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Master's Thesis - MPA: Economics and Governance

The Panel VAR Approach to Policy Modelling: Effectiveness of Ultra-low and Negative Interest Rates - Evidence from Europe

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Executive Summary

In the aftermath of the Global Financial Crisis (GFC), major central banks worldwide have substantially adjusted policy interest rates to historical low levels until the zero lower bound (ZLB). The cuts in nominal interest rates to the ZLB indicates that the monetary authorities confronted with the so-called "liquidity trap" that the ultra-low rates would constrain the monetary policy options to react to unexpected shocks to the economy. In the meantime, as the interest rate is lowered, some major central banks in the world such as the European Central Bank (ECB) have embarked upon a series of ambitious quantitative easing (QE) programmes, which are represented by the Asset Purchase Programme. However, the long-term ultra-low interest rates and quantitative easing programmes have not achieved the expected results; inflation has not fully reached its target of below 2%, and economic growth is still sluggish Against this backdrop, the Negative Interest Rate Policy (NIRP) is no longer a theoretical curiosity. It was initially adopted by the ECB in June 2014 when the Frankfurt-based monetary authority dropped its overnight deposit facility rate to the negative -0,1%. In 2016, the ECB has further decreased its deposit rate to -0,4%.

The NIRP was conceived in the context of quantitative easing. It departs from the demand side, aiming to spur economic recovery and prevent deflationary spirals. Despite the NIRP altering the prevailing paradigm that the policy rate cannot breach the ZLB, there is still an absence of a succinct consensus on the introduction and execution of this unconventional monetary tool. This is underlined by the divergence of opinions between the policymakers and monetarist economists. This necessitates a need for empirical research on the effectiveness of the NIRP taking into consideration the QE programmes.

Employing a Panel Vector Autoregressive Model (PVAR), this paper assesses the effectiveness of the unconventional policies of the ECB on the macroeconomic performance in Europe. The outcomes show that it is still too early to consider the NIRP as a success; the monetary policy works towards achieving the ECB's chief monetary objective: keeping inflation less than 2%. It has, however, triggered more significant adverse effects, reflected particularly in the current account deficit of the countries in Europe. Hence, policymakers at the monetary authorities are advised to carefully devise the monetary objective of the central bank in the long-run and should exit from the NIRP with appropriate measures to guide the liquidity flow.

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1. Introduction

1.1 Background

It has been a decade since the last financial crisis, and central banks worldwide have successively adopted ultra-loose monetary and fiscal policies to stabilise exchange rates, stimulate inflation and promote economic growth. With the expansion of monetary easing programmes, the aggregate money supply worldwide continued to grow. Meanwhile, the policy interest rates at major central banks have been dropped to the zero or near zero level, which the monetarists have referred to as the "Zero Lower Bound (ZLB)".

From a practical point of view, these ultra-loose monetary policies have hardly realised the transmission from the easing of borrowing conditions and an ample supply of liquidity to the sectors and industries where the liquidity were in fact needed. The investment and consumption levels of the real economy, as well as the level of inflation, have not been effectively improved in a world with innundation of cheap credit. Under the pressure of a stagnant economy, the ensuing political turmoil and the international funds' need for a safe harbour, the monetary authorities worldwide are compelled to seek radical and unconventional countermeasures.

Against this backdrop, the nominal negative interest rate was no longer remaining on the level of theoretical debate but had become a primary attempt by central banks to stimulate inflation or to suppress the tension of currency appreciation. In July 2009, the Sveriges Riksbank in Stockholm implemented the Negative Interest Rate Policy (NIRP) for the first time in the modern era; the rate only targeted the repo rates with the aim of achieving inflation expectations. Subsequently, Denmark also implemented the negative interest rate in July 2012.

The results of these monetary policy tools failed to reach their objectives. By July 2012, the deposit facility rate had already dropped to the zero bound and remained there for about two years. Due to the existence of the ZLB and liquidity traps in nominal interest rates the years of loose monetary policy was in danger of failure. The Eurozone, the ECB, and the EU were confronted with an immediate credibility crisis. In this context, the negative interest policy manifested itself as the default monetary toolkit for the central banks worldwide.

The European Central Bank's (ECB) implemented the historical negative deposit facility rate on excess overnight deposits in June 2014. This caused the 19 countries in the Eurozone to enter the era of negative interest rates. Straight after the Global Financial Crisis (GFC), the outbreak of the sovereign debt crisis in 2012, also a fully-fledged balance of payments crisis, inflicted heavy losses on the real economy, investments, demand for consumption and the overall confidence in the euro as a common currency.

In order to restore growth and resist inflation, the ECB continued to lower the policy rates to create more incentives for the commercial banks to increase lending and promote consumption, investment and exports. The Frankfurt-based monetary authority also adopted a series of non-traditional monetary policy tools alongside the negative interest rates such as the expansion of the long-term refinancing operations and asset purchase programmes.

1.2 Why Does It Matter?

Major central banks of developed economies, e.g. the ECB and Bank of Japan (BOJ), took the initiative to implement the negative interest rate in order to meet the inflation target. Central banks from smaller economies, e.g. Swiss National Bank (SNB) and Hungarian National Bank (MNB), on the other hand, passively implemented the negative interest rate, in order to stabilise domestic currencies (Heider, Saidi, & Schepens, 2016). When central banks promoted the negative interest rate, they did so in an effort to supplement the traditional quantitative easing, in order to release the liquidity to the market.

The NIRP is a highly controversial monetary policy instrument created following rounds after rounds of quantitative easing programmes. That being said, the lacunae of credit channels hindered the effects of policy on negative interest rates (Angrick & Nemoto, 2017). Meanwhile, geopolitical conflicts and other "Black Swan" events such as Brexit and the refugee crisis further exacerbate the market expectations. As a result, the effectiveness of NIRP had a limited effect in the short-term despite the claim of monetary authorities that the conditions would have been worse without the introduction of the NIRP. If the crisis were to hit again, the central banks would likely expand the scope and extent of negative interest rates, but there will be only restricted room for manoeuvre with monetary policy options.

Overall, the drawbacks of the NIRP have not received enough attention by the monetary authorities. Meanwhile, the cause of the economic doldrums remained to be examined. Therefore, understanding the effectiveness of the present unconventional monetary policies is necessary to give guidance to monetary authorities in order to forecast the development of future long-term interest rate trends. This paper hopes to contribute to our understanding of the efficacy of monetary policy and the ultra-low interest rate/NIRP in particular. By adding insight into the efficacy of the NIRP, policymakers may be convinced that cutting interest rates and additional monetary easing programmes may not be the optimal response to the current economic situation. This thesis hopes to aid policymakers in crafting more responsible and effective policies

1.3 Significance of the Subject

1.3.1 Theoretical Value

The Negative Interest Rate Policy as a non-conventional monetary policy has been implemented in many countries with far-reaching effects. The NIRP has been highly discussed by the scholars of monetarist economics since 2009 when Sveriges Riksbank firstly went below the zero line. Prior to that, most scholars believed that the monetary policy with interest rate adjustment would not break the constraint of ZLB. This prevailing paradigm has changed when the interest rates at major central banks in the world have dipped below zero. The policy act has also turned to be a theoretical innovation that the lower bound on nominal interest rate is no longer at zero, but remains to be defined.

The effects of the NIRP remains uncertain. Due to the relatively short time of implementation and varying objectives across countries, the monetary policy research on this issue is still in its infancy. Most of the studies that have been carried out are qualitative, without the use of empirical methods that allow us to establish and investigate claims. On the one hand, the NIRP is expected to stimulate commercial banks to increase lending, promote growth, and deter deflationary risks. On the other hand, the banks' profit margin could be reduced, or depositors may lose confidence and start excessive saving, threatening the stability of the financial market in the long-run.

Using statistical methods, empirical testing the negative-interest monetary policy transmission effect can have important scientific significance: 1) if the test finds that the negative interest rate is effective, then there is proof that the nominal interest rate can break through the constraint of the ZLB, and the NIRP is indeed a logical theoretical innovation 2) if the test finds that the NIRP's implication is not significant, there is proof for the correctness of the traditional interest rate theory and the nominal interest rate should not break through the ZLB.

1.3.2 Practical Value

The Eurozone accounts for one-fifth of the world's GDP and one-quarter of world trade (IMF, 2018) and it is the first economic community that has adopted the NIRP. Nevertheless, the fiscal conditions from country to country vary significantly in Europe, which has been highlighted in 2009 when the sovereign debt crisis broke out driven by the accumulation of large payment imbalances between member states. The massive deficits in the peripheral countries such as Greece reflect the surplus' accumulation in core countries represented by Germany.

An exhaustive analysis of the efficacy of the NIRP is conducive to guiding the direction of future monetary adjustments and has strong referential value to other central banks of the emerging markets. Private investors and companies, on the other hand, are able to make more informed prognoses of market trends and investment decisions.

1.4 Research Objective

This thesis attempts to demonstrate the validity of the traditional interest rate theory in monetary economic that the ZLB should not be breached. Irving Fisher (1930) proposed the constraint of the zero lower bound (ZLB) on the nominal interest rate as early as 1896. He recognised that if the economic agent borrowed money and received negative interest, then this person would prefer to hold cash. As a consequence, investments would fall due to the inability to access financing, leading to unemployment and output reduction. On this basis, Keynes suggested the famous liquidity trap theory that rendering monetary policy becomes effective when the market interest rate is lower than the liquidity premium.

The deflationary pressure in the Eurozone has coincided with the downward adjustment on the nominal interest rate of the ECB. Although breaching the ZLB is regarded as an "innovation" of the traditional interest rate theory, the overall effects of this unconventional monetary tool on the macroeconomy are yet to be empirically tested; the variation of its effectiveness in different countries/regions in Europe is still indeterminate.

To begin with, this paper discusses the historical evolution of the monetary policy from the conventional to unconventional policy tools. This is followed by a description of the discussions surrounding the negative interest rates, and theories of the key concepts used in this research. The empirical analysis employs the Panel-Vector Autoregressive Model (PVAR) to examine the effectiveness of the NIRP on the macroeconomic indicators in 14 representative economies in Europe. The monetary policy is put into test in a complete economic cycle from 2005 to 2017, covering periods of the GFC and the sovereign debt crisis. Based on established theories, the study divides the observed countries into the current account surplus and deficit countries in Europe, eliminating the interference caused by the simple geographical classification.

Hence, the three major research questions of this paper are:

What have the effects of the Negative Interest Rate Policy (NIRP) of the European Central Bank (ECB) been in achieving its chief monetary objective – price stability after four years following implementation?

What have the effects of the Negative Interest Rate Policy (NIRP) of the European Central Bank (ECB) been in promoting the macroeconomic recovery in Europe?

Is there variation in the effectiveness of the Negative Interest Rate Policy (NIRP) in the current account surplus and current account deficit countries in Europe?

