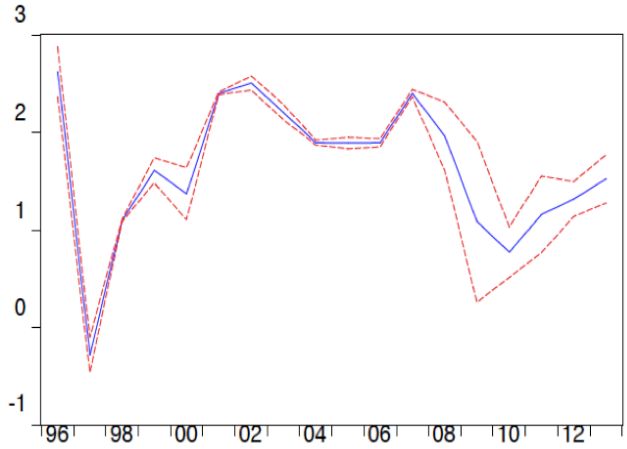


Model 1_m.defl *AIC: 3.89*

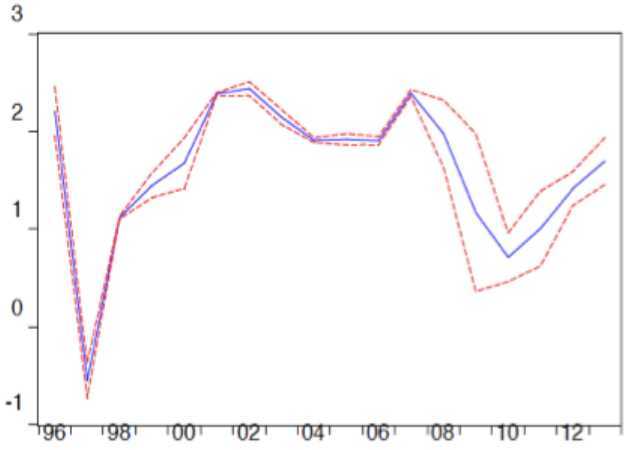


Model 1_mx.defl *AIC: 3.89*

—TR - - - -2MRSE

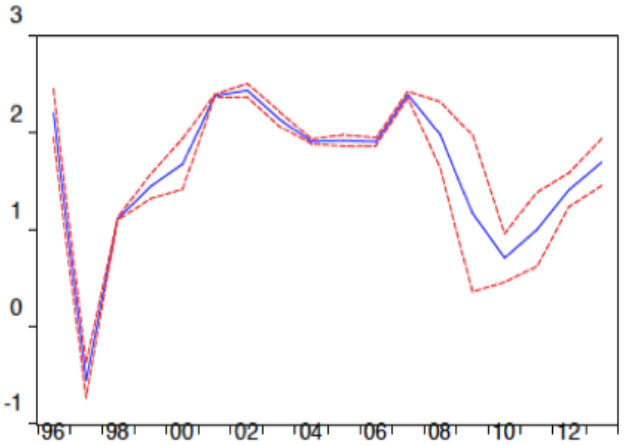


Model 2_infl *AIC: 4.56*

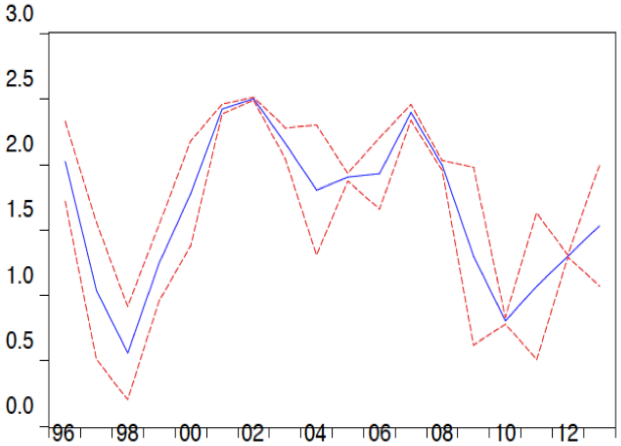


Model 2_m.infl *AIC: 4.63*

—TR - - - -2MRSE

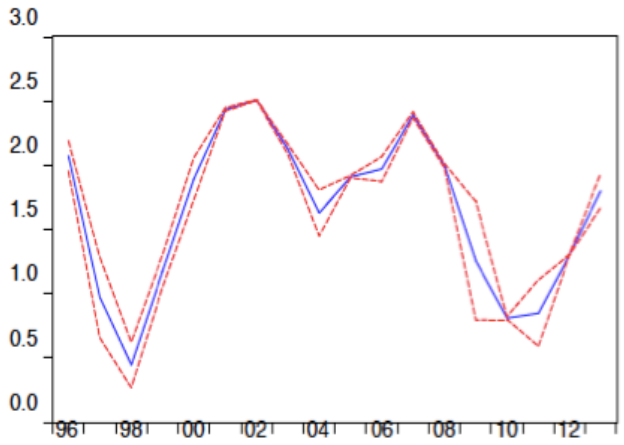


Model 2_mx.infl *AIC: 4.63*

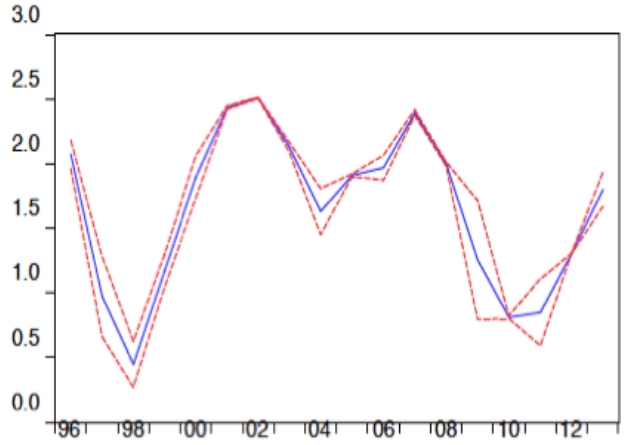


Model 2_defl *AIC: 3.82*

—TR - - - -2MRSE

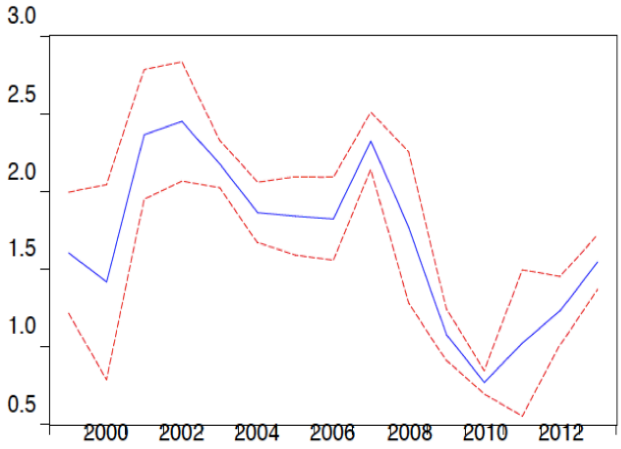


Model 2_m.defl *AIC: 3.70*

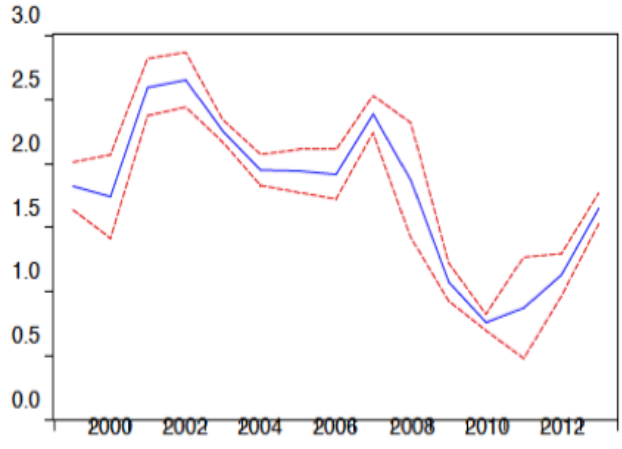


Model 2_mx.defl *AIC: 3.70*

—TR - - - -2MRSE

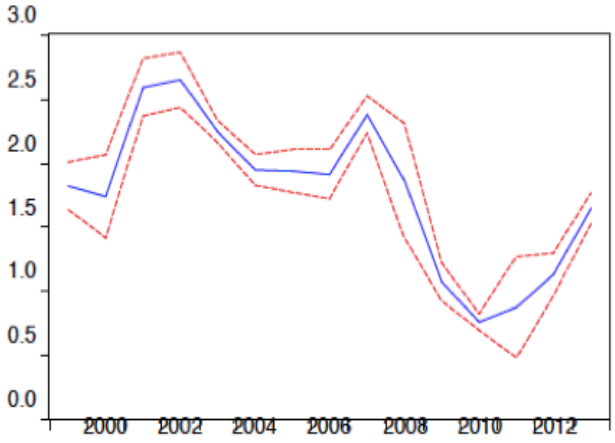


Model 3_infl *AIC: 3.60*



Model 3_m.infl *AIC: 3.69*

TR - - - -2MRSE



Model 3_mx.infl *AIC: 3.69*

TR - - - -2MRSE

The Effects of Quantitative Easing in the Eurozone: a Difference-in-Differences Approach

VERONICA BONANNO[·]*

Chapter 3

The empirical analysis in this paper continues with an assessment of the macro effects of Quantitative Easing (QE) in the Eurozone. QE is well represented by the increase of domestic assets in the balance sheet of the European Central Bank (started in 2015) with the main aim of boosting the European economy recovery. Considering the main scope of this unconventional monetary policy, I selected some macro and monetary variables that represent the targets of this manoeuvre. The estimates are carried out using a difference-in-differences methodology, that adopts an occurring event to create a policy shift between two groups and allows a before and after comparison across them. The Eurozone countries represent the 'treated' group, while the 'control' group is formed by the remaining countries of the European Union that do not join the Euro Area. Accordingly, the main questions are: (1) has this non-traditional policy had any effects on those selected macro and monetary variables? (2) If so, what is the magnitude of QE in the Eurozone compared to the other European countries that were not involved in this policy? In conclusion, an *Appendix Section* is proposed that contains a supplemental analysis for the study of the effects of QE in the Eurozone. In this section, the potential output growth of the single 19 Member States of the Euro Area is estimated using an AS state-space model and a Kalman filter methodology, and then, the impact of QE on that series through an ordinary least squares regression is investigated.

Keywords: quantitative easing, unconventional monetary policies, Eurozone, difference-in-differences.
JEL Codes: E52, E58, C13, C33
Supervisor: Professor Marco Alberto De Benedetto

1. Introduction

Since 2008, in the aftermath of the global financial crisis, many countries faced a period of recession due to the decline in short-term loans, the freeze in interbank markets and the collapse of international trade. Furthermore, when policy interest rates in many advanced economies reached the zero lower bound (ZLB), the traditional instruments of monetary policy became ineffective.
To ensure financial stability, price stability and economic growth, the main central banks started to use unconventional monetary policies (UMPs). Among them, Quantitative Easing (QE) was the preferred 'remedy' of many countries, consisting in large-scale domestic asset acquisition to inject sufficient liquidity into the banking system. The European Central Bank (ECB) followed the United States (US) example along with the United Kingdom (UK) and Japan to implement QE, starting in March 2015 (while the other UMPs were introduced from 2009). It was initiated with the sum of

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€1.1 trillion, acquiring 60 billion in government bonds and other types of securities on a monthly basis.

Therefore, focusing on the efficacy of the QE policy adopted by the ECB after the global financial crisis, the purpose in this paper is to study the effects of this new instrument on some macro and monetary variables. Considering the transmission channels through which QE is expected to affect the economy, with a huge increase of domestic assets being purchased by the ECB, people and firms should be able to borrow more credit from the banking system and expand savings, achieving the possibility of repairing debts. As a consequence, investments and consumption will rise. Further investments and higher consumption will improve employment and economic growth. At the end, given that prices will augment, the ECB should achieve its purpose of an inflation rate close to 2% over the medium term, offering a boost to the economic recovery. Consequently, there are some macro and monetary variables such as domestic credit, domestic consumption, economic growth, unemployment, openness to international trade and inflation that should be affected by the introduction of QE. Thus, this research is intended to empirically assess the effects of QE in the Eurozone on these variables, in a framework that allows a comparison with the other countries of the European Union (EU) that were not involved in QE.

The methodology is based on a difference-in-differences, or DID, approach. The basic setup of the DID estimator involves outcomes that are detected for two groups over two time periods. Then, a treatment occurs for one group during the second period but not in the first period (treated group). Conversely, the second group is not exposed to the treatment during either period (control group).
In this analysis, the Eurozone countries form the 'treated group', while the 'control group' is represented by the other EU countries that are not part of the Euro System. In order to adopt the euro and be part of the Euro Area, countries need to reach specific economic conditions defined by the EU Member States to guarantee economic convergence with members of the Eurozone, i.e. there are some convergence criteria for joining[2]. As a whole, the EU consists of 28 countries: 19 of them (Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, Spain), as part of the Eurozone, have a single monetary policy decided by the ECB. The other 9 (Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Poland, Romania, Sweden, the UK) have maintained their own currencies.
The DID approach uses some 'naturally' occurring event to create a policy shift for the first group and not for the other. Therefore, in this investigation the QE represents the policy shift.
Accordingly, the main questions are: (1) has this non-traditional policy had effects on those selected macro and monetary variables? (2) If so, what is the magnitude of QE in the Eurozone compared to the other European countries that were not involved in this policy?