1.6 Structure of the Paper

The thesis has eight chapters.

Departing from a century-long discussion surrounding the zero lower bound (ZLB), the literature review first discusses the evolution of monetary policies worldwide and then introduces the negative interest rate and its emergence and development traced back to the very beginning of the 20th century. Then, chapter two also reviews the effectiveness of the negative interest rate policy from the perspectives of academia, monetarist economists and the monetary authorities.

The following chapter presents the theoretical framework which contains discussions of the key concepts this paper. It elaborates on the definition and mechanisms of the nominal interest rate and real interest rate, the evolvement of monetary objectives and, the identification of the effectiveness of monetary policy. This chapter will also touch on the distinction between current account surplus and deficit countries in Europe. The hypotheses tested in this paper will then be spelt out at the end of this chapter.

The fourth chapter explores the evolution of ECB's monetary policies the GFC and explains the mechanism of the Interest Rate Corridor with which the ECB sets the floor and ceiling of the interest rate to influence the interbank lending rate. This chapter also makes a distinction of NIRP and monetary programmes that had been carried out by the ECB alongside the interest rate adjustment.

The fifth chapter discusses the empirical method – Panel Vector Autoregressive Model (PVAR) and sheds light on the data collection, determination of variables and the operationalisation process.

The sixth chapter presents the empirical analysis. The PVAR model is firstly established in the form of the equation to show the mechanism of the model, followed by the stationarity tests and selection of the optimal lag length. The PVAR employs the impulse response analysis and variance decomposition to interpret the substantive significance of the unconventional monetary policies

The following chapter underscores the empirical results in a non-technical manner. For the readers who are less acquainted with the PVAR model or the model is not of interest, it is suggested to skip ahead to Section 7.1. Furthermore, Section 7.2 attempts to interpret the underlying reasons behind the statistical analysis, which

At last, the eighth chapter concludes this paper and discusses the policy recommendations, limitations and room for future research.

2. Literature Review

To begin with, this chapter takes a historical path and reviews the transformation of the monetary policy since the Great Depression. It also zooms in on the century-long discussion surrounding the zero lower bound (ZLB) of the interest rate and sketches some of the most significant developments that have been the topics of discussion.

Then, this chapter focuses on the evaluation of the effectiveness of the NIRP from the perspectives of monetary authorities and monetary economists. Monetary authorities tend to acknowledge the effectiveness of the NIRP, but monetary economists emphasise that this unconventional tool does not exert effects on the macroeconomy or even pose threats to financial stability.

2.1 Conventional to Unconventional Monetary Policy

The study of monetary policy has always been the focus of economists, especially during times of economic crisis. The beginning of the discussion about the conventional monetary policy strictly started with *The General Theory of Employment, Interest and Money*. The emergence of unconventional monetary policy was only introduced in 2001 but was widely accepted during the financial crisis (Willes, 1980). Since then, it has become the policy of choice for both developed economies and emerging markets in order to cope with the financial crisis.

Monetary policy, in an open economy, refers to the art of managing the money supply (Holtrop, 1963). Central banks use monetary policy tools to adjust the money supply in the market in order to achieve policy objectives and regulate economic activities, so that new liquidity injected into the economy could be tantamount to the net spontaneous hoarding of liquidity.

Although Keynes (1936) emphasised the importance of fiscal policy as a tool for the government to intervene in the market economy, his theory of "liquidity preference" or "demand function for money", proposed in his book *General Theory of Employment Interest Rate and Money* provided a new analytical idea for the development of monetary policy. The Keynesian Money Demand function reveals the relationship between money demand interest rates and national income, affirming the influence of money supply on the real economy (Keynes, 1936).

Founded on the theoretical contributions of Keynes, the school of monetarism represented by Milton Friedman (1968) advocated the importance of money in circulation (liquidity). According to him, the change in short-term nominal GDP is casued by changes in the money supply, and that the amount of money in the long-term is mainly reflected in the price. Friedman also opposed the state's use of fiscal means, e.g. government spending, to intervene in the market economy while fighting economic meltdowns (Lothian, 2014), instead of maintaining the growth rate of money supply.

In the 1980s, the rational expectations school of thought pointed out that the private sector and the public would prejudge the central bank's policy management and act to contravene the monetary policy (Willes, 1980), because the public interests in the short term could be antagonistic to the long-run objective of the monetary authority. Therefore, the monetary authorities would have to consider the impact of the policy expectations on the economy when constructing monetary policy. In the meanwhile, the neoclassical economists believed that central banks faced another dilemma: monetary authorities were caught in a confidence crisis due to failed policies; the central banks' long-term objectives might not accord with public interests in the short-term. As a consequence, it would lead to distorted effects of the central bank's other monetary policies on meeting the targets (Hegedorn, 2008).

Although Reinhart (2009) argued that the U.S. Federal Reserve (FED) has already carried out an unusual monetary policy during the Great Depression in the United States, the discussion around unconventional monetary policy only began in 2001 when Japan first implemented the unconventional monetary policy - Quantitative Easing (QE). The QE programmes engaged in the purchase of a large amount of short-term government bonds with the main objective to boost inflation.

After having followed ultra-low interest rate at zero lower bound for about six years, the unconventional policy was engaged in the purchase of many short-term government bonds in order to boost inflation (Federal Reserve Bank St Louis, 2015).

Usually, unconventional monetary policy refers to another form of monetary policy that is adapted to prevent deflation when the interest rate is equal to zero or close to zero. Borio and Disyatat (2009) state that the main difference between conventional and unconventional monetary policy is that conventional monetary policy is an adjustment to short-term or even overnight policy interest rates, while non-conventional monetary policy is an adjustment to long-term interest rates. Filardo and Nakajima (2018) indicate that common unconventional monetary policy manifestations include the central bank's massive expansion of its balance sheet and attempts to influence long-term interest rates rather than short-term official interest rates. According to Smaghi (2009), unconventional monetary policy refers to the policy tool of the central bank to reduce the financing costs of banks, enterprises and households and directly provide funds to them.

2.2 The Evolvement of Monetary Objectives

In order to conceptualise and quantify the effectiveness of ECB's monetary policy in the later chapters, it is crucial to explore the evolvement of the monetary objectives in major economies. This section reviews the evolution of monetary objectives since the Second World War.

Price Stability and Full Employment

Before the Federal Reserve Reform Act in 1977, the primary objective of the Federal Reserve was to provide liquidity for financial institutions (Taylor, 2011). The reform aimed to make the Fed more accountable for its monetary policies in order to reach the goals of full employment as well as price stability, for the first time in its monetary policy. The Fed's flawed operating guides and preservation of the gold standard were widely criticised by the citizens, forcing the Fed to focus on the full employment in the economy (Wheeler, 1998).

After the Second World War, despite the monetary objectives of price stability and full employment, the United States adopted expansionary monetary policies. Surging demand for American exports from Europe during the reconstruction period fuelled the American economic growth and allowed for the expansion of the US' political and economic influence (Hubbard, 1991). This was subsequently followed by surging price levels and inflation, leading to unemployment and the collapse of stock markets and ultra-high oil prices. After two months in office, the then Federal Chairman, Paul Volcker, responded quickly to the runaway inflation present since the mid-1960s by strictly controlling the money supply (Poole, 2005). The drastic change of policy resulted in two recessions. After those, the inflation rate tapered off, and the prices finally stabilised.

Inflation Targeting

Both Europe and Japan have experienced the baptism of war. The goal of the monetary policy of most economies in these two regions was set to full employment. During the period from 1960 to 1980 as the western countries and Japan entered the stage of rapid economic development, the inflation rate began to rise gradually. The central banks then turned to contractionary monetary policy aiming at decelerating the economy. After the abovementioned reform implemented by Volcker, these countries also began to adopt this new monetary policy regime – inflation targeting: central banks set an inflation rate as its numerical target to stimulate the economy, in the hope that people would then increase their current consumption and have less time preference (Pétursson, 2005).

Balance of Payments

Meanwhile, the Bretton Woods Fixed Exchange System collapsed. This meant that the dollar-centred international currency system based on the fixed amount of gold held by the country came to an end (Ford, 1977). Immediately, governments around the world started floating their own currencies because these currencies were pegged to the U.S. dollar which was fixed to gold. Due to the growth of the Asian Tigers and later China, the American balance of payments gradually turned into a deficit. Hence, maintaining the balance of payments also gradually developed into one of the monetary objectives.

Financial Stability

After the subprime mortgage crisis in 2007, the then Federal Reserve Chairman Ben Bernanke did not adhere to the decades-long monetary goal of low inflation targeting (Kohn, 2010). Instead, the maintenance of financial stability and low unemployment rate became the main objectives, and the unconventional monetary policy tools such as quantitative easing and ultra-low interest rates came onto the stage as the countermeasures to recovery. The crisis greatly raised the awareness of the vulnerability of the financial system. After the gradual exit of the QE, Yellen added financial stability to the list of objectives of the Fed's monetary policy (Yellen, 2014), putting an emphasis on the regulatory and supervisory efforts of the Fed to minimise the development of systematic risks.

To sum up this section, so far five major monetary objectives (in bold) have been presented. They represent five important aspects that a central bank has to consider when implementing monetary policies. This section lays the foundation for the theoretical framework and selection of macroeconomic variables.

2.3 Negative Interest Rate Demarcation

The alleged "negative interest" refers to central banks' negative interest rate on the excessive deposits of commercial banks in the central bank (ECB, 2018). In other words, it is a percentage of interest paid by the central bank to the deposits of financial institutions in the central bank, rather than the negative interest rates paid by financial institutions for deposits or loans to enterprises or residents.

The development of research on NIPR has witnessed an evolutionary process as the global economic landscape changed. As an unconventional means of monetary policy, early studies on negative interest rate have mostly stayed on the theoretical basis of the Zero Lower Bound (ZLB) (Ilgmann & Menner, 2011). The main research subjects are the instrument of breaching the ZLB and the impact of interest rates on the macroeconomy when the interest rate is approaching zero. After the GFC, developed economies such as the United States, the Eurozone and Japan encountered the "liquidity trap", and its interest rate finally reached the zero bound (Angrick & Nemoto, 2017). After 2009, Sweden took the lead in implementing the NIPR, and major economies followed and tested this unconventional monetary tool, giving rise to the gradual maturity of research on NIPR in monetary policy research.

The conventional demand-side channel transmission mechanism is the earliest and most core monetary policy transmission mechanism (Schäfer, Stephan, & Hoang, 2017). When the money supply in the market is higher than the demand for money, the excess money will be used by people to lend and make transactions, and then the interest rate will fall. When the interest rate is below the return on investment, the assumption is that it will relax borrowing constraints and prompt people to increase investment

rather than saving. This would stimulate consumption, ultimately leading to higher inflation (Rabanal, 2007).

2.4 Nominal Negative Interest Rate and the Zero Lower Bound

2.4.1 Keynes – Liquidity Trap

In his book published in 1936, *The General Theory of Employment, Interest, and Money*, Keynes analysed the relationship between the rate of interest and investment demand-schedule (the schedule of the marginal efficiency of capital) that the interest rate and the marginal efficiency of capital determine the size of investment demand. When the capitalist's expected return on investment is fixed, the decline in interest rates will increase the demand for investment by reducing the costs of capital collection. Conversely, higher interest rates will reduce investment demand.

During recessions, monetary authorities can stimulate demand of investment by lowering interest rates; changes in investment can have a greater impact on the total national income through the principle of the multiplier (Keynes, 1936). At the same time, Keynes also believed that the interest rate would not fall indefinitely. The investors are diffident and pessimistic about prospects during a recession, and the marginal efficiency of capital will be lower. When the rate of interest is hovering above zero, people's liquidity preferences (demand for currencies) will become infinite, and the monetary authority will not be able to stimulate the investment and influence aggregate demand by increasing the money supply. Consequently, the economy will fall into a so-called "liquidity trap".

2.4.2 Gesell Taxes

Traditional economic theories often reckon that the nominal interest rate cannot be negative because of the existence of the "zero lower bound (ZLB)" which is seen as insurmountable in mainstream economics. Issues arise because a negative nominal rate could lead to a deflation spiral and threaten the government's credibility for maintaining the price stability. Furthermore, monetary authorities are cautious by nature and concerned about a potential or political backlash.

The existence of the ZLB greatly restricted the ability of the monetary authorities to influence the market by changing the market interest rate. In this regard, the German economist Silvio Gesell, the founder of "Freiwirtschaft", first proposed the concept of "Besteuerung des Geldes" – a carry tax, which provided a theoretical basis for the concept of the negative interest rate policy (Cœuré, 2014). Gesell argued that during an economic crisis, it is necessary to "tax" the money to avoid people hoarding cash excessively and being reluctant to increase investment and consumption. In other words, the act of saving would increase the costs of holding money, forcing people to increase lending.

The Gesell Tax can only be levied when the ZLB has been breached. Similarly, the current NIPR adopted by the central banks worldwide mainly deals with the national bank and commercial banks without the involvement of personal accounts, because the public is unlikely to accept a negative interest rate on their deposit. The policy needs a firm legal basis to come into force.

2.4.3 Issue of the Zero Lower Bound

Coins and currencies are anonymous bearer instruments and the deposits in public or commercial bank accounts are registered instruments (Buiter, 2009). Together they comprise the most liquid form of assets, usually known as "the monetary base". A rational economic agent will choose to hold the base money unless there are other assets that generate a higher return. Since these two components are substitutes to each other, a decrease in the interest rate on the deposits in commercial banks would quickly result in the rise of the demand for coins and currencies.

Hence, it is essential for a monetary authority to consider the complete monetary base when imposing a negative interest rate (Buiter & Panigirtzoglou, 2003). It is difficult to trace transfers due to anonymity of coins and currencies, and the holders of coins and currencies also lack incentives to pay for the costs incurred by a negative interest rate (Ilgmann & Menner, 2011).

Goodfriend (2000), Buiter and Panigirtzoglou (2003) considered the Gesell Tax as a means of breaking through the zero lower bound. Their study suggests that the zero lower limits are based on the premise that cash is held without cost, but that cash storage has a certain administrative cost. Therefore, it is possible for a central bank to keep the nominal interest rate negative as long as the rate is not lower than the actual value of the administrative costs of hoarding money. In other words, the amount of the costs determines whether dropping the nominal interest rate below zero would cause social unrest.

Buiter (2010) emphasises the redundancy of coins and notes as a media of exchange and supports the abolishment of coins and currency as well as the introduction of a new government-issued currency. The central bank can then set a negative interest rate on all registered accounts since all transactions would be traceable. Rogoff (2014) also backs this notion in his working paper published in 2014, by pointing out the anonymity nature of cash, which tends to encourage tax evasion or underground businesses. He argues that it is crucial to promote cashless payments and gradually phase out the paper currency so that people will have to accept paying a negative interest rate.

2.5. Discussion around the effectiveness of the NIRP

2.5.1 Positive Outlook of the NIRP

Examination of the effectiveness of nominal interest rate determined by the Central Bank began with the Fisher Effect created by American economist Irving Fisher (1930). His theory states how inflation

rates affect the nominal interest rate in response to a change in the money supply. It establishes a positive correlation between inflation and nominal interest rate in the long-run. Fisher also distinguishes between real and nominal interest rate by taking purchasing power into consideration; the distinction between nominal and real interest rates is the inflation rate as it changes the number of goods at a given amount of money can buy.

The phenomenon of the Fisher Effect exists in the long run, but they may not be present in the short-run (Fisher, 1930). Nominal interest rates do not immediately drop when inflation shifts, because the number of loans has fixed nominal interests, which were set according to the expected level of inflation. Unexpected inflation, nevertheless, could cause real interest rates to drop in the short-run because the nominal interest rates are fixed in some degrees. The nominal interest rate will adjust to changes in expected inflation and raising interest rates will be an effective measure to suppress inflation.

In contrast to the traditional perspectives, modern monetary authorities and studies before 2016 tend to generally hold positive views on the implementation of the NIRP. For example, both the Governor of the Bank of Japan and the President of the ECB are staunch advocates of the NIRP. The term "quantitative easing" or "QE" was invented by the Bank of Japan (BOJ). As the head of the BOJ, Haruhiko Kuroda (2016) claims that the rapid growth of world economy in the past decades, accompanied by increasing volatility, has turned the Japanese corporate sector from a net borrower into a net saver. He believes that, through the implementation of the NIRP, the scale of reserves held by financial institutions and corporates will be reduced, and the supply of loans to non-financial enterprises and the amount of money in circulation will be increased. As a result, this will stimulate the inflation and growth of the real economy and, in particular, of the manufacturing sector. In the face of slowing capital investment and dropping productivity, it is claimed to be a necessary approach, as it will reinstall the balance-investment balance enabling the banks to facilitate monetary easing. He also disregards the adverse effects of the NIRP on bank profitability as a negative rate given that the GFC's impact on Japanese financial institutions was only trivial and credit costs[1] for commercial banks have declined greatly over time.

Similarly, ECB president Draghi also stressed that the NIRP was an inevitable way to restore the economy, even if inflation and currency fluctuations react little to negative interest rates in the short term. He thinks that negative interest rates are still feasible and there is still room for further reduction in the future. Furthermore, both the most recent former Chairmen of the Federal Reserve Ben Bernanke (2017) and Janet Yellen (2017) noted that the NIPR is likely to be an alternative policy tool in the near future for the Fed. There is a room that interest rate only slightly drops below the zero bound as there are costs associated with the storage and security of the cash.

[1] Credit Costs: the amount which the commercial bank expects to lose because of standard credit risks

Jobst and Lin, in their IMF Working Paper published in 2016, argue that the NIRP is beneficial to the overall economy as it reduces funding costs and lifts the asset prices; the wealth costs increased household consumption and corporate borrowing. They discuss three benign aspects of the policy that outweigh the adverse effects of an extremely low-interest-rate: credit booming and growth of non-interest income, higher asset prices and lower funding costs, and more robust aggregate demand. More lenient credit makes borrowing easier. This encourages both households and companies to invest and consume, boosting aggregate demand (Jobst & Lin, 2016).

Former ECB economist Linas Jurkšas (2017) also ascertains the positive implication of the negative interest rate on the real economy, despite having the impact of various magnitude across different economic factors in the Eurozone, e.g. indices of consumer confidence and the broad stock market index. Through a difference-in-difference analysis on both short and long-term impacts, a negative interest drove down the borrowing and deposit rates for both households and non-financial corporations, causing more consumption and investments. The public tends to show more positive expectations of economic growth and inflation in the long-term.

2.5.2 Apprehension about the NIPR

On the contrary, most scholars are not optimistic about the expected effects since the implementation of this round of negative interest rate policy. Resting on the defect of theory and policy evaluation, Palley (2016) believes that the NIPR is not only ineffective but also dangerous to future growth. He believes that the pre-Keynesian economic reasoning is inherently fallacious in holding that the interest rate cuts, which affect employment and increase debts on future, are used to increase inflation today. Palley expounds on this by arguing that a negative interest rate may blindly lead to the reduction of aggregate demand. He also denies the assumption that the NIRP increases aggregate demand by increasing investment and reducing saving. In fact, according to him that the policy is likely to disrupt financial stability, insurance and pension schemes, causing asset bubbles and currency wars.

Mersch (2016) elaborates on the side-effects of the NIRP implementation in the Eurozone from a societal and legal perspective. With shadow banks becoming increasingly active and private savers feeling discriminated, the collapse of a number of banks in a low-interest rate environment due to low profitability is likely to result in unemployment and social unrest. Therefore, the policy also challenges to both public and private law (Mersch, 2016). The yield of many financial products is constructed based upon a market interest rate in the transaction agreement in which there is no unequivocal identification of whether the interest rate is positive or negative. With established market practices, the interest rate should not be negative. Hence, relevant contract law must be revised to provide a reasonable explanation of the negative interest rate policy and its impact on transactions. Mersch (2016) reckons

that the NIRP could lead to market inefficiency, tremendous legal costs and interpretation costs for the ECB because these transaction agreements are also in the realm of public law in Europe.

Employing a difference-in-difference approach, Heider, Saidi and Schepens (2017) analyse the riskiness of firms financed by banks with a high rate and low rate of deposit after the implementation of the NIRP in the Eurozone in 2014. The results clarify that the transmission of the NIRP depends upon the funding structure of a bank. Banks with high deposits are more impacted by the policy than low-deposit banks due to higher loss of profitability in a low-interest environment. Consequently, these high-deposit banks tend to seek out riskier options, such as excessive syndicated loans to risky assets, bringing a double blow to credit supply and market stability.

2.5.3 Uncertainty of the NIPR

Couré (2014) points out that the NIRP lowers commercial banks' debt costs, so funding becomes cheaper. In the short term, the impact on commercial banks' short-term lending business model is positive, and its long-term total impact remains dicey. Under normal circumstances, the short-term interest rate of the money market will track a central bank's policy interest rate (ECB overnight deposit rate). If the policy rate is lowered, the short-term interest rate of the money market will then decrease; short-term interest rates will lead to a decline in long-term interest rates due to market expectations, which in turn will lower the equilibrium rate[2] across the money market. However, whether negative interest rates can ultimately lead to a decline in the borrowing costs of the physical sector is still unknown.

Schäfer, Stephan, & Hoang (2017) find that ECB's policy rate drop has heterogeneous inflationary effects within the Eurozone. They used the panel data from the German manufacturing sector to identify the cost channel effect of the interest rate drop on the price index of the respective industry. However, no significant results on Germany's inflation rate were found in the following VAR analysis, but Spain and Italy show significant results in terms of combating deflation.