[2] "Agreed in Maastricht by the EU Member States in 1991 as part of the preparations for introduction of the euro, the convergence criteria are formally defined as a set of macroeconomic indicators which measure: price stability, to show inflation is controlled; soundness and sustainability of public finances, through limits on government borrowing and national debt to avoid excessive deficit; exchange-rate stability, through participation in the Exchange Rate Mechanism (ERM II) for at least two years without strong deviations from the ERM II central rate; long-term interest rates, to assess the durability of the convergence achieved by fulfilling the other criteria. The exchange-rate stability criterion is chosen to demonstrate that a Member State can manage its economy without recourse to excessive currency fluctuations, which mimics the conditions when the Member State joins the euro area and its control of monetary policy passes to the European Central Bank (ECB). It also provides an indication of the appropriate conversion rate that should be applied when the Member State qualifies and its currency is irrevocably fixed.
According to the Treaty, at least once every two years, or at the request of a Member State with a derogation, the Commission and the European Central Bank assess the progress made by the euro-area candidate countries and publish their conclusions in respective convergence reports." (European Commission, Convergence criteria for joining, www.ec.europa.eu, 2018).

The implementation of this non-standard monetary policy is recent in Eurozone and its functionality and effects are still a marginally discussed topic in macro studies. Therefore, this paper links to literature that studies the effects of QE (and UMPs in general) on macroeconomy. Furthermore, I propose an analysis that goes over the standard evaluations on output and inflation, considering also other variables such as domestic credit, consumption, unemployment and openness, in an original framework that contributes to the literature giving a prospective comparison with the other EU member states that were not involved in QE. Also, the use of a DID methodology is original in the sense that usually this kind of approach is employed in micro studies, and is rarely applied to macro studies (generally because using it in a macro framework is quite risky).

The remainder of the paper is organized as follows. The following section gives a brief review of literature that focuses on the macroeconomic effects of QE and UMPs in the Eurozone. *Section 3* describes the methodology, the data and the econometric model used to assess the effectiveness of the QE policy on the selected variables. *Section 4* considers the validity tests and reports the results, while *Section 5* includes some robustness checks. *Section 6* concludes.

2. Literature

Literature studies on the effects of UMPs and QE in the Euro Area (and in the other countries such as the US, the UK and Japan) generally show a positive trend when assessing their impact on asset prices. However, the situation in completely different when the effects of these policies regard the macro variables, given that it is much more difficult to examine how economic conditions would have evolved without the unconventional monetary instruments introduction. Indeed, literature has focused much more on the effects of these manoeuvres on financial markets, rather than on the broader economy.
In *Table 1* the papers that focus on the effects of the UMPs and QE in the Eurozone in the macro area are summarized. They all show a positive and significant increment of real output such as the level of prices following the implementation of QE and the other non-traditional monetary policies.
Therefore, this paper links to literature studies dealing with the quantification of the effects of QE, and UMPs in general, on real GDP and inflation in the Eurozone, contributing with an overview also on other macro and monetary variables such as domestic credit, consumption, unemployment and openness (even if has to be stressed that at the end of the empirical investigation the study concentrates on only two variables: openness and inflation). Moreover, the choice of the DID methodology is original in the sense that it is not generally used in macro studies, appearing mostly in microeconomic studies, due to the riskiness of applying it in a macro framework.

Table 1. **Literature findings: UMPs and QE effects on Macroeconomy (Eurozone)**

Author(s)	Methodology	Sample Period/Frequency	Size of the Shock	Main Findings
EURO AREA				
Andrade et al. (2016)	General Equilibrium Model	2015/16	APP programme	Without the APP, the shock would have reduced inflation rate by more than 2% and output by around 7%
Baumeister and Benati (2010)	TVP SVAR	1981q1-2009q3	100 bps negative shock to the 10-yr Treasury bond yield spread	GDP growth increases by 1 pp / Inflation increases by 0.8 pps
Burriel and Galesi (2016)	GVAR	January 2007-September 2015	UMP shocks	Output and inflation response with a peak effect of about 4 and 3 bps respectively. The impact is augmented when the spillover effects are considered
Giannone et al. (2012)	BVAR/Counterfactual Analysis	1999m1-2011m4	Counterfactual IP is calculated by predicting the level of CB intermediation between 2007 and 2011 without policy intervention	IP increases by 2%
Lenza et al. (2010)	BVAR/Counterfactual Analysis	1991m1-2007m12	Counterfactual inflation and industrial production are calculated by assuming reduction in money market spreads	IP growth increases by 1.5-2.5 pps / Inflation increases by 0.1-0.2 pps
Peersman (2011)	SVAR	1999m9-2009m12	8% increase in the monetary base	IP and CPI price levels both increase

Notes:
Bps denotes basis points / pps denotes percentage points
IP denotes Industrial Production
CB denotes Central Bank
SVAR: Structural Vector Autoregression
TVP SVAR: Time-Varying Parameter Vector Autoregression
BVAR: Bayesian Vector Autoregression
GVAR: Global Vector Autoregression

Source: Author

3. Methodology

3.1 Data

The empirical approach implemented in my analysis focuses on the effects of QE on specific monetary and macroeconomic variables. Those variables are selected considering the transmission channels[3] through which unconventional manoeuvres (and QE in particular) are usually expected to affect the broad economy and considering also the targets of ECB in implementing QE. I use panel quarterly data of the 28 countries that form the EU, over the period 1995q1–2017q3.

[3] For a complete overview regarding the transmission channels through which QE is expected to affect the economy I suggest to referring to paragraph 2.1 in Chapter 1.

The choice is made considering that the primary scope of QE is to boost economic recovery. To do so, the ECB started to buy public assets from commercial banks, increasing the price of these bonds and creating money in the banking system. Therefore, different types of interest rates diminished, and credit became cheaper. As a consequence, expectations drove a rise in borrowing for firms and individuals that need less to repair their debts. Then, investment and consumption were expected to increase, giving a boost to economic growth and employment. Once prices rise, the ECB is clearly dealing with its main purpose of achieving a rate of inflation below, but close to, 2% in the medium-short term.
Thus, the selected variables are: domestic credit, domestic consumption, economic growth, unemployment, openness to international trade and inflation. *Table 2* reports the variables description and their source.

Table 2. **Variables specification**

Variable	Description	Source
domestic credit	Domestic credit to private sector by banks (% of GDP)	World Bank dataset
consumption	Total (% of GDP)	Eurostat
g	Output growth	Eurostat/Author's calculation
unemployment	Total (% total population)	Eurostat
openness	Imports + Exports shares (% nominal GDP)	IFS dataset/ Author's calculation
inflation	CPI (annual rate of change)	Eurostat

Source: Author

Table 3, *4* and *5* report descriptive statistics of the variables used. *Table 3* contains values regarding the full sample of 28 countries in the EU. The first column shows the mean of each variable for the full period. The second and the third parts of the table report the values before and after the introduction of QE in 2015. The last column shows the difference in means between the before and after values.
The same descriptions are reported in *Table 4* and *5* for the treatment group (the 19 countries that have adopted the policy) and for the control group (the 9 countries that have not adopted QE), respectively.

Table 3. **Descriptive statistics. Full sample**

Full sample				
	Full Period	**Before 2015**	**After 2015**	**Before/ After**
Variable	**Mean**	**Mean**	**mean**	**diff in means**
domestic credit	89.87	90.58	86.44	4.13
	45.75*	46.13*	43.79*	
consumption	55.91	56.00	55.25	0.75
	8.76*	8.51*	10.33*	
g	0.74	0.72	0.87	-0.15
	1.56*	1.57*	1.50*	
unemployment	5.58	5.57	5.59	-0.01
	2.65*	2.63*	2.76*	
openness	113.18	110.47	133.28	-22.80
	62.04*	59.59*	74.92*	
inflation	3.54	3.97	0.45	3.52
	8.14*	8.59*	1.14*	

*The second number represents the standard deviation.
Source: Author

Table 4. **Descriptive statistics. Treatment group**

Treatment Group				
	Full period	**Before 2015**	**After 2015**	**Before/ After**
Variable	**Mean**	**Mean**	**mean**	**diff in means**
domestic credit	96.82	98.42	89.64	8.87
	40.28*	39.88*	41.33*	
consumption	56.44	56.62	55.14	1.48
	8.97*	8.65*	10.94*	
g	0.79	0.77	0.90	-0.13
	1.74*	1.73*	1.78*	
unemployment	5.82	5.76	6.19	-0.43
	2.91*	2.90*	2.98*	
openness	119.65	116.61	141.83	-25.22
	69.95*	67.01*	85.41*	
inflation	2.69	2.98	0.47	2.51
	3.46*	3.56*	1.13*	

*The second number represents the standard deviation.
Source: Author

Table 5. **Descriptive statistics. Control group**

Control Group				
	Full period	**Before 2015**	**After 2015**	**Before/ After**
Variable	**Mean**	**Mean**	**mean**	**diff in means**
domestic credit	77.74	77.38	79.72	-2.34
	51.85*	52.53*	48.07*	
consumption	54.60	54.46	55.5	-1.04
	8.07*	7.96*	8.76*	
g	0.62	0.59	0.82	-0.23
	1.05*	1.09*	0.62*	
unemployment	5.07	5.19	4.32	0.87
	1.89*	1.90*	1.62*	
openness	99.32	97.38	114.14	-16.76
	36.51*	36.05*	36.78*	
inflation	5.50	6.27	0.40	5.87
	13.60*	14.44*	1.16*	

*The second number represents the standard deviation.
Source: Author

3.2 Econometric Model

Having established which variables should be included in the empirical study, a strategy was called to isolate the effect of the unconventional policy on the dependent variables in the Eurozone. To empirically assess the importance of QE for the macro and monetary variables selected, the estimation was carried out with a DID methodology.

From the time of Ashenfelter and Card's work (1985), the implementation of DID methodologies has become quite common. The basic framework is that variables are observed for two groups over two time periods. Then, a treatment occurs for one group during the second period but not in the first one (treated group), while the second group is not exposed to the treatment at all (control group). Therefore, the DID methodology includes some "naturally" occurring episodes to consider a "policy" change for the first group but not for the second one. Generally, this approach realises a before and after policy introduction comparison between the groups. The policy shift can include, for example, a change in a law for one country but not another, or a modification in some main policy after a natural adversity in one area but not another. References regarding the methodology used can be found in Larsson and Zetterberg (2013).

In this analysis, policy is represented by the QE that was implemented by the ECB in the aftermath of the global financial crisis. A subset of 19 countries in the data introduced this policy, as they belong to the Eurozone and the ECB has a single monetary policy for all members, while the other 9 countries maintained their domestic currencies after the introduction of the euro and thus were not affected by this manoeuvre. This implies that the Eurozone countries (Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, Spain) are the 'treatment' group, while the

remaining countries of the EU form the 'control' group (Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Poland, Romania, Sweden, the UK).

Next, it was possible to use a DID approach to analyse the effect of the policy over the treated group compared to the control group. The DID estimator uses both longitudinal data, where the unit is observed over time, and repeated cross section data, where units come from the same 'group' before and after the policy occurs.

One of the major problems met in DID studies is to detect the impact on some outcomes of the exposure of the units to the treatment. Thus, there are two critical features:

a) Units can be exposed to multiple treatments, even to treatments we cannot observe;

b) As a consequence of the fact that the same units cannot be treated and untreated at the same time, to recover the effect of the treatment in some way we have to compare the outcomes of treated units and untreated units. The latter is known as the fundamental problem of causal inference (Holland, 1986).

Let us assume the change in policy that occurs at time t = k, and each unit is observed before and after the policy change, at times t = t_0 < k and t = t_1 > k, respectively. For simplicity of notation, I denote by s_i the treatment group to which individual i belongs to, and for the moment I assume it can take only 2 values, either 0 or 1:

$$d_{it} = \begin{cases} 1 \; if \; s_i = 1 \; and \; t > k \\ 0 \; otherwise \end{cases}$$

The DID uses a common trend assumption and an additive structure:

$$E\left[y_{0ist} | \, s, t\right] = \gamma_s + \lambda_t \tag{1}$$

In the absence of policy the outcome of group s = 1 and group s = 0 would have followed the same trend. The first component is group specific, while the second is a common trend. The observed outcome can be written as:

$$y_{it} = \gamma_s + \lambda_t + \alpha_i d_{it} + u_{it} \tag{2}$$

where d_{it} is an interaction between the group indicator and the dummy at which the policy takes place. The DID strategy is based on the following assumption:

$$E[u_{it1} - u_{it0} | s_i = 1] = E[u_{it1} - u_{it0} | s_i = 0] = E[u_{it1} - u_{it0}] \tag{3}$$

In other words, this assumption does not rule out selection on the unobservable, but it restricts its source by ruling out the possibility of selection based on transitory individual/group-specific shocks. Let us re-write the observed outcome:

$$y_{it} = \gamma_s + \lambda_t + \alpha_i d_{it} + u_{it} \tag{2}$$

Now, it is possible to derive the following conditional expectations for

$$E(y_{it} | s_i = 0, t = t_0) = \gamma_s = 0 \tag{4}$$

$$E(y_{it}|s_i = 0, t = t_1) = \gamma_s = 0 + \lambda \quad (5)$$
$$E(y_{it}|s_i = 1, t = t_0) = \gamma_s = 1 \quad (6)$$
$$E(y_{it}|s_i = 1, t = t_1) = \gamma_s = 1 + \lambda + \alpha \quad (7)$$

Let us eliminate both the group/individual specific fixed effect and the common macro trend by double differencing:

$$\alpha = E\big(E(\alpha_i|s_i = 1)\big) \quad (8)$$
$$= [E(y_{it}|s_i = 1, t = t_1) - E(y_{it}|s_i = 1, t = t_0)] \quad (9)$$
$$-[E(y_{it}|s_i = 0, t = t_1) - E(y_{it}|s_i = 0, t = t_0)] \quad (10)$$
$$= [\gamma_s = 0 + \lambda - \gamma_s = 0] - [\gamma_s = 1 + \lambda + \alpha - \gamma_s = 1] = \alpha \quad (11)$$

This is the DID identification strategy. Estimation results are reported in *Table 6* in *section 4.2*.