[2] An interest rate which is consistent with potentially stable output and inflation (Cœuré, 2016)

3. Theoretical Framework and Hypotheses

Before 2008, monetary economists and policy analysts believed that it was unlikely for short-term interest rates to have a "zero lower bound (ZLB)", so it was difficult to restrain traditional monetary policy. When the overall economic situation and market speculations changed dramatically during the crisis, the conventional monetary policy fell into a "liquidity trap", and central banks were immediately confronted to risks of failure and potential loss of credibility. As a result, the theoretical zero lower bound was finally breached and the nominal negative interest rate was proposed and implemented.

This chapter elaborates on the theoretical basis of the empirical analysis. Sub-chapter 3.1 defines the interest rate in a modern context and distinguishes between nominal and real interest rate. Then the evolvement of the monetary objectives is reviewed from a historical perspective, laying the groundwork for the demarcation of the effectiveness of monetary policy.

3.1 Negative Interest Rate in a Modern Context

Monetary policy exerts influence over the economy through the manipulation of liquidity and interest rates (Holtrop, 1963). The manipulation of liquidity, including both primary and secondary liquidity, concerns with the currency that the central bank deposits in the economic system based on objectives of macroeconomic regulation and control. The adjustment of interest rate is carried out by raising or lowering the rate to alter the behaviour of commercial banks, enterprises and individuals. The interest rate is characterised by rapid response and high sensitivity as it regulates the macroeconomy by controlling for consumption and investment that are highly sensitive to the profit brought by the interest rate.

The negative interest rate policy, as a non-standard kind of the monetary policy, concerns with the central bank's objective of imposing nominal negative interest rates on commercial banks' deposits at the central bank in order to achieve bank lending and indirect credit control. The ECB is implementing the interest rate corridor mechanism; its negative interest rate policy adjusts the lower limit of the interest rate corridor; the deposit facility rate is only for the excess reserve of commercial banks.

3.2 Nominal and Real Interest Rate

Classic economic models assume that economic agents do not suffer from money illusion, meaning that they consider the fact that inflation erodes the purchasing power of money (Blot & Hubert, 2016). Thus, from a strictly theoretical point of view, the existence of a negative real interest rate is not in itself an anomaly. Monetary policy using interest rate as a policy tool means that the uniform benchmark interest

rate set by ECB across the Eurozone member states is negative. This is because inflation rates across the integrated market may vary significantly due to demand and supply fluctuations in the particular region (ECB, 2004). Hence, the introduction of a "real interest rate" is essential to study region-specific effects.

In his 1930 published book *The Theory of Interest*, Irving Fisher shows that the nominal interest rate must include an inflation premium to compensate for the actual purchasing power loss induced by the expected inflation to the lender. When the real interest rate remains stable, the nominal interest rate will increase as the expected inflation rate increases. Therefore, the real interest rate is usually computed by subtracting the actual inflation rates from the benchmark interest rate set by the ECB, which can be denoted in the formula:

Nominal interest rate – Expected inflation rate ≈ Expected real interest rate

The inflation rate is "expected", which means that the inflation in the future is uncertain for the borrowers and lenders, so the nominal interest rate above is the contracted rate decided on the moment of a loan agreement.

3.3 Effectiveness Demarcation

In practice, the NIRP denotes that a central bank imposes custodian fees on the excess reserves of commercial banks that are deposited in the central bank (Blot & Hubert, 2016). The central bank, on the other hand, uses this monetary instrument to adjust the interbank market interest rates, encouraging commercial banks to reduce deposits in the central bank, and increase the scale of loans on the credit market, thereby promoting consumption, investment and driving growth.

As for other monetary policy tools, the interest rate policy is measured by the changes in the proxy indicators in correspondence with monetary objectives. With a downward movement, the NIRP's efficacy, in this case, can be measured by the degree of achievement of operational objectives (whether banks reduced their excessive saving at the central bank). Alternatively, intermediate variables such as bank profitability and ultimate objectives/outcomes also constitute a way of gauging the NIRP (Wu & Xia, 2014). Nonetheless, the ultimate impact of the NIRP lies in whether the ultimate objectives of the monetary policy of a particular central bank is realised, in other words, the effectiveness of the NIRP refers to the extent to which the ECB achieves its ultimate monetary objectives through various interest rate policy instruments.

Therefore, this paper examines the effectiveness of the ECB's NIRP by delving into the problem of whether the ultimate monetary objectives pursued by the interest rate adjustment are ultimately achieved (ECB, 2018). The ECB has emphasised that its chief monetary objective is to promote price

stability, as measured by HICP. However, monetary objectives need to contribute to the overall health of the economy, instead of solely focusing on the prevention of a deflationary spiral. Therefore, the empirical analysis of this thesis examines the effectiveness of the macroeconomic recovery via four classic monetary objectives: **economic growth, price stability, full employment, the balance of payments.** As discussed in Section 2.2 Evolvement of Monetary Objectives, these four objectives have been previously taken into consideration by central banks worldwide.

A central bank has a specific focus when formulating monetary policy because of conflicts between these very different objectives (Taylor, 2011). As far as the final objectives of the ECB's negative interest rate policy are concerned, though its officially announced policy goal is to promote inflation and prevent deflation risks and protect price stability, the **financial stability** is, undoubtedly, of great concern. This is particularly the case after the AFC in 2008 when the monetary authorities have begun to realise the fragility of the financial market within Europe. Therefore, this paper also adds the measurement of financial stability to the objectives' list.

3.5 Current Account Surplus and Deficit

The current account is the main and the most critical component of a country's balance of payments, mainly including the trade balance of goods, that is, the import and export of tangible goods, and the trade balance of services, that is, the exchange of various services such as tourism, banking and insurance (Holinski, Kool, & Muysken, 2012). The current account does not contain long-term borrowing and investment flows, which are items on the capital account.

The current account balance is the difference between the total debit value of a country's goods, services, income and current transfer items and the total loan value of the goods on the goods, services, income and current transfer items over a period of time. When the total value of the lender is higher than the total value of the debt, the current account is surplus; vice versa, the current account is a deficit.

Current Account = Trade balance + Net factor income + Net transfers (Holinski, Kool, & Muysken, 2012)

If there is a current account surplus, the country's net foreign assets will correspondingly increase. The current account summarises the country's net debtor and creditor status and can reflect the close ties between a domestic and foreign economy. Therefore, the current account balance is considered by international bankers as one of the important variables when assessing loans to foreign countries.

Giannellis and Koukouritakis (2007) explain that within a monetary union, Southern European (SE) countries accumulate debts, but Northern European (NE) countries do not. They found that there has been an increasing divergence regarding competitiveness since the launch of the euro between the

current account deficit and surplus countries, leading to more accumulation of debts in the account deficit countries represented by the SE states. Holinski, Kool, & Muysken (2012) agreed on the previous argument and pointed out that in the Eurozone, countries with similar current account surpluses show strong economic decisions consistency and a similar performance in macroeconomic indicators such as inflation and GDP per capita.

Wallerstein's World-Systems Theory has strong explanatory power in explaining this division within the European Single Market. His main concept concerns with the inter-regional social division of labour, which contributed to the partitioning of the world economy into core, semi-periphery and periphery countries (Wallerstei, 2004). In a globalised market with fierce competition, only a few countries emerged into the "core" countries where a complicated division of labour can be found, and these countries are able to access resources, establish a legal framework to support this division, thereby gaining advantageous position in the competition. The expanding preponderance of these core countries is mirrored in the weakening in trade and simplifying the economic structure of the semi-periphery and periphery. These regions are left with inexpensive labour work or the production of industrial components (mainly agricultural products, labour intensive products and mineral products) for the "core" regions.

As a result of this division, the periphery countries are engaged in more and more simple work, and the added-value of their products are significantly lowered, and finally, the entire economic system has undergone serious wealth differentiation, and a large amount of wealth is gathered in the core area (Horvath & Grabowski, 1996).

In the case of the Eurozone, the amassing surplus of the core countries such as Germany and the Netherlands are associated with the deficits accumulation in the semi-peripheral (Spain) and peripheral countries (Poland). The investigation into the balance of payments across the European continent helps to explain this phenomenon and eliminate the interference caused by the simple geographical classification of the Eurozone. Such specification is able to generate more convincing and insightful empirical results, leading to more efficient and feasible policy recommendations.

3.6 Hypotheses:

Based on the three research questions proposed in Chapter 1, three correlative hypotheses have been formulated:

H1*: Since the implementation of the Negative Interest Rate Policy (NIRP), the interest rate adjustment of the European Central Bank (ECB) has not achieved its chief monetary objective of price stability.*

H1 corresponds to the first research question: *What have been the effects of the Negative Interest Rate Policy (NIRP) of the European Central Bank (ECB) in achieving its monetary objective after four years of implementation?* The ECB's price stability target is at below 2%. H1 is accepted if the interest rate adjustment of the ECB facilitates the realisation of this target.

H2*: Since the implementation of the Negative Interest Rate Policy (NIRP), the interest rate adjustment carried out by the ECB has not contributed to the macroeconomic recovery in Europe.*

This hypothesis is accepted if the NIRP does not fulfil the other four monetary objectives: unemployment rate, economic growth, the balance of payments and financial stability.

If an ultra-low nominal interest rate below the zero lower bound can better facilitate the economic recovery, it will be seen that the interest rate adjustment implemented by the ECB has been an effective policy tool in tackling sluggish economic performance in Europe, so that the policy tool is considered as a valid measure and should be continued and promoted. Moreover, the ECB can delve deeper into negative interest rates and explore where the effective lower bound lies.

However, if lowering interest rate does not contribute to the improvement of the abovementioned objectives, the NIRP will not be an effective monetary policy tool. The ECB should then explore other monetary policy alternatives.

H3*: Current account deficit countries in Europe are more negatively affected by the interest rate adjustment of the ECB than the current account surplus countries.*

H3 connects to the third research question: *Is there variation in the effectiveness of the Negative Interest Rate Policy (NIRP) in the current account surplus and current account deficit countries in Europe?* H3 is only accepted when the interest rate adjustment leads to more perverse effects on current account deficit countries than current account surplus countries. This hypothesis is rejected if no significant difference is identified between these two country groups.

4. Policy Landscape

The unconventional monetary instruments adopted by the ECB differ significantly from those in Japan and the US, this chapter explores the evolvement of the two types of unconventional monetary policies of the ECB. Interest Rate Corridor framework is the interest rate adjustment's mechanism that is unique to Europe. The other unconventional measure is the quantitative/monetary easing programmes that have been concurrently implemented by the ECB alongside the NIRP, and a distinction between LTRO and APP is made.

Moreover, this chapter also discusses the critical points and the time series movements of the macroeconomic indicators in the European context corresponding to the monetary objectives discussed in the literature review.

4.1 Overarching Context behind the Implementation of the NIRP

Affected by the GFC, the EU has witnessed a severe economic recession since 2008. As shown in figure 32131 the average GDP growth of the EU dropped to 0,5% and in the ensuing year, the growth rate even fell below – 4,0%.

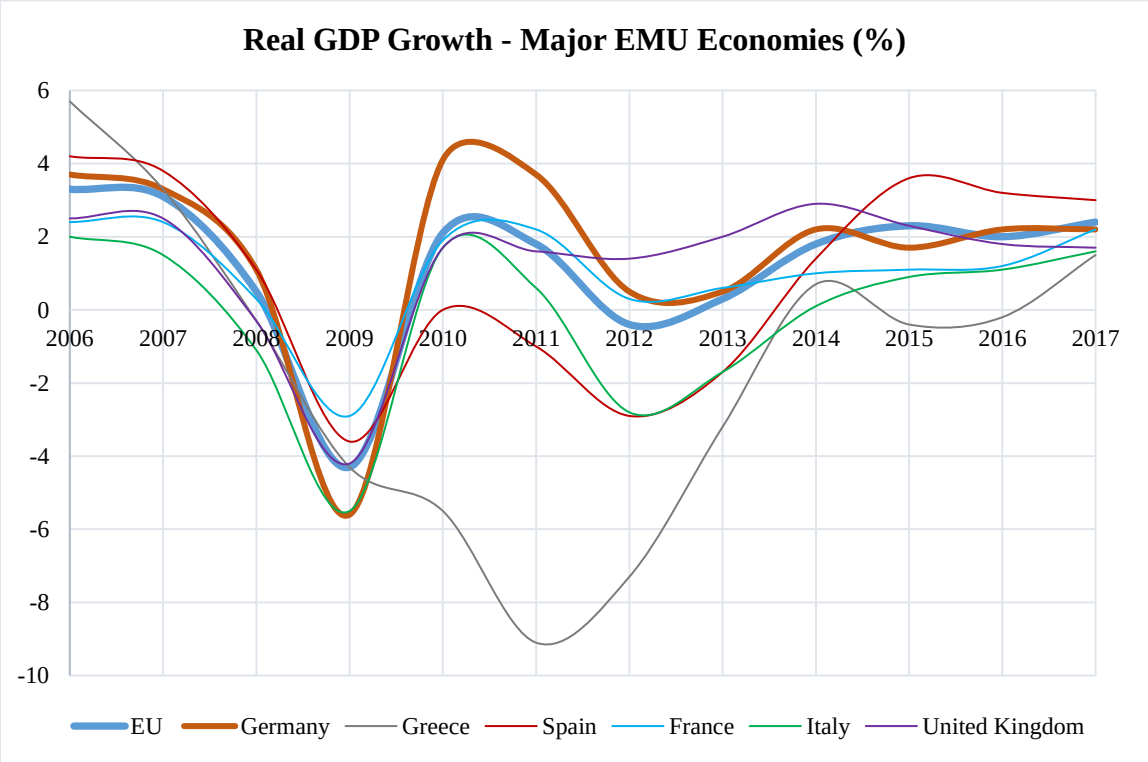


Figure 1 Real GDP Growth - Major EU Economies (%)

In October 2009, the Greek government announced that the government fiscal deficit and public debt-to-GDP ratio in 2009 are expected to reach 12.7% and 113% respectively, both far exceeding the EU's

3% and 60% ceilings. The three major international rating agencies Fitch, Standard & Poor's and Moody's successively lowered the Greek sovereign credit rating, leading to the breakout of the Greek debt crisis. Subsequently, the debt and fiscal deficit issues of some of the Eurozone countries such as Portugal, Italy, and Spain were also exposed in the limelight.

As the crisis unfolds, rising unemployment and deteriorating employment conditions in the southern states led to public outrage and social disturbances. From the government's perspective, paying off debts and reorganising fiscal balances are not expected to be realised in the short-term, indicating that the fiscal policy still needs to remain tightened in the years to come after 2010. This has jeopardised the consumer confidence, resulting in the aggravation of the already weak consumer spending.

4.2 Interest Rate Corridor

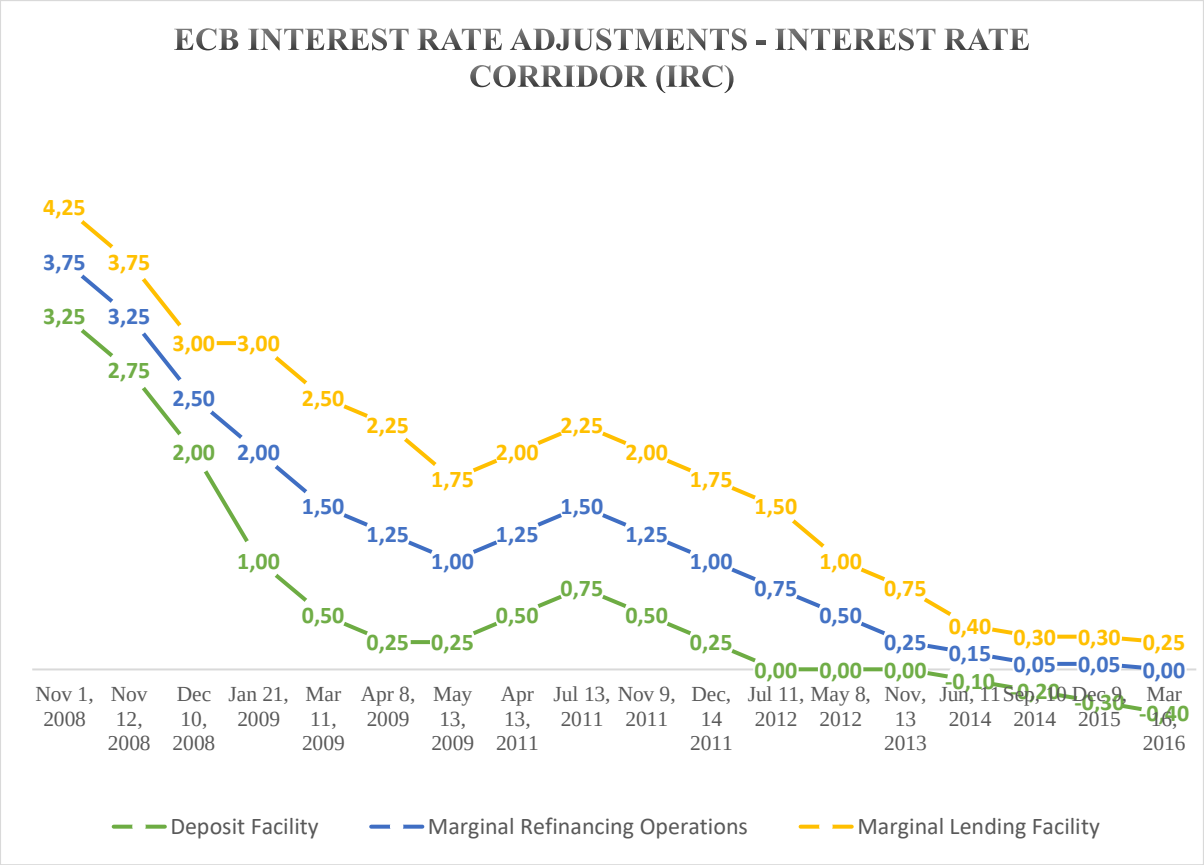
The NIRP implemented by the ECB aimed at stimulating the inflation and promoting economic recovery by lowering the benchmark interest rate in the money market. The ECB adjusts the market interest rate through the Interest Rate Corridor (IRC) (ECB, 2018). Under the IRC framework, the ECB sets the floor and ceiling of the policy rate of liquidity operations to guide short-term market interest rates moving towards the target rate. This method modifies the interbank lending rate between commercial banks by adjusting the deposit and loan interest rates of commercial banks in the central bank.

As shown in Figure 2, the floor (lower limit) is the interest rate determining the interest paid by the central bank to commercial banks deposits. The ceiling (upper limit), on the other hand, is the interest rate charged to commercial banks for borrowing from the central bank. The interbank lending rate will then fluctuate between the ceiling and floor. When the deposit and loan interest rate set by the central bank increases, the inter-bank lending rate will rise accordingly; on the contrary; the inter-bank lending rate will fall.

ECB's standing facilities employed to implement the Interest Rate Corridor consists of the Deposit Facility Rate (DF), the Main Refinancing Operations (MRO) and the Marginal Lending Facility Rate (MLF). DF acts as the deposit rate of financial institutions in the central bank; MLF refers to the overnight interest rate of the ECB lending to financial institutions. These two interest rates constitute the floor and ceiling of the Eurozone interest rate corridor.

The MRO involves the interest to be paid by financial institutions when borrowing from the central bank; it influences the liquidity in the market and lending rates of the interbank market, thereby affecting the interest rates of commercial banks on the private deposits (ECB, 2018). The operation it carried out via an auction mechanism, and it takes place once per week, injecting a loan with a maturity of one week.

Figure 2 ECB Adjustments of Interest Rate Corridor



In June 2014, as shown in the line chart, the ECB lowered its DF rate to -0.1% and officially entered the stage of NIRP. The yellow line represents the MLF, marking the ceiling of the interest rate corridor. The green line, on the other hand, implies the changes of the lower floor of the corridor. The negative DF rate is only be imposed on the excess reserve of commercial banks at the ECB. MRO rate applies to the statutory deposit reserve, which was reduced to 0% on March 16, 2016. While the DF rate has been lowered to the negative area, the other two benchmark interest rates have also been lowered.

4.3 Concurrent Quantitative Easing Programmes: LTRO and APP

4.3.1 Evolution of LTRO and APP

While other conventional loose monetary policies failed to improve inflation performance, the ECB was required to seek stronger measures to prevent inflation from a debt-deflation spiral. At this time, the negative interest rate policy has become a reluctant move by the Frankfurt-based central bank.