4. Validity Tests and Results

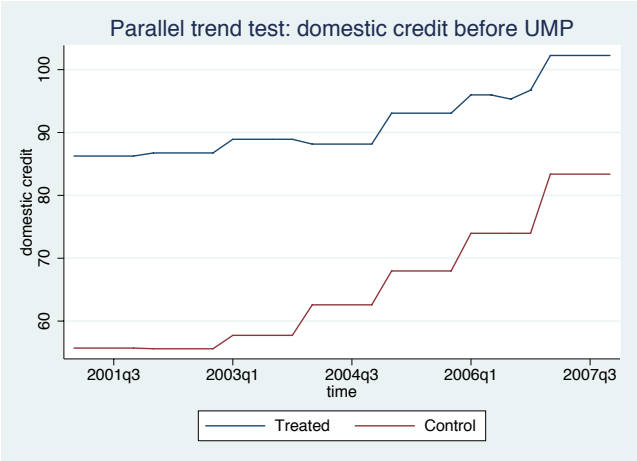
4.1 Parallel Trend

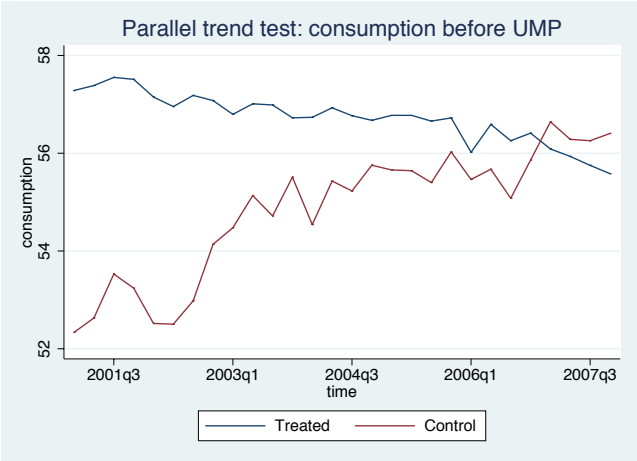
When attempting to identify the impact of QE on any variable, it is important to exercise some caution. The identifying assumption is that, among the countries of the treatment and the control groups, there are parallel trends in the dependent variables that are shifted exclusively by the introduction of the extraordinary policy.

I thus needed to ensure that there were no events prior to the point in time when QE was implemented (2015), or when the previous unconventional programmes took place since 2009, that caused structural breaks in the dependent variables. Moreover, it is possible that the impact of QE is not immediately visible in the short term, and it is also possible that the effects are amplified or diminished over time. Therefore, the validity of the DID methodology is centred on the statement that both the treatment and the control group show the same underlying trend in the outcome variables.

Thus, I tested this assumption for the period that goes from 2001 to 2008, i.e. considering the time before the introduction of any kind of UMP in the Eurozone. Results show that the underlying trend in the treated and the control group for the dependent variables chosen in the model were parallel in the case of domestic credit, unemployment, openness and inflation. On the contrary, consumption and output growth present divergent trends between the two groups in the period before 2008. The trends are reported in *Figure 1,2,* and *3*.

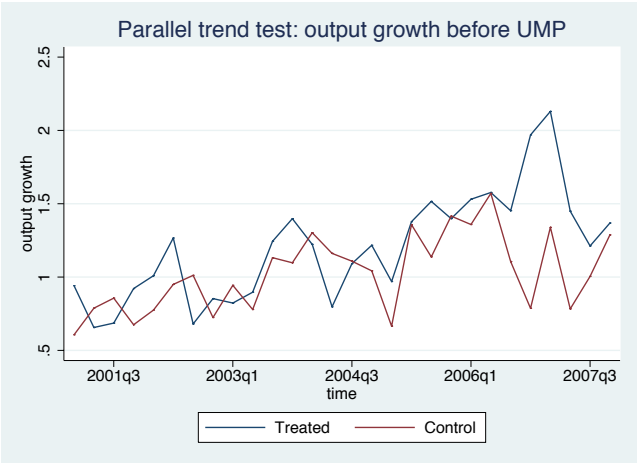
Figure 1. **Parallel trend: domestic credit and consumption**

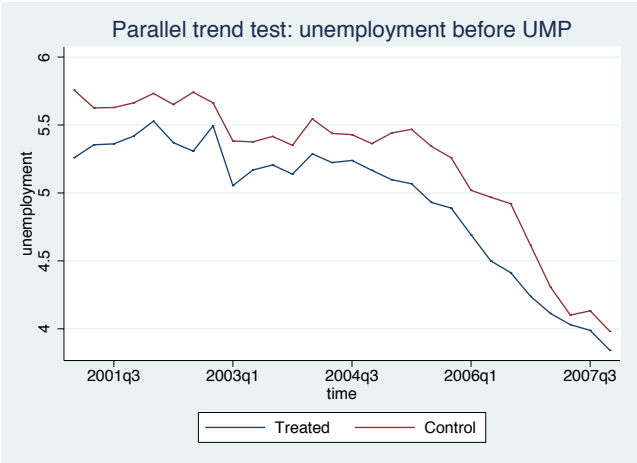




Source: Author's calculations Panel (a) Panel (b)

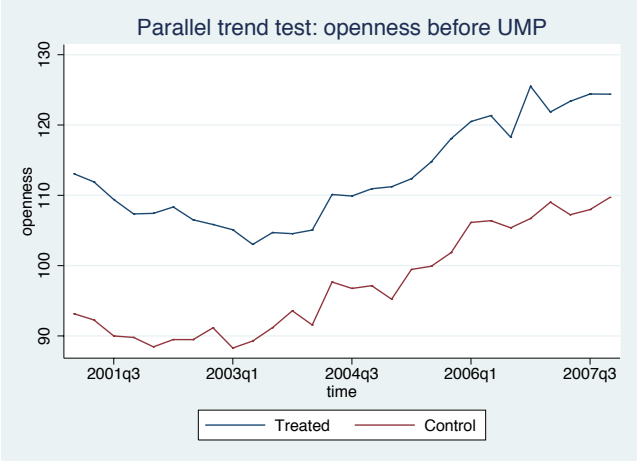
Figure 2. **Parallel trend: output growth and unemployment**

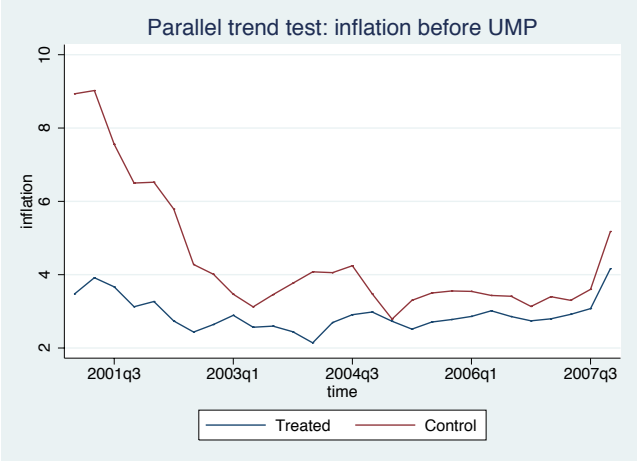




Source: Author's calculations Panel (c) Panel (d)

Figure 3. **Parallel trend: openness and inflation**





Source: Author's calculations Panel (e) Panel (f)

4.2 Results

Considering the results of the parallel trend tests, I performed the DID estimation using only those variables (domestic credit, unemployment, openness and inflation) that exhibit a parallel trend in the periods under consideration. Therefore, the other two selected variables that did not present a parallel trend, i.e. consumption and output growth, were used as control variables during the robustness checks in the following section. DID estimations results are reported in *Table 6*.

The regression was performed considering the period 2011-2017 thus, observing after the beginning of the global financial crisis (2007/2008) to eliminate possible effects of the crisis[4], while the DID estimator was created through the interaction of *time* (2015, i.e. introduction of QE) and *treated* (Eurozone countries). I also introduced quarterly dummies for the same period, to take potential shocks that affected all countries in specific quarters over the period considered in the analysis into account.

Table 6. **Difference-in-differences estimation**

	Domestic credit	**Unemployment**	**Openness**	**Inflation**
treated	12.07***	1.38***	26.29***	-0.24**
time	23.49***	2.35***	-16.29	0.15
DID	-2.13	0.49	1.61	0.34**

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

The results of the DID estimation show that for the treated group, i.e. the Eurozone, domestic credit to the private sector diminished by 2.13% after the introduction of the policy, compared to control countries. Therefore, the negative sign of the DID coefficient is opposite to expectations, given that one of the scopes of QE was to permit to businesses and people to be able to borrow more thanks to cheaper loans. As far as unemployment is concerned, QE positively affected it in the treatment by 0.49% in comparison to the control group. Also for this variable the sign of the DID estimate is opposite to what was expected, because QE was implemented for supporting economic growth and job creation. Thus, unemployment was expected to diminish after the policy introduction because of higher consumption and more investments. Conversely, openness to international trade shows a rise of 1.61% after the introduction of QE. This positive coefficient is in line with literature expectations since a positive change of this variable after 2015 is a primary sign of the economic recovery pursued by QE. Finally, the coefficient for inflation rate show a statistically significant increment of 0.34% in the Eurozone compared to control group countries, underlining a positive trend for one of the main objective of the ECB, i.e. to deal with deflation. Nonetheless, it has to be mentioned that DID results are not statistically significant for domestic credit, unemployment and openness, confirming that QE purposes are directed over the medium-long term, and so, in the short term, it is still not possible to make a sure assessment of the effects of this policy.

Later, I used a dynamic regression model to detect the differences between the short-term and the medium-term impact of the QE policy, considering that the adoption of QE itself is endogenous

[4] Results remain unchanged even checking for a longer period (2009-2017) i.e. including the beginning of the other unconventional monetary policies, and also checking for year fixed effects.

respect to the selected variables. Therefore, trying to assess the possibility of endogeneity, the regressors are instrumented with the first lag. Results of this second estimation are reported in *Table 7*.

Table 7. **Dynamic difference-in-differences estimation**

	Domestic credit L1	**Unemployment L1**	**Openness L1**	**Inflation L1**
Treated	5.08	-0.80***	14.01***	1.20***
Time	16.73	-5.50***	-54.00***	-3.27***
DID	11.29	1.68***	-0.32	0.78**

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

The DID coefficients of this dynamic estimation show opposite signs in the case of domestic credit and openness respect to the previous one; however, results still not present statistically significance in these cases. Conversely, unemployment and inflation confirm their positive trends (1.68% and 0.78% respectively), presenting a statistically significant increment in the treated group compared to the control countries.

5. Robustness Checks

5.1 Placebo Test

To assess the robustness of the identification strategy used, I set up an anti-test (or Placebo Test). Anti-tests provide counter evidence by applying a model or identification strategy in a context or a period where no effect should be detected. If an apparent 'effect' is found, then the validity of the identification strategy must be called into question. The idea of an anti-test can provide a useful strategy as part of a robustness/sensitivity analysis (Jones 2008).

The results of the placebo test applied to the identification model in a period before the QE policy introduction (such as the UMPs introduction) i.e. (2000-2006) show non-significant effects in the Eurozone for inflation and openness, while for domestic credit and unemployment significant effects were detected. Thus, considering that the validity of the Placebo calls the strategy used into question, the two variables that present effects in the period before the introduction of the UMP were dropped from the analysis from this point in time and were used as control variables. Therefore, the analysis proceeded only using the variables inflation and openness, which did not show effects during the 'placebo period'. The results of the placebo test are reported in *Table 8*.