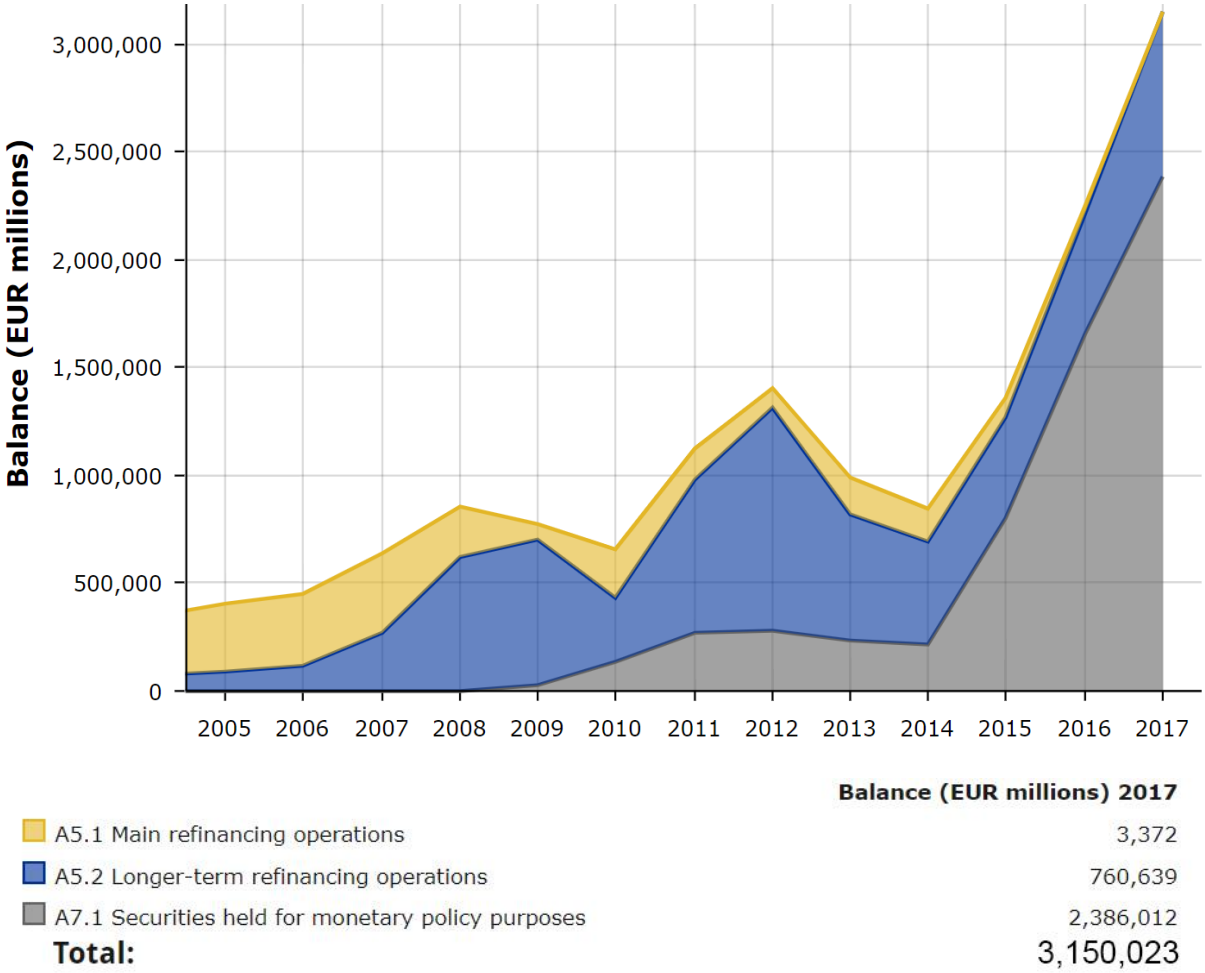


Figure 3 Monetary Policy Operation *Source: Statistical Data Warehouse*

In September 2014, the deposit facility rate was lowered to -0.20% and the Long Term Refinancing Operation (LTRO) was implemented as a new long-term liquidity supply operation, and these loans have six-month, twelve-month and thirty-six-month maturity (FT, 2018), much longer than the previous period attempted. In October of the same year, another non-conventional monetary policy measure - expanded asset purchase programme (APP) was launched, including a series of purchase programmes from public sector securities to corporate assets (TKP Investment, 2015).

In March of the ensuing year, the ECB once again lowered the three major interest rates, of which the DF rate was dropped to -0.40%. In the meanwhile, the scale of quantitative easing has been expanded to EUR 80 billion per month, and a new round of LTRO has been launched.

4.3.2 MRO & LTRO

Figure 5 identifies the evolution of the three most important components of ECB's assets on the ECB's balance sheet. The quantitative easing programmes since the GFC have soared up the balance sheets of the ECB. The main refinancing operations (MRO) and long-term refinancing operations (LTRO), prior

to the implementation of APP and NIRP, were already adopted by the ECB before the GFC, but the scale of loans was only lifted after the GFC and the sovereign debt crisis (Lewis & Roth, 2017).

Vivien Lewis and Markus Roth (2017) note that the allotment of MRO and LTRO are considered as an unconventional monetary measure due to the full allotment policy and the dramatic increase of scale. In 2017, EUR 760 billion was made available for the European banks through LTRO comparing to a minor amount of EUR 3 billion made available by MRO. Due to the auction process, banks were incentivised to post good forms of collateral, as required by the LTRO loans. Sovereign government bonds issued by countries such as Italy or Spain, for example, became the best form of collateral as they are backed by the government and taxpayers. ECB's purchase of these sovereign bonds in Greece, Portugal, Italy, Spain and Ireland, to a large extent, pushes down the bond yields and reduces their financing costs for these governments.

4.3.3 APP - Assets Purchase Programme

The term "*securities held for monetary policy purposes*" (SHMPP) on the Consolidated Balance Sheet of the ECB represents the assets involved in the Assets Purchase Programme (APP). (See Appendix A) It consists of three purchase programmes – the covered bonds, asset-backed securities, public & corporate programmes.

The ECB started with first-round Covered Bond Purchase Programme (CBPP1) in 2009; these instruments issued by a bank and secured by mortgages were claimed to be a crucial source for bank's financing. In November 2014 and March 2015, the CBPP2 and CBPP3 were introduced and covered bonds with a total value of EUR 236 billion were held by the ECB by the end of 2016 (Hale, 2017).

During this period, the purchase programmes of Assets-Backed Securities (ABSPP), Public Sector Purchase Programme (PSPP) and Corporate Sector Purchase Programme (CSPP) were introduced, of which the PSPP, launched in March 2015, accounts for 85% of the euro system purchases. By the end of 2017, the total liquidity created by the ECB via these two unconventional monetary measures is as high as EUR 3 trillion, accounting for almost 40% of the Euro Area GDP.

Among all purchases, the ECB accounts for 8% of the purchases, and European institutional bonds purchased by national central banks account for about 12, of which the risks are borne by the Eurozone (ECB, 2018). The remaining 80% are purchased by central banks in proportion to their contribution (capital key) to the ECB's capital, at their own risk. Appendix B lists out the contribution of each national central bank in the Eurozone to the capital reserve of the ECB. Germany and France, which have substantially low bond yields, have a large share of the capital key, while southern European countries such as Greece and Portugal, which have high bond yields, have a smaller share of the capital key.

4.3.4 Liquidity Injection

The QE programmes have commenced before the implementation of the NIRP. Despite not being a sovereign state like the US, these programmes reflect the risk-sharing and solidarity of the Eurozone. The programmes including MRO, LTRO, and APP and have injected an unprecedented amount of liquidity into the Eurozone economy. Although there have been arguments as to what extent these quantitative easing programmes are considered as unconventional monetary policy, the impact of the excessive liquidity should not be neglected while conducting empirical analysis on the effects of the NIRP.

4.3 Overview of Macroeconomic Indicators

The last section makes a distinction between the two types of monetary policies: interest rate adjustment and quantitative easing (liquidity injection). It also delves into the operating mechanism behind these two policies and how it has evolved since the time previous to the GFC.

This chapter explores the evolvement of macroeconomic indicators including the ECB– inflation rate, unemployment, industrial output, the balance of payments and debt levels throughout the same period in which the monetary policies have also been examined. The movements of each time series are analysed alongside the evolvement of the monetary policies.

4.3.1 Inflation Targeting of the Eurozone

The European Central Bank was established in 1998; its Governing Council is composed of the Executive Committee and the heads of the central banks of the Eurozone member states. It devises the monetary policy of the Eurozone, including setting intermediate targets and determining policy interest rates. In the same year, the ECB announced a quantitative definition of the price stability target – inflation level below 2% over the medium term, which is measured by the Harmonised Indices of Consumer Prices (HICP), published by the European Union. The HICP is the weighted average price index for the change over time in the price level of consumer goods and services acquired by households (Eurostat, 2018). The medium-term orientation leaves the ECB with flexibility when reacting to sudden or unforeseeable economic shocks. The monetary policy devised by the ECB can, therefore, affect price level fluctuations with significant time lags.

In May 2003, the quantitative indicator of price stability was further clarified: its final goal is to keep the inflation rate below but close to 2% since the central bank believes that 2% is offering sufficient safety margin against the risk of a liquidity trap. When the HICP continues to rise, an increase in inflationary pressure will be expected, and the central bank tends to consequently lift the interest rate.

Despite being on a relatively smooth recovery path in the past three years, the slow pace of recovery and continued deflation that is drifting far from the target inflation rate have triggered concerns for the

ECB. The official price stability mandate of the ECB is to maintain a medium-to-long-term inflation rate close to and below 2%. From October 2008 to the end of May, the ECB has reduced the benchmark interest rate by 14 times in the Eurozone. In May 2009, the deposit facility rate fell to a record low of 1.00%. In the first quarter of 2011, the inflation rate in the Eurozone climbed above 2.5%, exceeding the 2% target plan set by the central bank, showing signs of further escalation risks. In July 2012, the ECB was forced to reduce the main refinancing operation rate to 0.75% due to debt pressure, and the deposit facility rate became zero.

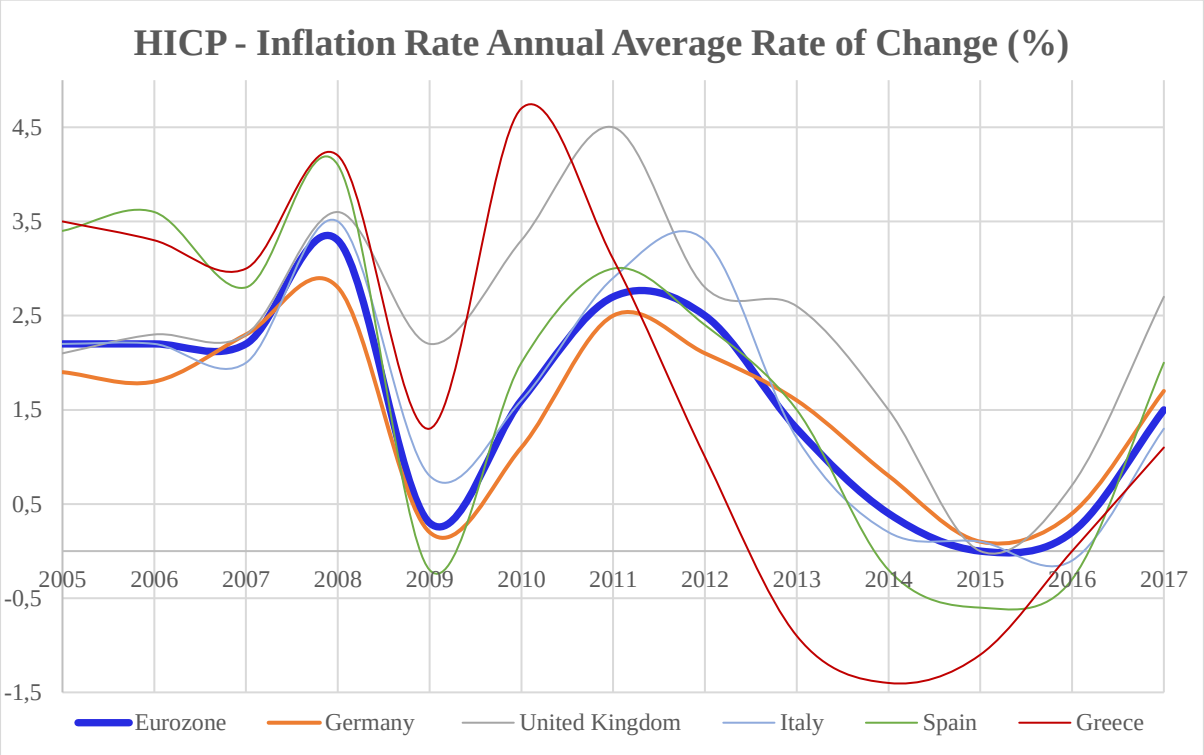


Figure 4 HICP - Inflation Rate Annual Average Rate of Change (%) Source: Eurostat

The inflation rate in the Eurozone finally fell to below 2% in the first quarter of 2013 after reaching a two-year high at 2.94% by the end of 2011. Subsequently, it immediately fell until approaching 0 in 2015, showing deflationary pressure. Deflation tends to cause negative expectations of the economy. Individuals and enterprises are likely to restrict their investment and demand for consumption, slowing the economic recovery (Holtrop, 1963). In the second quarter of 2014, the deposit convenience rate had been maintained at zero interest rate for nearly two years. The main refinancing operation rate has also dropped to a historical low of 0.25%.

4.3.2 Unemployment Rate in the Eurozone

Figure 6 plots the movement of time series of some of the Eurozone countries, the dashed line represents the Eurozone average. GFC in 2008 has been the turning point for the unemployment rate's trend in all

listed countries except for Germany whose unemployment rate flattens shortly and then continues to decline from 2009. In particular, unemployment rates in Spain (green line) and Greece (grey line) had soared and finally peaked around 2012 when the sovereign debt crisis broke out.

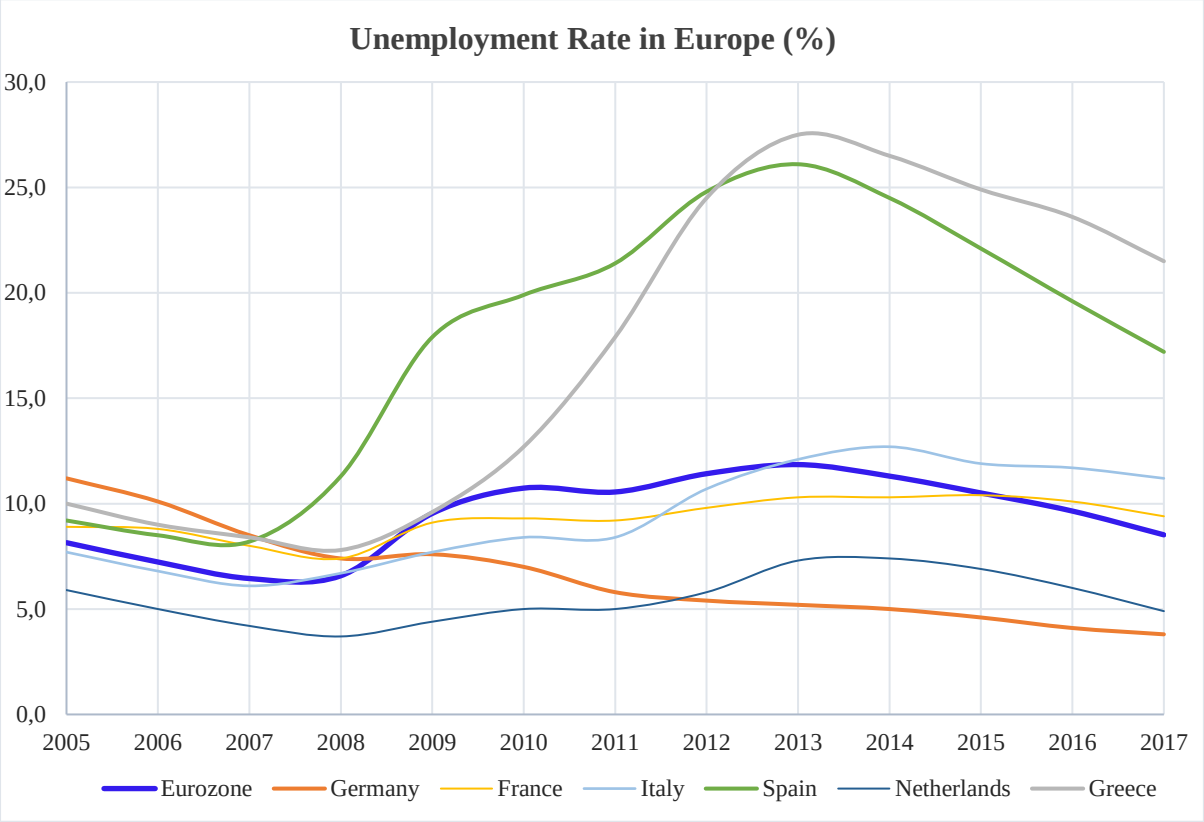


Figure 5 Unemployment Rate in Europe (%) *Source: Eurostat*

The ECB responded to this economic predicament by slashing the interest rate down to the zero lower bound in 2012 and then plunging the negative territory in 2014 accompanied by the boost of monetary easing measures particularly through APP. As of the end of June 2014, a total of 18 million workers in the Eurozone were unemployed, a number that exceeds the population of the Netherlands, of which 3 million belong to the age group between 15 and 24 (IMF, 2015). However, this absolute figure does not mirror the overall situation of youth unemployment. Due to demographic changes, the size of the European workforce has gradually shrunk, especially for women and the elderly. Coupled with the financial crisis, young people have been severely affected by the crisis.

Since then the unemployment rate has gradually declined, and by the end of 2017, the unemployment rate was at about 8.5% which is the lowest level since 2008. The data confirms the steady economic recovery of the Eurozone as one of the essential manifestations of the economic recovery is the decline in the unemployment rate (Brash, 1994). However, this is nowhere near enough to justify the impact of the NIRP for two reasons. 1) After 2014, the time series of some countries such as Germany did not exhibit the same noticeable inflexion as in Greece. 2) It is difficult to segregate the effects of the interest rate cuts and the QE programmes.

4.3.3 Weakening of the Industrial Output

Industrial output is another crucial indicator in measuring the short-term macroeconomic recovery, forecasting GDP growth and inflation rate, as well as steering monetary/fiscal policies. The industrial sector, including manufacturing or utilities, exhibits the most volatility during a business cycle peak to trough as this sector is highly sensitive to variations in interest rates (Ezeaku et al, 2018). A change in nominal interest rate would be followed by a change in demand for consumption, which particularly affects the profitability of the companies operating in the industrial sector.

In the EU, the industrial output pertains to one of the alleged *PEEI - Principal European Economic Indicators*[3] The statistics of the industrial output in the EU are centrally produced and released on Eurostat as the Industrial Production Index, abbreviated as IPI (Eurostat, 2018). This index estimates monthly changes in the price-adjusted industrial output produced by companies on the territory of the reporting member state; the production for industry covers manufacturing, quarrying/mining, utilities (electricity, gas, steam) and construction. The index is computed on capacity utilisation as a percentage or the proportion of potential industrial output that is realised. If the industry is operating at close to full capacity, the price is likely to rise.

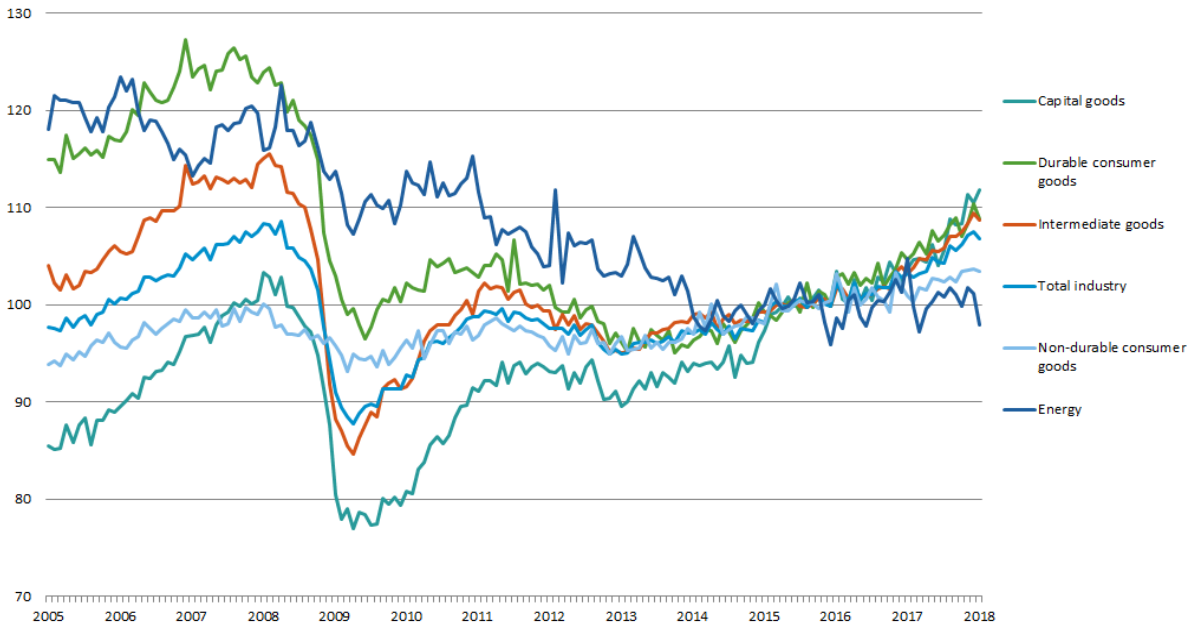


Figure 6 EU-28 Industrial Production Index (Total) from 2015 to 2018 Source Eurostat

Figure 7 shows the fluctuations of the IPI (total) of the EU 28 from the beginning of 2015 to the end of 2017 with the breakdown of specific categories of goods (Eurostat, 2018). It is noticeable that the time series of all goods shared comparable and synchronous trends; the total output was on a gradually rising

[3] The Principal European Economic Indicators (PEEI) consist of a set of key economic indicators reported from each member state of the EU. All statistics are published on Eurostat.

path and peaked in the first half of 2008. The outbreak of the GFC inflicted heavy losses on the industrial sector, and the output index plummeted; the steady growth momentum was restored after the financial crisis only until 2014 when the sovereign debt crisis led to a slight downturn of the industrial output. Starting from the beginning of 2013, the volume was again on a steady rise, and by 2018 it has reached more than 90% of the peak level.