Table 8. **Placebo Test. Difference-in-differences estimation**

	Domestic credit	**Unemployment**	**Openness**	**Inflation**
treated	13.32***	1.24***	22.19***	-3.72***
time	46.52***	1.80**	-6.34	2.95**
DID	14.13***	-1.51***	-5.82	1.38

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

5.2 Fixed Effects and Control Variables

A common exercise in empirical studies is a robustness check that examines how certain "core" regression coefficient estimates behave when the regression specification is modified by adding or removing regressors. Therefore, to test if results are sensitive to alternative ways to measure the treatment, or to the use of alternative control groups, robustness checks involve reporting different specifications that test the same hypothesis. Thus, robustness is necessary for valid causal inference, in the sense that the coefficients of the critical core variables should be insensitive to adding or dropping variables, under appropriate conditions. In this section I perform three different types of robustness checks.

First, I checked for fixed geographical effects, adding some variables that represent the division of European countries in four geographical zones to the main regression: *north*, *south*, *east* and *west*. These variables are equal to 1 if the country belongs to that area, and 0 otherwise.

Second, I added the variables that were excluded at the beginning of the analysis as control variables, because of the negative results of the parallel trend tests (consumption and economic growth), such as those excluded after the placebo test (domestic credit and unemployment).

Third, the control variables are introduced in the regression with the addition of the first lag.

The DID coefficients were unchanged with respect to the addition of these 'zones', 'control' and 'lagged control' variables; in fact, they are very similar to the coefficients of the main regression, showing a positive but not significant trend for openness and a still statistically significant increment of 0.33% for inflation in the first two cases and of 1.22% when the regression was shifted by the lag. Results of these estimations are reported in *Table 9*.

Table 9. **Fixed effects and control variables. Difference-in-differences estimation**

	Geo. Fixed Effects		**Control Var.**		**Lagged Control Var.**	
	Openness	**Inflation**	**Openness**	**Inflation**	**Openness**	**Inflation**
treated	55.20***	-0.13	44.82***	-0.10	1.27	0.13
time	-24.58*	0.40*	-18.15	0.48**	-73.16***	-6.22***
DID	0.81	0.33**	0.59	0.33**	10.69	1.22***

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

5.3 Control Group QE Check

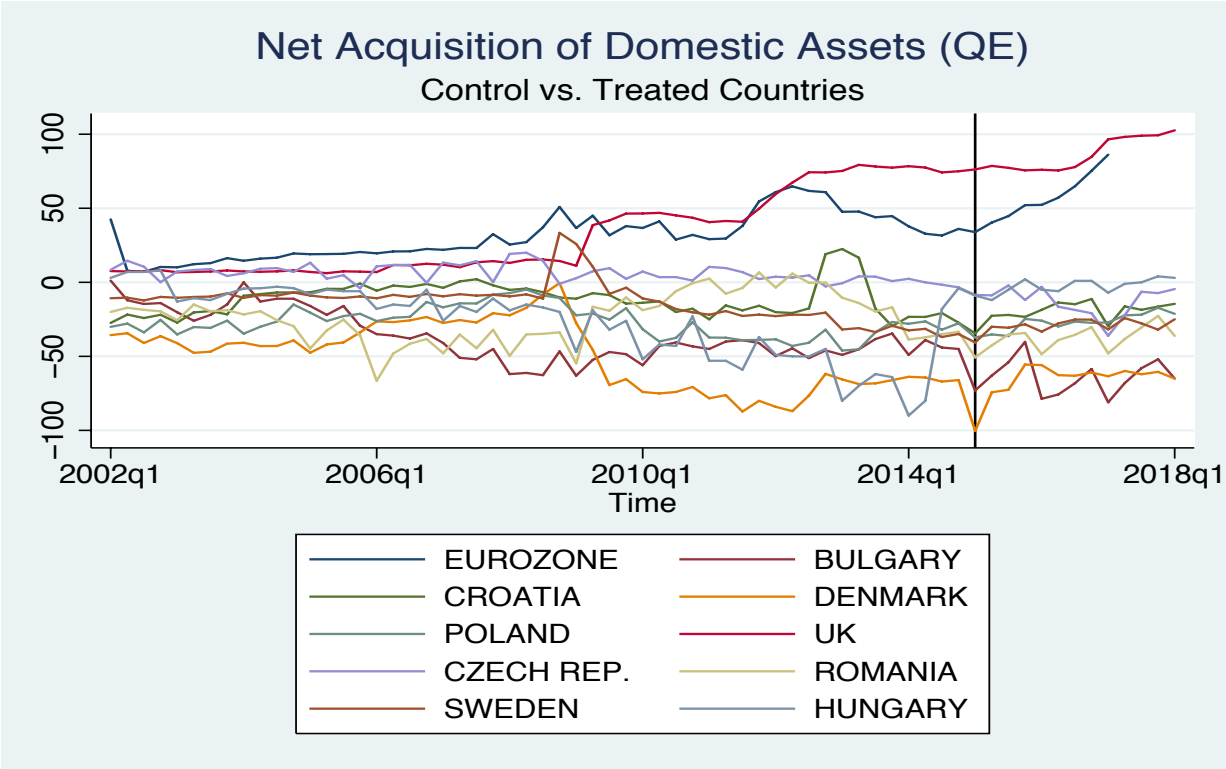
Working to improve another robustness check, in this section I analysed the monetary policy of the control group countries (Bulgaria, Croatia, Denmark, Poland, the UK, Czech Republic, Romania, Sweden, Hungary), to detect if they had implemented any unconventional manoeuvres like QE during the same period of the treated group, i.e. after 2015.

To effectively measure the magnitude of QE policies, I used the central bank acquisitions of domestic assets as a proxy for QE, as proposed by Gagnon et al. (2017): "for the major advanced economies, this proxy corresponds well with the unconventional policy known as Quantitative

Easing. This definition measures the extent to which the central bank expands its balance sheet to take risk off the balance sheets of domestic market participants, thus potentially easing financing conditions. Indeed, the measure looks broadly as expected in known QE cases following the Global Financial Crisis".

Thus, having checked which countries of the control group adopted a massive acquisition of net domestic assets[5] over the period 2002q1-2018q1, results showed a significant acquisition of these assets only for the UK. The increase in domestic assets performed by the treated group (Eurozone) and by the UK, compared to the remaining control group members, is shown in *Figure 4*, and expressed as a percentage of the national GDPs. The vertical benchmark indicates the introduction of QE for the treated group in 2015q1.

Figure 4. **: Net Acquisition of Domestic Assets (QE)**
Control Group Countries and Treated Group Countries



Source: Author's calculations

As shown in *Figure 4*, the net acquisition of domestic assets (QE) was carried out after 2015q1 by the UK in a greater amount compared to the treated group (Eurozone).

I thus performed a new extension of the benchmark model, regressing a DID estimation and eliminating the UK from the control group. Results are reported in *Table 10*.

[5] Data are taken from the IMF/IFS data set.

Table 10. **Control Group QE check**. **DID estimation without UK**

	Openness	**Inflation**
treated	19.83***	-0.15
time	-15.39	0.16
DID	0.60	0.31**

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

Results from this last estimation report similar DID coefficients with respect to the main regression model. In fact, the coefficient for openness to international trade still present a positive trend that is not significant, while inflation confirms its statistically significant and positive increment of 0.31%. Therefore, even eliminating the only country (UK) that acquired domestic assets from the control group, i.e. that have implemented a QE policy, this robustness check does not change the main estimation results.

6. Conclusions

Considering the results from this analysis, after the parallel trend test and the placebo test elimination of four of the six macro and monetary selected variables, the evaluation presented robustness in the case of openness to international trade and inflation CPI.
The coefficient for *inflation* showed a statistically significant and positive rise between 0.31-0.34% and 0.78-1.22% (when the lagged variables are considered), demonstrating a sizable increase in the Euro Area compared to the other European countries after QE implementation. Therefore, this result is in line with literature findings that assessed a general positive increment in the Eurozone of CPI inflation.
On the other hand, the variable *openness* confirmed its positive trend between 0.59-1.61% (even though the coefficient is negative (-0.32%) only in the dynamic model), but remains non statistically significant during the entire estimation. This means that the Eurozone countries faced an increment of openness to international trade compared to the control group countries after the introduction of QE in 2015, but did not present a statistical significance in this case.
It is necessary to continue an evaluation of the impact and effectiveness of QE over time. There are obvious effects on financial market stimulation due to QE; however, there are many questions regarding the effectiveness of QE in the Euro System's bond market, as evidenced by the poor recovery of the banking sector. The macro framework did not demonstrate a truly sustainable recovery either. There are heavy debts, labour market inflexibility and lack of sufficient long-term investment, which have impeded full recovery so far. Thus, there is a strong need for member-state governments to consider performing more practical reforms.
Nonetheless, the ECB QE had the effect of reducing the urgent need for reform in some nations and boosted the international importance of the euro. It also helped to increase short-term competitiveness in the Euro area economy (as demonstrated also by the positive sign of the openness coefficient) and has attained one of the main objectives of the ECB, i.e. to deal with deflation (as showed by the increase of CPI inflation). Undoubtedly, further positive effects will be reached in the medium-long term.

Appendix. Supplemental Analysis

The Effects of QE on Potential Output Growth: Evidence from Eurozone's States Members

This *Appendix* section contains an alternative way to detect the impact of QE in Eurozone compared to the one used in *Chapter 3*. The analysis already implemented in *Chapter 2* is proposed, i.e. the estimation of the potential output growth rate by a multivariate approach and a Kalman filter methodology, such as the ordinary least squares (OLS) regression analysis, but now the focus concentrates on the single 19 States Members that belong to the Euro Area (Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, Spain). Therefore, instead of assessing the effects of QE in the Eurozone as a whole, I have provided the estimate of the natural growth rate of each State Member, evaluating then the impact of *qe* and the other proxies on that estimated series[6].

1. Potential Growth Rate Estimation

For each economy, I produced estimates of the potential output growth (g^N) using quarterly data over the period 1995q1-2018q3. My estimations were carried out relying on *Model 1* and *Model 2* already used in the preceding analysis, but not on *Model 3*, given that the data for expected inflation for each Eurozone State Member are not fully available. Then, to estimate the expected inflation rate (π_t^e), two possible specifications are here assumed.
The first is in *Equation (1),* where expected inflation in time *t* is a time-varying function of actual inflation in *t*:

$$\pi_t^e = \alpha_t \pi_t + \varepsilon_t \tag{1}$$

where α_t is a time-varying parameter reflecting the public's degree of accuracy in forecasting inflation and ε_t is an independent normally distributed error term, with zero mean and constant variance. The estimated model (*Model 1*) in this case is

$$g_t = g_t^N + \frac{(1-\alpha_t)}{\varphi_t}\pi_t + \varepsilon_t \tag{1'}$$

The second specification assumes an extreme form of adaptive expectations in which expected inflation in *t* is equal to actual inflation in $t-1$ plus a random error term:

$$\pi_t^e = \pi_{t-1} + \varepsilon_t \tag{2}$$

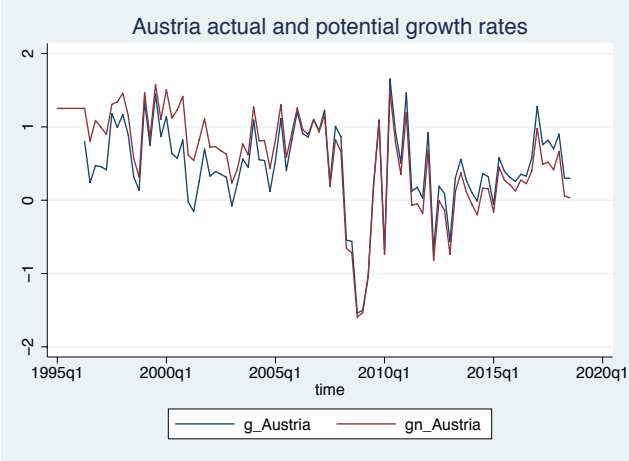
and the relative model (*Model 2*) is

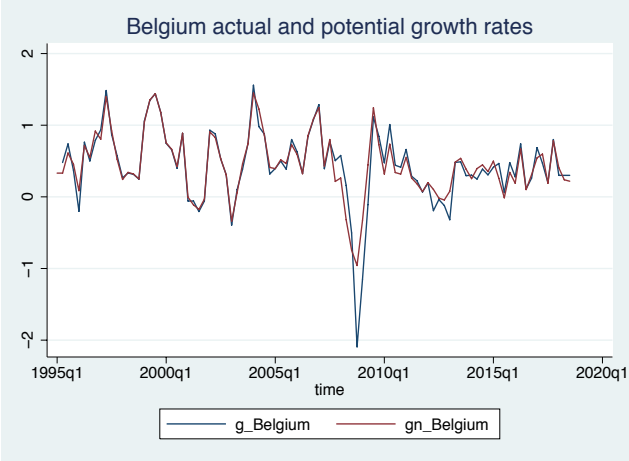
$$g_t = g_t^N + \frac{1}{\varphi_t}\Delta\pi_t + \varepsilon_t \tag{2'}$$

[6] A detailed description of the methodology used to produce the potential output growth rates is contained in *Section 3.3 (Chapter 2)*, while the description of the proxies and the data used is in *Section 4 (Chapter 2).*

Then, I select the most appropriate version of the model according to the significance of the estimated parameters, relying on the lower Akaike Information Criterion (AIC). Estimation results are reported in *Figures 1,2,3,4,5,6,7,8,9,* and *10,* where *g* represents the actual GDP growth rate and *gn* indicates the potential output growth rate estimated for each country.

Figure 1. **Austria and Belgium actual and potential growth rates**

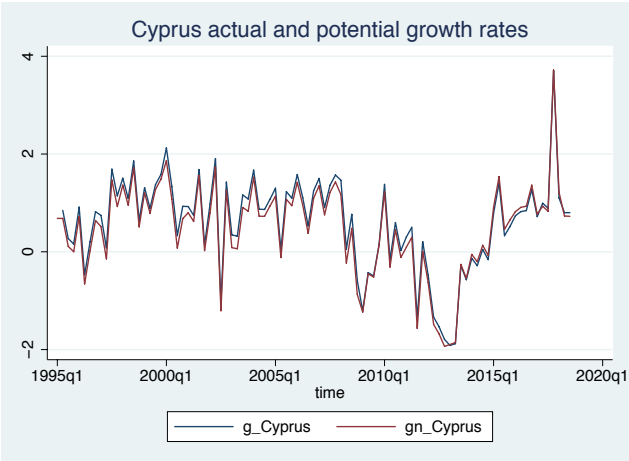


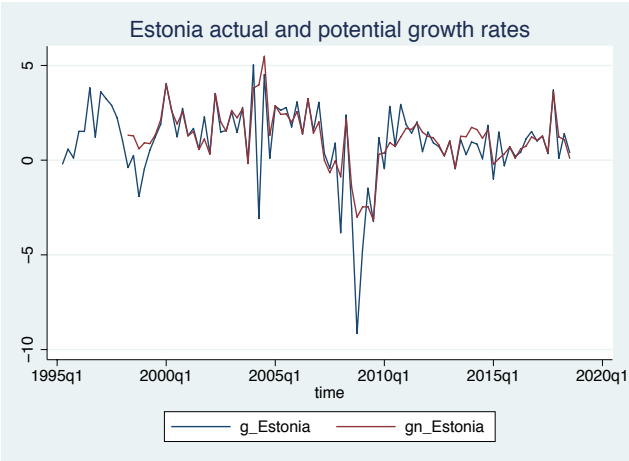


Source: Author's calculations Panel (a) Panel (b)

Regarding the estimation results for Austria (named *gn_Austria*) the most significant model (*Model 1*) is the one represented in *Equation (1'),* where expected inflation in time *t* is a time-varying function of actual inflation in *t*; the estimate in this case shows the lower Akaike criteria (2.29 instead of 2.30 in the case of *Model 2*) (*Figure1 Panel (a)*).
On the other hand, for Belgium (*gn_Belgium*), the preferred model is *Model 2* (*Equation (2')*) in which expected inflation in *t* is equal to actual inflation in $t - 1$ plus a random error term with an AIC of 1.60 instead of 1.67 in the case of the other model (*Figure 1 Panel (b)*).

Figure 2. **Cyprus and Estonia actual and potential growth rates**

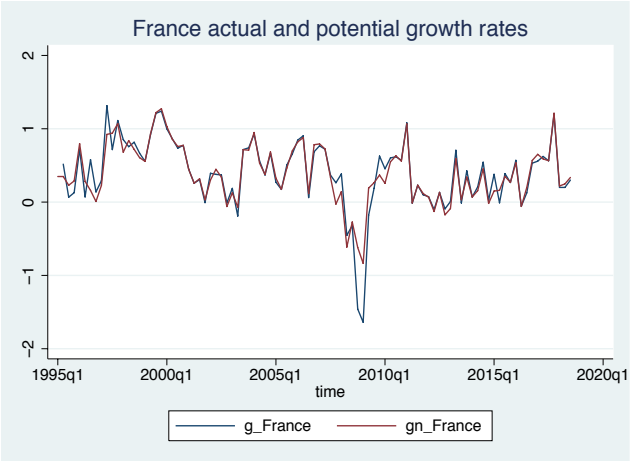




Source: Author's calculations Panel (c) Panel (d)

For Cyprus (*gn_Cyprus*) the selected model is *Model 1* (*Equation (1')*), with an Akaike of 3.0446 (instead of 3.0455 in the other case) (*Figure 2 Panel (c)*), while for Estonia (*gn_Estonia*) the model chosen is *Model 2* (*Equation (2')*), with an AIC of 4.91 (5.01 for the other model) (*Figure 2 Panel (d)*).

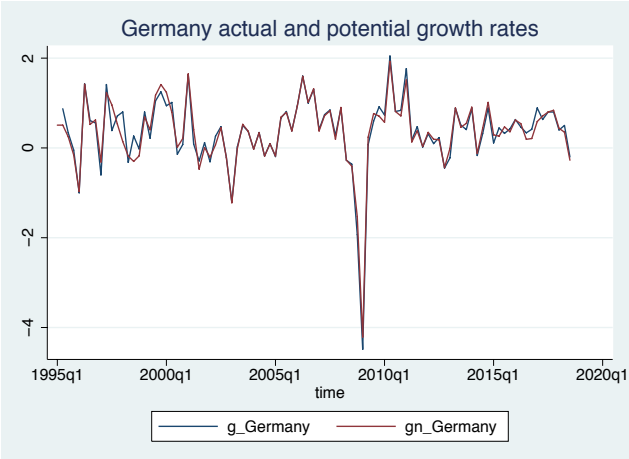
Figure 3. **Finland and France actual and potential growth rates**

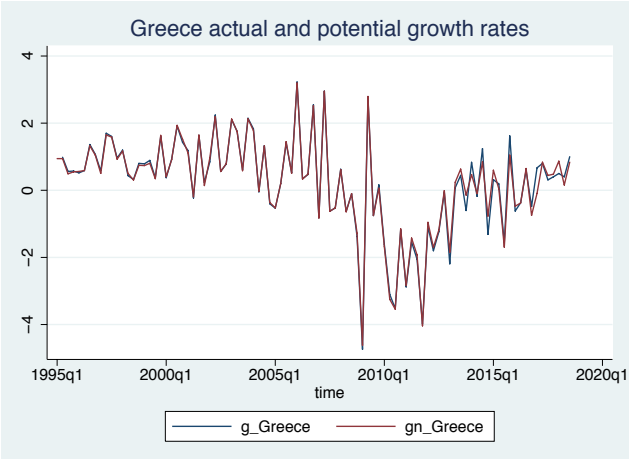


Source: Author's calculations Panel (e) Panel (f)

Regarding Finland (*gn_Finland*) and France (*gn_France*), in both cases the best model is *Model 2* (*Equation (2')*), with an Akaike of 3.50 and 1.45 respectively (3.50 and 1.54 for the other model), (*Figure 3 Panels (e) and (f)*).

Figure 4. **Germany and Greece actual and potential growth rates**

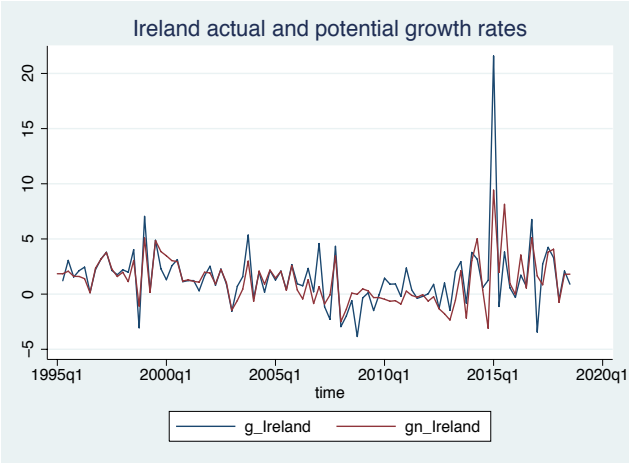


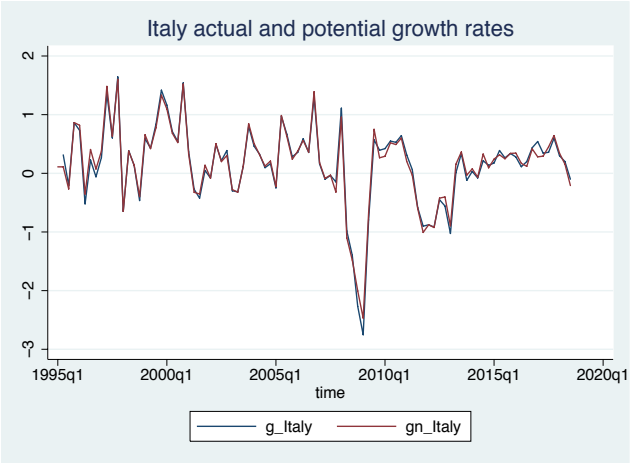


Source: Author's calculations Panel (g) Panel (h)

The preferred model for Germany (*gn_Germany*) and Greece (*gn_Greece*) is also *Model 2* (*Equation (2')*), with an AIC of 2.95 and 4.2219 respectively (2.99 and 4.2290 in the case of *Model 1*), (*Figure 4 Panel (g) and (h)*).

Figure 5. **Ireland and Italy actual and potential growth rates**

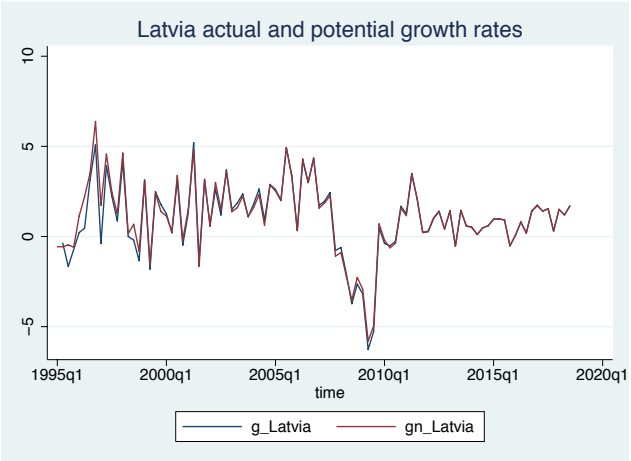




Source: Author's calculations Panel (i) Panel (j)

Model 2 is the best one also in the estimations performed for Ireland (*gn_Ireland*) (AIC 6.05 instead of 6.16 in the other case) and Italy (*gn_Italy*) (AIC 2.24 instead of 2.35 when using *Model 1*), (*Figure 5 Panel (i) and (j)*).

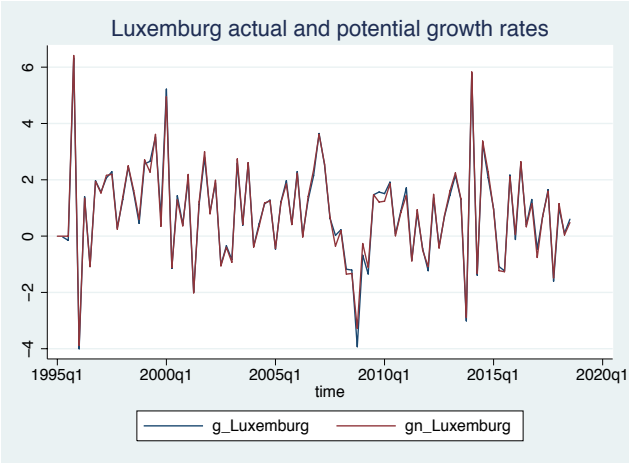
Figure 6. **Latvia and Lithuania actual and potential growth rates**

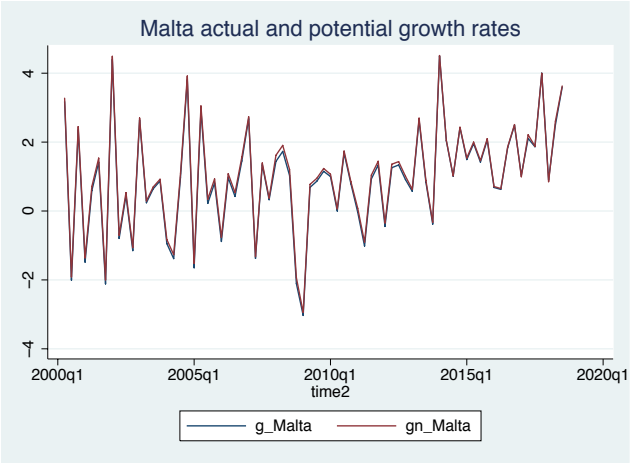


Source: Author's calculations Panel (k) Panel (l)

Regarding Latvia (*gn_Latvia*) and Lithuania (*gn_Lithuania*) also in these cases *Model 2* shows the preferred estimations results and the lower Akaike (4.74 and 4.62 respectively instead of 4.77 and 4.74), (*Figure 6 Panel (k) and (l)*).

Figure 7. **Luxemburg and Malta actual and potential growth rates**

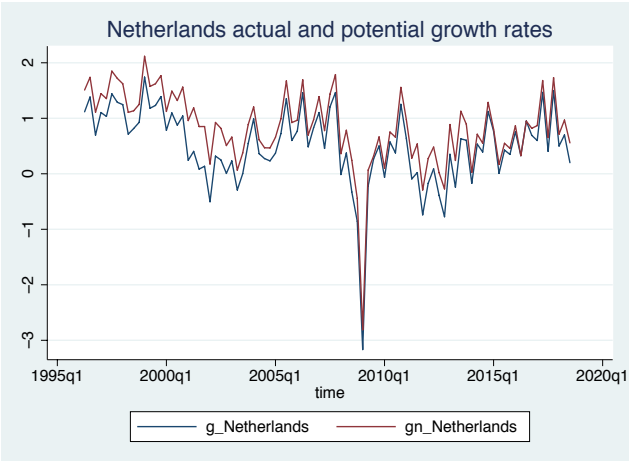


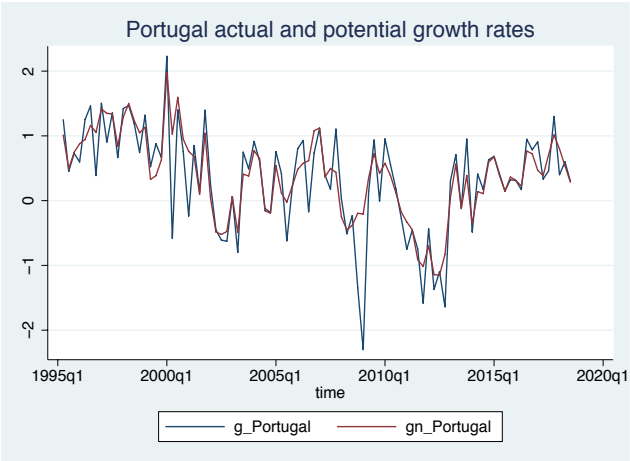


Source: Author's calculations Panel (m) Panel (n)

For Luxemburg (*gn_Luxemburg*) the model chosen is *Model 2*, with an AIC of 5.1787 (instead of 5.1789 in the other case) (*Figure 7 Panel (m)*), while for Malta (*gn_Malta*) *Model 1* shows a better performance (AIC 4.99 instead of 5.0 for the other model), (*Figure 7 Panel (n)*).

Figure 8. **The Netherlands and Portugal actual and potential growth rates**

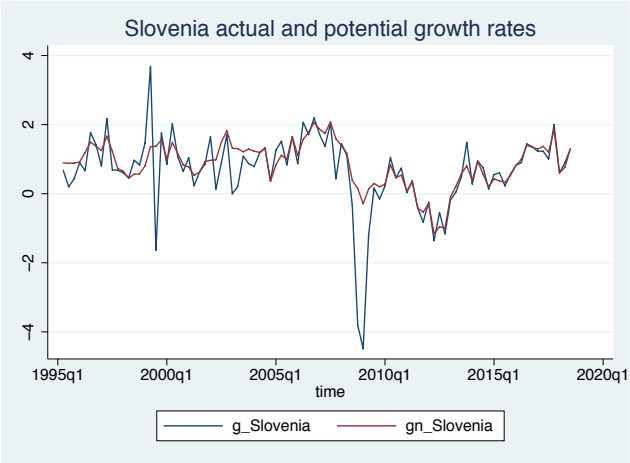




Source: Author's calculations Panel (o) Panel (p)

Regarding the Netherlands (*gn_Netherlands*), the selected model is *Model 1*, with an Akaike of 2.44 (2.45 in the other case) (*Figure 8 Panel (o)*). On the other side, *Model 2* is the preferable for Portugal (*gn_Portugal*) (AIC 2.83 instead of 2.86) (*Figure 8 Panel (p)*).

Figure 9. **Slovakia and Slovenia actual and potential growth rates**



Source: Author's calculations Panel (q) Panel (r)

Figure 10. **Spain actual and potential growth rates**

Source: Author's calculations Panel (s)

Finally, for Slovakia (*gn_Slovakia*) and Slovenia (*gn_Slovenia*) the model chosen is *Model 2*, with an Akaike of 4.27 and 2.96 respectively (instead of 4.46 and 3.37 for the other model) (*Figure 9 Panel (q) and (r)*), while for Spain (*gn_Spain*) the best estimate is produced by *Model 1* (AIC 0.7536 instead of 0.7579 in the other case) (*Figure 10 Panel (s)*).

2. Regression Analysis and Results

Having selected the best time-series estimates of g^N for each Eurozone State Member, I then turned to an investigation of the impact of QE policy on the potential output growth rates obtained. The regressions were performed through the OLS methodology and using the central bank acquisitions of domestic assets as proxy for QE (*qe*), as proposed by Gagnon et al. (2017). Given that potential output growth is defined as the sum of the growth rates of labour force and labour productivity, in

the regression I also considered potential determinants of g^N. These potential determinants and their definitions and data sources are (re)-presented in *Table A1* (they are the same as those already used in *Chapter 2*), but data now refer to the single States Members and not to the Eurozone as a whole as before.

Table A1. **Variables specification**

Variable	Description	Source
qe_i	Net domestic assets (single states) (% nominal GDP)	IFS dataset /Author's calculation
$g\_lf\_tr_i$	Labour force growth trend	OECD dataset /Author's calculation
$openness_i$	Imports + Exports shares (%nominal GDP)	IFS dataset /Author's calculation
exp $\_rd_i$	Total R&D expenditure (%nominal GDP)	FRED dataset /Eurostat
ger_s_i	Gross enrolment ratio, secondary, both sexes (%total enrolment)	World Bank dataset
$qe_i\_openness_i$	Interaction term ($qe_i \times openness_i$)	Author's calculation
$gdev_i$	Average deviation of actual growth from the potential growth rate ($g_i - g_i^N$)	Author's calculation

Source: Author

The main difference compared to the previous analysis implemented in *Chapter 2* regards the proxy for QE (*qe*), as the total amount of net acquisitions of domestic assets is now divided proportionally for each Eurozone State Member following the 'capital key' parameters. In fact, "during the net purchase phase, the ECB's capital key guided net purchases under the PSPP (Public Sector Purchase Programme) on a monthly basis". "The capital of the ECB comes from the national central banks (NCBs) of all EU Member States and amounts to €10,825,007,069.61". "The NCBs shares in this capital are calculated using a 'key', which reflects the respective country's share in the total population and gross domestic product of the EU. These two determinants have equal weighting. The ECB adjusts the shares every five years and whenever there is a change in the number of NCBs that contribute to the ECB capital. These are the NCBs of EU Member States". "The fully paid-up subscriptions of Euro Area NCBs to the capital of the ECB amount to a total of €7,536,110,121.69 (69.61%) and break down as shown in *Table A2*" (ECB, 2019). The remaining part of the capital amount (30.38%) regards the non-Eurozone State Members (which are not under analysis here). Therefore, the proxy qe_i is obtained calculating from the total amount of net domestic assets purchased by the ECB, the share acquired by the single Eurozone Member States, using the capital key parameter, and then this amount is expressed in percentage of the nominal GDP of each country.

Table A2. **Euro Area NCBs' contributions to the ECB's capital**

National Central Bank	Capital Key (%)	Paid-up capital (€)
Nationale Bank van België (Belgium)	2.5280	273,656,178.72
Deutsche Bundesbank (Germany)	18.3670	1,988,229,048.48
Eesti Pank (Estonia)	0.1968	21,303,613.91
Central Bank of Ireland (Ireland)	1.1754	127,237,133.10
Bank of Greece (Greece)	1.7292	187,186,022.25
Banco de España (Spain)	8.3391	902,708,164.54
Banque de France (France)	14.2061	1,537,811,329.32
Banca d'Italia (Italy)	11.8023	1,277,599,809.38
Central Bank of Cyprus (Cyprus)	0.1503	16,269,985.63
Latvijas Banka (Latvia)	0.2731	29,563,094.31
Lietuvos bankas (Lithuania)	0.4059	43,938,703.70
Banque centrale du Luxembourg (Luxembourg)	0.2270	24,572,766.05
Central Bank of Malta (Malta)	0.0732	7,923,905.17
De Nederlandsche Bank (The Netherlands)	4.0677	440,328,812.57
Oesterreichische Nationalbank (Austria)	2.0325	220,018,268.69
Banco de Portugal (Portugal)	1.6367	177,172,890.71
Banka Slovenije (Slovenia)	0.3361	36,382,848.76
Národná banka Slovenska (Slovakia)	0.8004	86,643,356.59
Suomen Pankki – Finlands Bank (Finland)	1.2708	137,564,189.84
Total*	**69.6176**	**7,536,110,121.69**

* Owing to rounding, the total may not correspond to the sum of all figures shown.
Source Author. Reference *ecb.europe.eu.*

In the succeeding step of my empirical investigation, I estimated the following dynamic models for the 19 countries under analysis:

Model (1):

$$g_{it}^{N} = \mathrm{l}.qe_{it} + \mathrm{l}.openness_{it} + l.g\_lf\_tr_{it} + l.\exp\ \_rd_{it} + l.ger\_s_{it} + \varepsilon_{it} \quad (3)$$

Model (2):

$$g_{it}^{N} = \mathrm{l}.qe_{it} + \mathrm{l}2.qe_{it} + openness_{it} + \mathrm{l}.qe\_openness_{it} + \mathrm{l}2.qe\_openness_{it} + g\_lf\_tr_{it} + \exp\ \_rd_{it} + ger\_s_{it} + \varepsilon_{it} \quad (4)$$

Model (3):

$$g_{it}^{N} = \mathrm{l}.qe_{it} + openness_{it} + \mathrm{l}.qe\_openness_{it} + g\_lf\_tr_{it} + \exp\ \_rd_{it} + ger\_s_{it} + \varepsilon_{it} \quad (5)$$

Model (4):

$$g_{it}^{N} = \mathrm{l}.qe_{it} + openness_{it} + \mathrm{l}.qe\_openness_{it} + g\_lf\_tr_{it} + \exp\ \_\mathrm{rd}_{it} + ger\_s_{it} + l.gdev_{it} + \varepsilon_{it} \quad (6)$$

Models 1,2,3 and *4* are the same already used in *Chapter 2*. *Tables A3, A4 and A5* reports the results only for the best model for each economy.

Table A3. **Determinants of EZ Member States g^N: OLS Estimations**

Variable	Austria Model (3)	Belgium Model (4)	Cyprus Model (4)	Estonia Model (2)	Finland Model (4)	France Model (4)
qe	-	-	-	-	-	-
L1.	0.219*	0.247***	-0.117**	-0.260**	0.197**	0.222***
L2.	-	-	-	0.236***	-	-
openness	0.096**	0.002	0.035	0.032	0.035	0.119**
L1.	-	-	-	-	-	-
qe_openness	-	-	-	-	-	-
L1.	-0.002*	-0.001***	0.009*	0.001**	-0.002**	-0.004***
L2.	-	-	-	-0.001***	-	-
g_lf_tr	-4.757**	6.705***	7.282***	14.627***	3.640**	3.020
L1.	-	-	-	-	-	-
exp_rd	-1.193**	3.289***	14.881*	1.720	-1.390**	1.488
L1.	-	-	-	-	-	-
ger_s	0.310**	0.005	-0.125***	-0.162*	-0.011	0.013
L1.	-	-	-	-	-	-
gdev	-	-	-	-	-	-
L1.	-	0.046	-2.654*	-	-0.097**	-0.031

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

Results from the first group of countries reported in *Table A3* show an overall good performance of the models. In particular, for Austria, Belgium, Finland and France the coefficient for *qe*, which represents the elasticity of natural growth rate with respect to QE, is positive and statistically significant, indicating that a 1% increase of net domestic assets corresponds to an impact on potential output growth of 0.21%, 0.24%, 0.19% and 0.22% respectively. These results are also in line with the findings of *Chapter 2*, where the natural GDP growth of the Eurozone turned out to be positively affected by QE with an impact of 0.20%. On the other hand, the *qe* coefficient for Cyprus and Estonia shows a negative sign, denoting that a 1% increase in domestic assets has a decreasing effect on their potential output rates of -0.11% and -0.26% respectively.
Looking at the other proxies, *openness* displays a positive and statistically significant effect only for Austria (0.09%) and France (0.11%). The interaction term between QE and openness (*qe_openness*) shows overall a very small impact, negative for Austria, Belgium, Finland and France, and positive for Cyprus and Estonia. The coefficient on *g_lf_tr*, which represents the elasticity of potential output with respect to the labour force growth trend, is positive and significant for Belgium, Cyprus, Estonia and Finland, but is not as close to 1 as expected (considering that theory suggests that an increase of 1% in the labour force growth leads to a 1% increase in potential output growth, and this is consistent with the definition of the natural growth rate used in this analysis). Finally, *exp_rd* has a positive impact for Belgium and Cyprus, but negative for Austria and Finland; *ger_s*

displays a confident impact for Austria, but decreasing for Cyprus and Estonia; *g_dev* turns out to be negative for Cyprus and Finland.

Table A4. **Determinants of EZ Member States g^N: OLS Estimations**

Variable	Germany Model (4)	Greece Model (4)	Ireland Model (4)	Italy Model (4)	Latvia Model (2)	Lithuania Model (4)
qe	-	-	-	-	-	-
L1.	0.318***	-0.067	-0.109	0.046***	-0.153*	0.031
L2.	-	-	-	-	0.020	-
openness	0.093***	0.078	-0.018	0.003	0.104***	0.121**
L1.	-	-	-	-	-	-
qe_openness	-	-	-	-	-	-
L1.	-0.004***	0.001	0.005	-0.008***	0.009	-0.005
L2.	-	-	-	-	-0.002	-
g_lf_tr	2.453	13.761***	-0.453	-0.130	7.723***	-7.713**
L1.	-	-	-	-	-	-
exp_rd	0.448	4.431	-8.733	-2.202***	0.313	-10.910**
L1.	-	-	-	-	-	-
ger_s	-0.128	-0.057	0.182*	0.048***	-0.215***	0.229
L1.	-	-	-	-	-	-
gdev	-	-	-	-	-	-
L1.	2.647	-1.178	-0.063	0.003	-	-0.627**

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

Findings for the second group (*Table A4*) indicate a positive and statistically significant impact of an increase of domestic assets (*qe*) on g^N for Germany (0.31%) and Italy (0.04%), while for Latvia the effect is negative (-0.15%). On the other hand, Greece, Ireland and Lithuania potential outputs do not reply to the models used as expected, as the coefficients for *qe* (but also the other proxies) are not statistically significant for the majority. *Openness* has a small but increasing impact for Germany, Latvia and Lithuania. *Qe_openness* displays a very small but negative effect for Germany and Italy. The proxy for labour force growth trend shows also here coefficients that are not close to 1, positive for Greece and Latvia but negative for Lithuania. *Exp_rd* demonstrates a decreasing effect for Italy and Lithuania; *ger_s* is positive for Italy but negative for Latvia; and finally, the only result for *g_dev* is a negative sign for Lithuania.

Table A5. **Determinants of EZ Member States g^N: OLS Estimations**

Variable	Luxemburg Model (4)	Malta Model (4)	Netherlands Model (4)	Portugal Model (2)	Slovakia Model (2)	Slovenia Model (4)	Spain Model (4)
qe	-	-	-	-	-	-	-
L1.	0.772	-0.080	0.069	0.285***	-0.437***	0.100***	0.129*
L2.	-	-	-	-0.031	0.111**	-	-
openness	0.017	-0.034**	0.050**	0.091***	-0.022	0.048***	0.120***
L1.	-	-	-	-	-	-	-

qe_openness	-	-	-	-	-	-	-
L1.	-0.002	0.002	-0.006	-0.003***	0.002***	-0.009***	-0.002**
L2.	-	-	-	0.003	-0.001***	-	-
g_lf_tr	-6.968	7.674**	3.716**	2.134	-48.495***	2.355***	-0.491
L1.	-	-	-	-	-	-	-
exp_rd	2.411	-3.946	1.553	-0.624	-2.862**	-0.629	-2.564**
L1.	-	-	-	-	-	-	-
ger_s	0.332	0.077	-0.070*	0.041**	-0.424**	0.053***	0.007
L1.	-	-	-	-	-	-	-
gdev	-	-	-	-	-	-	-
L1.	-4.314**	-3.296	0.653	-	-	-0.085	1.786

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.
Source: Author's calculations

Regarding the last group of countries (*Table A5*), the coefficient for *qe* shows a positive effect for Portugal, Slovenia and Spain, demonstrating that a 1% increase in net domestic assets leads to an increase in their potential growth rates of 0.28%, 0.10% and 0.12% respectively.
However, Slovakia g^N is affected by a negative performance of -0.43%. On the other hand, Luxemburg, Malta and the Netherlands do not reply with a statistically significant effect. Looking at the other regressors, *openness* has a small but positive impact for the Netherlands, Portugal, Slovenia and Spain, but negative for Malta and Slovakia. *Qe_openness* continues with very small coefficients, increasing for Slovakia and decreasing for Portugal, Slovenia and Spain. *G_lf_tr* persists with results greater than 1, positive for Malta, the Netherlands and Slovenia and negative for Slovakia. *Exp_rd* has a decreasing effect for Slovakia and Spain; *ger_s* is negative in the cases of the Netherlands and Slovakia and positive for Portugal and Slovenia; finally, *g_dev* works with a negative coefficient for Luxemburg.

3. Conclusions

The intent of this supplemental analysis was to detect, using a different methodology compared to that implemented in *Chapter 3* (but recalling that already used in *Chapter 2*), the impact of QE policies in the Eurozone. However, the focus was shifted from the Euro Area as a single economy to the single 19 Member States that belong to it. This study continues to rely on the branch of literature that studied the macroeconomic effects of UMPs and QE, particularly on real GDP and inflation, but innovating with an original effort that looks at the potential output growth instead of the actual output.
Results from this analysis suggest an overall positive impact of QE on the potential output growth rates estimated. In particular, for Austria, Belgium, Finland, France, Germany, Italy, Portugal, Slovenia and Spain, the coefficient for *qe*, which represents the elasticity of natural growth rate with respect to QE, is positive and statistically significant, indicating that a 1% increase of net domestic assets correspond to an impact on potential GDP growth of 0.21%, 0.24%, 0.19%, 0.22%, 0.31%, 0.04%, 0.28%, 0.10% and 0.12% respectively. These results are also in line with the findings of *Chapter 2*, where QE positively affected the natural output growth of the Euro Area with an impact of 0.20%.

On the other hand, the *qe* coefficient for Cyprus, Estonia, Latvia and Slovakia shows a negative sign, denoting that a 1% increase in domestic assets has a decreasing effect on their potential output rates of -0.11%, -0.26%, -0.15%, -0.43% respectively. For the remaining countries, Greece, Ireland, Lithuania, Luxemburg, Malta and the Netherlands, the proxy for *qe* does not reply with a statistically significant effect.

In conclusion, divergences on output growth, inflation and labour force across Eurozone countries continue to display effects even if they have been moderated since the beginning of the monetary union and are visible also in the non-homogeneous results of this analysis. Indeed, the differences in economic structures and performances lead to divergences in the speed of their adjustment even if the UMP implemented was the same for all members of the monetary union.

Conclusions

This thesis examined the results of the effects of Quantitative Easing (QE) extraordinary monetary policies that were introduced by central banks after the 2007/2008 global financial crisis.

An overview regarding the present literature on unconventional monetary policies (UMPs), and particularly QE, is specified in the first paper. Generally, this monetary policy instrument is classified by reflecting on its impact on financial markets or on macroeconomic variables and is well represented by an increase in net domestic assets in the balance sheets of central banks. Considering that the effects of QE in the first field are much more explored, my empirical research was thus focused on the examination of its impact on the macroeconomic framework. Literature findings in this latter context suggest that in the Eurozone, after the introduction of this programme, actual GDP as well as inflation CPI have showed a positive increment. For the United States (US), the studies report an increase of real output of around 0.36-3%, and an inflation increment between 0.4-1.6 percentage points (pps). Finally, for the United Kingdom (UK) the estimation results assess an increase between 0.18-1.5% for real GDP and 1-2 pps for the inflation rate.
Moreover, it is important to underline that, within the macro framework, literature only reports the effects of asset purchases on real GDP and inflation CPI. Therefore, given that, to my best knowledge, there are no previous studies that examine the impact of QE on potential output growth for the US and Eurozone economies, my empirical research is intended to fill this gap.

The purpose of my second study was to analyse the effect of this increase of domestic assets on the balance sheets of the Federal Reserve (FED) and the European Central Bank (ECB). QE was introduced also to positively affect the labour productivity growth rate and the natural or potential growth rate, acting primarily through the credit channel. Thus, using an AS state-space model with time-varying parameters and a Kalman filtering methodology, I specified quarterly and annual estimates of potential growth for the US and Eurozone economies. Then, having chosen the finest time series estimates for each economy, I regressed with the ordinary least squares (OLS) methodology a dynamic model where variables are instrumented with first lag, using a proxy for QE policies, and four proxies for labour force and labour productivity. Next, three alternatives of the primary specification were regressed. In *Model (4)* the coefficients for QE show a positive and statistically significant effect on potential growth, meaning that a 1% increase in domestic assets corresponds with an impact on potential output of 0.95% for the US and 0.20% for the Eurozone.
Therefore, this analysis is in line with the literature findings regarding the effects of QE (and UMPs in general) on the macro framework; actually, the majority of the estimates showed an increase of real output in the Euro Area, while for the US the actual GDP displayed a positive increment of around 0.36-3%. Thus, these results suggest that one of the main purposes of central banks in the wake of the financial crisis, i.e. to help the economy in its recovery facilitating an increment of the actual as well as the long-run growth rate, is achieved.

Then, in the third chapter I focused on the investigation of the impact of QE in the Euro Area, using six macro and monetary variables that characterize the aim of the asset acquisitions of the ECB. The framework involved a difference-in-differences (DID) methodology that generally evaluates a policy shift among groups generated by a 'natural occurring event' (QE in this case). Results are provided considering a comparison between the 'treated' group (the Eurozone countries in this analysis) and the 'control' group (the other states of the European Union (EU) that are not

part of the Eurozone and do not use the euro). Results from this analysis presented a robust coefficient for inflation CPI that showed a statistically significant and positive trend between 0.31-0.34% (0.78-1.22% when the lagged variables are considered), representing a sizable increase in the Eurozone compared to the other European economies after QE introduction. Consequently, this result confirmed literature findings on a general positive increment of inflation CPI.

Finally, at the end of *Chapter 3,* an *Appendix Section* has been added, that includes a supplemental analysis to detect the impact of QE in the Eurozone. Using the methodology proposed in *Chapter 2*, i.e. the estimation of the potential output growth with an AS state-space model and a Kalman filter methodology, such as the OLS regression analysis, in this section the focus was shifted to the single 19 Member States of the Euro Area. The results report a positive impact of QE policies on the potential growth rates estimated for 9 countries (Austria, Belgium, Finland, France, Germany, Italy, Portugal, Slovenia and Spain) assessing that a 1% increase in net domestic assets had a general impact on long run GDP growth of 0.19% on average. This finding continues along the line of the results of *Chapter 2*, where QE positively influenced the Eurozone's natural output growth with an impact of 0.20%. However, regarding the other countries, the *qe* coefficient has either a negative sign (Cyprus, Estonia, Latvia and Slovakia), or shows a non-statistically significant effect (Greece, Ireland, Lithuania, Luxemburg, Malta and the Netherlands).

The effectiveness of QE and its ensuing impact should be further evaluated, considering that its effects will probably be well detected in the medium-long term. Nonetheless, the unconventional manoeuvres conducted by the ECB and the FED helped to minimize the need for reforms, clearly boosting the short-term competitiveness of the European and US economies. The effects on stimulating financial markets are much more evident, but a clear-cut recovery in the broad economy is yet to be seen. However, some structural problems, particularly in the Eurozone, remain to be solved, such as labour market flexibility, insufficient long-term investments, and the banking system recovery. Therefore, it may be advisable for the governments of Member States to conduct more concrete reforms.

References

Abbassi P., and Linzert T., "*The Effectiveness of Monetary Policy in Steering Money Market Rates during the Recent Financial Crisis",* ECB Working Paper No. 1328, 2011.

Anand R., C. Cheng K., Rehman S., and Zhang L., *"Potential Growth in Emerging Asia",* IMF Working Paper WP/14/12, 2014.

Anderson R.G., Gascon C.S. and Liu Y., "*Doubling Your Monetary Base and Surviving: Some International Experience",* Federal Reserve Bank of St. Louis Review, 92(6), pp. 481-505, November/December 2010.

Andrade P., Breckenfelder J., De Fiore F., Karadi P. and Tristani O., *"The ECB's asset purchase programme: an early assessment",* ECB Working Paper Series No. 1956, 2016.

Andre´s J., Lopez-Salido J.D. and Nelson E., *"Tobin's imperfect asset substitution in optimizing general equilibrium"*, Journal of Money, Credit and Banking, vol. 36(4), pp. 665–90, 2004.

Angelini P., Nobili A., Picillo C., "*The Interbank Market after August 2007: What Has Changed, and Why?",* Journal of Money, Credit and Banking, 43 (5): 923–58, 2011.

Ashenfelter O. and Card D., "*Using the Longitudinal Structure of Earnings to Estimate the Effect of Training Programs",* The Review of Economics and Statistics, Vol. 67, No. 4, pp. 648-660., 1985.

Baumeister C. and Benati L., *"Unconventional monetary policy and the great recession - Estimating the impact of a compression in the yield spread at the zero lower bound",* Working Paper Series No. 1258, European Central Bank, 2010.

Bean C., Paustian M., Penalver A. and Taylor T., *"Monetary policy after the fall"*, Federal Reserve Bank of Kansas City Annual Conference, 2010.

Beffy P.O., Ollivaud P., Richardson P. and Sédillot F., *"New OECD methods for supply-side and medium-term assessments: a capital services approach",* Economics department Working Paper Series No. 482, OECD, 2006.

Beirne J., Dalitz L., Ejsing J., Grothe M., Manganelli S., Monar F., Sahel B., Suˇsec M., Tapking J., and Vong T., "*The Impact of the Eurosystem's Covered Bond Purchase Programme on the Primary and Secondary Markets",* ECB Occasional Paper No. 122, 2011.

Bernanke, Ben S., "*Monetary Policy Since the Onset of the Crisis"*, presented at a symposium sponsored by the Federal Reserve Bank of Kansas City, "The Changing Policy Landscape," Jackson Hole, Wyoming, August 31, 2012.

Blagrave P., Garcia-Saltos R., Laxton D., and Zhang F., *"Where are we headed? Perspectives on potential output",* IMF (April 2015), chapter 3, pp. 1-42, 2015.

Bluford H.P., "*Essential concepts necessary to consider when evaluating the efficacy of Quantitative Easing",* Review of Financial Economics, Volume 22, Issue 1, pp. 1-7, 2013.

Borio C. and Zabai A., "*Unconventional monetary policies: a re-appraisal",* Bank for international settlements, BIS working papers n.570, 2016.

Bridges J. and Thomas R., *"The impact of QE on the UK economy - some supportive monetarist arithmetic"*, Bank of England Working Paper No. 442, 2012.

Brunetti C., Di Filippo M., and Harris J.H., "*Effects of Central Bank Intervention on the Interbank Market during the Subprime Crisi"s,* Review of Financial Studies, 24 (6): 2053–83, 2011.

Burriel P. and Galesi A., *"Uncovering the heterogeneous effects of ECB unconventional monetary policies across Euro Area countries",* Banco de España, Documentos de trabajo n.1631, 2016.

Christensen J.H.E. and Rudebusch G.D., *"The response of government yields to central bank purchases of long-term bonds"*, Economic Journal, vol. 122(564), pp. F385–414, 2012.

Christiano L., *"Commentary: remarks on unconventional monetary policy"*, International Journal of Central Banking, Vol. 7, No. 1, pages 121–30, 2011.

Christiano L.J., Eichenbaum M. and Evans C.L., *"Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy",* The Journal of Political Economy, Vol. 113, pp. 1(45), 2005.

Chung H., Laforte J.P., Reifschneider D., Williams J.C., "*Have We Underestimated the Probability of Hitting the Zero Lower Bound?"*, Journal of Money, Credit and Banking, Vol. 44, No. 2, pp. 47-82, 2012.

Claeys G., Leandro A., Mandra A., "*European Central Bank Quantitative Easing; the detailed manual",* Bruegel Policy Contribution, March 2015.

Curdia V. and Woodford M., *"The central-bank balance sheet as an instrument of policy"*, Journal of Monetary Economics, vol. 58, pp. 54–79, 2011.

D'Amico S. and King T.B., *"Flow and stock effects of large-scale treasury purchases"*, Finance and Economics Discussion Series, No. 2010-52, 2010.

Dale S., *"QE - one year on"*, remarks at the CIMF and MMF Conference, 2010.

De Grawe P., Ji Y., "*Quantitative Easing in the Eurozone; it's possible without fiscal transfers",* Cesifo Area Conference on Macro, Money and International Finance, 2015.

De Pooter M., Martin R.F., and Pruitt S., "*The Effects of Official Bond Market Intervention in Europe",* Mimeo, Board of Governors of the Federal Reserve System, 2012.

European Commission, Convergence criteria for joining, www.ec.europa.eu, 2018.

European Central Bank, Capital subscription, www.ecb.europa.eu, 2019.

Eggertsson G. and Woodford M., *"The zero bound on interest rates and optimal monetary policy"*, Brookings Papers on Economic Activity, vol. 1, pp. 139-211, 2003.

Engen E., Laubach T., and Reifschneider D., "*The Macroeconomic Effects of the Federal Reserve's Unconventional Monetary Policies"*, Federal Reserve Board, January 14, 2015.

Eser F., and Schwaab B., "*Assessing Asset Purchases within the ECB's Securities Markets Programme",* ECB Working Paper No. 1587, 2013.

Fahr S., Motto R., Rostagno M., Smets F. and Tristani O., *"Lessons for monetary policy strategies from the recent past"*, ECB Working Paper Series No. 1336, 2010.

Fawley B.W. and Neely C.J., "*Four Stories of Quantitative Easing",* Federal Reserve Bank of St. Louis Review , 95 (1), pp. 51-88, January/February 2013.

Felipe J., Lanzafame M. and León-Ledesma M., *"Asia's Potential Growth",* Asian Development Outlook, pp. 43-84, 2016.

Furceri D. and Mourougane A., "*The effect of financial crises on potential output: New empirical evidence from OECD countries",* Journal of Macroeconomics 34, 822-832, 2012.

Gagnon J. E., Bayoumi T., Londono J.M., Saborowski C., and Sapriza H., *"Direct and Spillover Effects of Unconventional Monetary and Exchange Rate Policies",* IMF Working Paper 17/56, 2017.

Gagnon J., Raskin M., Remache J. and Sack B., *"Large-Scale Asset Purchases by the Federal Reserve: Did They Work?",* Federal Reserve Bank of New York Economic Policy Review, May, 17(1), pp. 41-59, 2011. (a)

Gagnon J., Raskin M., Remache J. and Sack B., *"The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases",* International Journal of Central Banking, March, 7(1), pp. 3-43, 2011. (b)

Gambacorta L., Hofman B. and Peersman G., *"Effectiveness of unconventional monetary policy at the zero lower bound: a cross-country analysis"*, Journal of Money, Credit and Banking, forthcoming, 2013.

Gern K.J., Jannsen N., Kooths S. and Wolters M., "*Quantitative Easing in the Euro Area: Transmission Channel and Risks",* ZBW- Leibniz Information Center of Econimics, 2015.

Gertler M. and Karadi P., *"A Framework for Analyzing Large-Scale Asset Purchasesas a Monetary Policy Tool",* International Journal of Central Banking, Vol. 9, pp. 5(53), 2013.

Ghysels E., Idier J., Manganelli S., and Vergote O., "*A High Frequency Assessment of the ECB Securities Markets Programme",* CEPR Discussion Paper No. 9778, 2013.

Giannone D., Lenza M., Pill H. and Reichlin L., *"Non-standard monetary policy measures and monetary developments"*, in (Jagjit.S. Chadha and Sean. Holly, eds), Interest Rates, Prices and Liquidity - Lessons from the Financial Crisis, pp. 195–221, Cambridge: Cambridge University Press, 2011.

Giannone D., Lenza M., Pill H. and Reichlin L., *"The ECB and the interbank market"*, Economic Journal, vol. 122(564), pp. F467–86, 2012.

Hamilton, J. D., and Wu J.C., "*The Effectiveness of Alternative Monetary Policy Tools in a Zero Lower Bound Environment"*, Journal of Money, Credit and Banking 44 (s1): 3–46, 2012.

Harrison R., *"Asset purchase policy at the effective lower bound for interest rates"*, Bank of England Working Papers No. 444, 2012.

Harrod R. F., *"An Essay in Dynamic Theory",* The Economic Journal 49 (1939): 14–33, 1939.

Harvey A., *"Forecasting: Structural Time Series Models and the Kalman Filter",* Cambridge, UK: Cambridge University Press, 1989.

Hausken K. and Ncube M., *"Quantitative Easing and Its Impact in the US, Japan, the UK and Europe",* SpringerBriefs in Economics, 2013.

Holland Paul W., *"Statistics and Causal Inference",* Journal of the American Statistical Association, 81:396, pp. 945-960, 2012.

Honda Y., "*The effectiveness of non traditional monetary policy: the case of Japan",* The Japanese Economic Review, Vol. 65, No. 1, March 2014.

International Monetary Fund, *"Unconventional Monetary Policies –Recent Experience and Prospects",* April 18, 2013.

Jones Andrew M., *"Panel data methods and applications to health economics",* in Palgrave Handbook of EconometricsVolume II: Applied Econometrics, Mills TC, Patterson K (eds), 2008.

Joyce M., Lasaosa A., Stevens I. and Tong M., *"The financial market impact of quantitative easing"*, International Journal of Central Banking, Vol. 7, No. 3, pages 113–61, 2011.

Joyce M., Miles D., Scott A. and Vayanos D., "*Quantitative Easing and Unconventional Monetary Policy: An Introduction",* The Economic Journal, 2012.

Kapetanios G., Mumtaz H., Stevens I. and Theodoridis K., *"Assessing the economy-wide effects of quantitative easing"*, Economic Journal, vol. 122(564), pp. F316–47, 2012.

Kohn D.L., *"Monetary Policy Research and the Financial Crisis: Strengths and Shortcoming",* Speech at the Federal Reserve Conference on Key Developments in Monetary Policy, Washington DC, October 9, 2009.

Krishnamurthy, A., and Vissing-Jorgensen A., "*The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy"*, Brookings Papers on Economic Activity 43 (2, Fall): 215–87, 2011.

Lanzafame M., and R. Nogueira,*"Credibility in Emerging Economies: Does Inflation Targeting Matter?",* The Manchester School 79 (6): 1080–98, 2011.

Lanzafame M., *"Potential Growth in Asia and Its Determinants: An Empirical Investigation",* Asian Development Review, vol. 33, no. 2, pp. 1–27, 2016.

Larsson Seim A. and Zetterberg J., *"Testing the impact of inflation targeting and central bank independence on labour market outcomes",* Oxford Economic Papers 65, 240–267, 2013.

Lenza M., Reichlin L., and Pill H., "*Monetary Policy in Exceptional Times",* Economic Policy 25 (6): 295–339, 2010.

Lu Xun and White Halbert, *"Robustness checks and robustness tests in applied economics",* Journal of Econometrics, Elsevier, vol. 178(P1), pages 194-206, 2014.

Meier A., *"Panacea, curse, or nonevent: unconventional monetary policy in the United Kingdom"*, IMF Working Paper, No. 09/163, 2009.

Meyer L. H. and Bomfim A.N., *"Quantifying the Effects of Fed Asset Purchases on Treasury Yields",* Macroeconomic Advisers Monetary Policy Insights: Fixed Income Focus, June 17, 2010.

Neely C.J., *"The Large-Scale Asset Purchases Had Large International Effects",* Federal Reserve Bank of St. Louis, Working Paper No. 2010-018D, July 2010, revised April 2012.

Neely C.N., "*Unconventional monetary policy had large international effects"*, Journal of Banking and Finance, Vol. 52, pp. 101-111, 2015.

Okun A., *"Potential GNP: Its Measurement and Significance",* Proceedings of the Business and Economic Statistics Section, American Statistical Association, 1962.

Pattipeilohy C., Willem J., Tabbae M., Frost J., and De Haan J., "*Unconventional Monetary Policy of the ECB during the Financial Crisis: An Assessment and New Evidence",* DNB Working Paper No. 381, 2013.

Peersman G, "*Macroeconomic Effects of Unconventional Monetary Policy Measures in the Euro Area",* ECB Working Paper No. 1397, 2011.

Romer D., *"Openness and Inflation: Theory and Evidence",* The Quarterly Journal of Economics 108 (4): 869–903, 1993.

Schenkelberg H., Watzka S., "*The Real Effects of Quantitative Easing at the Zero Lower Bound: Structural VAR-based Evidence from Japan",* Journal of International Money and Finance, Vol. 33, No. C, pp. 327-357, 2013.

Sims C., *"Comments on Sargent and Cogley's Evolving Post-World War II US Inflation Dynamics",* NBER Macroeconomics Annual 16 (2001): 373–79, 2001.

Smets F. and Wouters R., *"Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach",* The American Economic Review, Vol. 97, pp. 586(606), 2007.

Stroebel J.C. and Taylor J.B., *"Estimated Impact of the Fed's Mortgage-Backed Securities Purchase Program",* NBER Working Paper No. 15626, National Bureau of Economic Research, December 2009.

Swanson E.T., *"Let's twist again: a high-frequency event-study analysis of operation twist and its implications for QE2"*, Federal Reserve Bank of San Francisco, Working Paper Series No. 2011-08, 2011.

Szczerbowicz U., "*Are Unconventional Monetary Policies Effective?",* CELEG Working Paper No. 1107, Dipartimento di Economia e Finanza, LUISS Guido Carli, 2011.

Szczerbowicz U., *"The ECB Unconventional Monetary Policies: Have They Lowered Market Borrowing Costs for Banks and Governments?",* International Journal of Central Banking, 2015.

Taylor J.B., and Williams J.C., "*A Black Swan in the Money Market"*, American Economic Journal: Macroeconomics 1 (1): 58–83, 2009.

Tobin J., *"A general equilibrium approach to monetary theory",* Journal of Money, Credit and Banking, I(1):15–29, 1969.

Ueda K., "*The Effectiveness of Non-Traditional Monetary Policy Measures: The Case of the Bank of Japan",* Japanese Economic Review, 63 (1): 1–22, 2012.

Ueda K., "*The Response of Asset Prices to Abenomics: Is It a Case of Self-Fulfilling Expectations?",* CIRJE Discussion Paper No. F-885, Faculty of Economics, University of Tokyo, 2013.

Ugai H., "*Effects of the Quantitative Easing Policy: A Survey of Empirical Analyses"*, Bank of Japan Working Paper Series, July 2006.

Vayanos D. and Vila J.L., *"A preferred-habitat model of the term structure of interest rates",* NBER Working Paper No. 15487, 2009.

Weale M. and Wieladek T., *"What are the macroeconomic effects of asset purchases?"*, Discussion Paper n.42, External MPC Unit, Bank of England, April 2014.

Wright J., *"What does monetary policy do at the zero lower bound?"*, Economic Journal, vol.122(564), pp. F447–66, 2012.