On a country-spefici level, there has been a convergence in the volume of the industrial output amonst the member states. The range between the maxium and minimum of the index value amongst the eight countries shown in Figure 8 declined from 80 in 2005 to less than 10 in 2017.

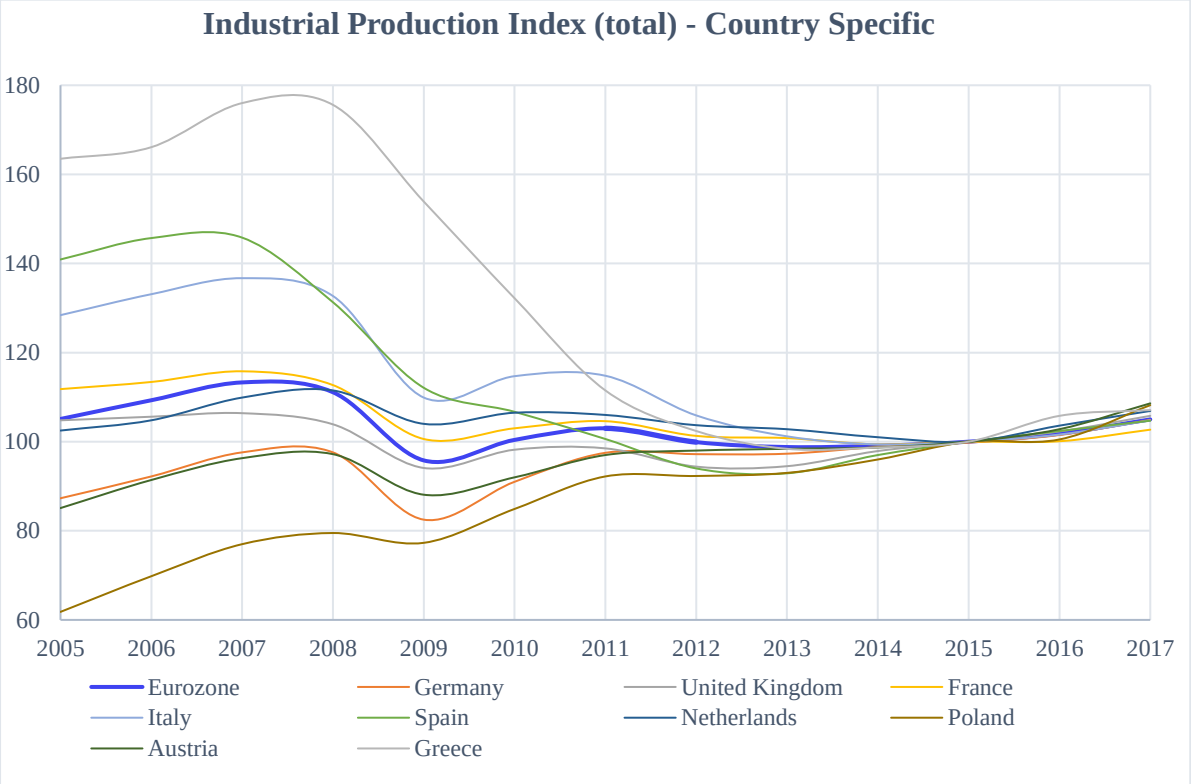


Figure 7 Industrial Production Index of eight major economies in the EU *Source: Eurostat*

The above graph depicts that the point of convergence is at around 2015, which is one year after the implementation of the negative interest rate. It seems that the growth momentum has picked up again, but it is still difficult to detect the direct causal relationship between the monetary policy and movements of the industrial output.

4.3.4 Balance of Payments Crisis

The balance of payments disequilibria in the Eurozone is not a new phenomenon, and the persistent imbalances between the core and periphery countries raise doubts on the long-term sustainability of the monetary union as well as the European Union. The underlying reason is that the monetary unification

is established without the elimination of market segregation and in the meanwhile, the fiscal policies remained domestic and continued to carry on domestic objectives (Micossi, 2016).

The account balances as a percentage of GDP in seven representative EU countries in the form of time series are exhibited in Figure 8. The current account surpluses in the core countries represented by Germany (bold orange line) and the Netherlands (bold blue line) reflects a large deficit in southern countries such as Spain (bold green line). At the beginning of the time series, Germany already held a substantial surplus vis-à-vis with its European counterparts. Despite an enormous cost of reunification by the turn of the century, labour market reforms and low unit labour costs led to more competitive German exports and heavy losses in wage competitiveness of other Eurozone countries. This is also a valid argument explaining the GDP acceleration and the damping manufacturing sector in the periphery (Dustmann, 2014).

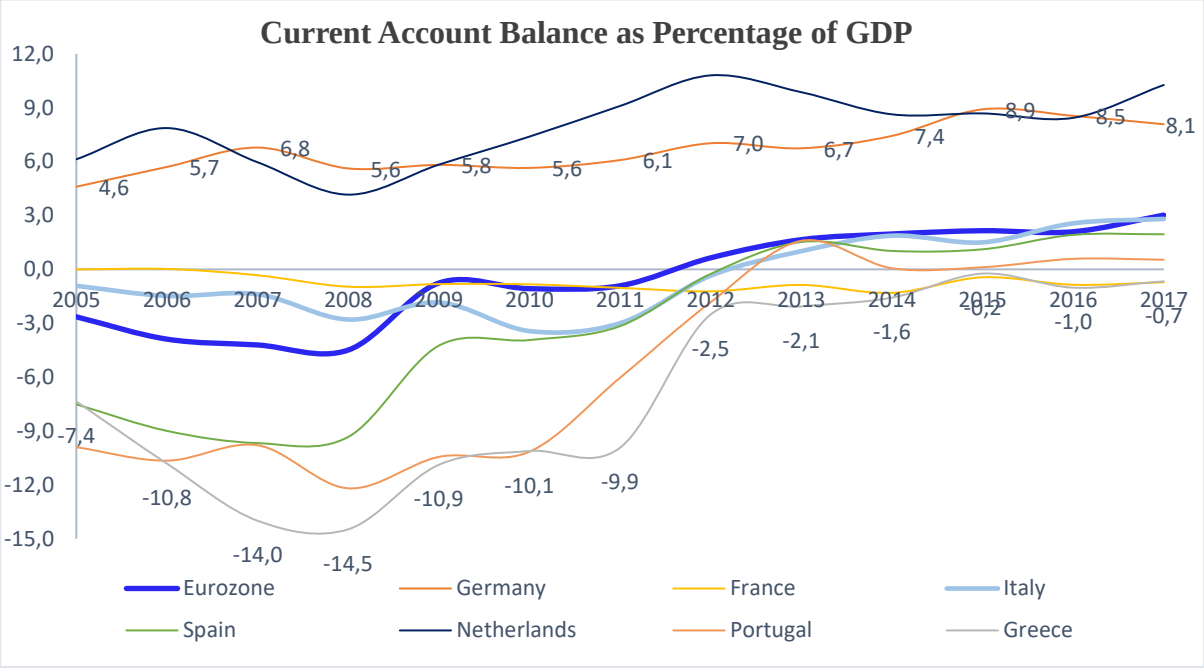


Figure 8 Balance of Payments Movements Eurozone *Source: Eurostat*

In the years preceding the GFC, the imbalance between the core and peripheral countries has been enlarged; old industrial powerhouse Greece's current account balance fell to -14,5% of its GDP in 2008. The convergence trend appeared in the ensuing years after the crisis that Portugal, Spain, Italy and Greece all revealed upward movements and some of them moved out of the negative territory around 2012. The crisis led to falling demand for foreign products in the account deficit countries (periphery) and these countries also confronted with deeper recessions. Nevertheless, both Germany and the Netherlands remained high surpluses, of which the German surplus reached its record level 8,9% of its

GDP in 2015, indicating that the core countries were switching to other emerging markets, for example, the United States and China.

Starting from 2014 when the NIRP was implemented, the growth momentum flattened out until the end of 2017. The refinancing operations that involved the ECB's purchase programmes in sovereign bonds of the deficit countries could have temporarily eased the deterioration of these economies muted the domestic issues of these countries in the periphery, whether this is the case remains to be empirically tested.

4.3.4 Divergence of Debt Levels as Percentage of GDP

Since the introduction of the euro, a unified banking and monetary institution – the ECB were set up without the presence of a unified fiscal policy framework. As a direct consequence, the institutions that are responsible for handling debts have not been established since the introduction of the euro. The establishment of the Economic and Monetary Union (EMU) has greatly increased the degree of integration of the EU, and the transaction costs within the single market have been greatly reduced.

In order to stabilise the value of the euro and prevent externalities caused by excessive fiscal deficits within the EU, the Stability and Growth Pact (SGP) was outlined by the EU in July 1997 (European Parliament, 2015). When the SGP stipulates that the annual fiscal deficit of each member state of in the EU cannot exceed 3% of GDP, and the total government debt is required to remain below 60% of GDP (Bagus, 2010). The country that surpasses the limits will be warned, and if the corrective measures are still not in place, sanctions can be issued against this member state.

As a fundamental guarantee for the unified euro currency, the SGP's enforcement has been widely criticised (Grauwe, 2005). Punitive measures were absent concerning with debt levels of Greece and repetitive inertia from the two governments; the current account deficits of southern European countries and Ireland have also exceeded the red line. The Eurozone has adopted a unified monetary policy, but it has not been conduced to the convergence of the wealth gap within the Eurozone, so the standards for budget deficits and debts are just soft constraints.

Two essential tools for the fine-tuning of the economy – interest rate and exchange rate, and the national central banks can only resort to fiscal policies to regulate the economy but still need to comply with the Pact (Holinski, Kool, & Muysken, 2012). The relatively low financing costs have brought about the fiscal deficits in countries such as Greece and Portugal, and the result of long-term deficit fiscal policies is bound to be a heavy debt burden (Horvath & Grabowski, 1996). The result of fiscal policy under long-term current account deficit is bound to be a heavy debt burden.

Figure 9 maps out the evolvements of the debt-to-GDP ratio of some of the Eurozone countries. In 2005, current account surplus countries represented by Germany (bold orange line) exhibit more steady trends comparing to those of account deficit countries. At the beginning of the time series, Greece and Italy

already confronted with significantly larger debt levels (>100% of the GDP) than the ceiling of SGP. Meanwhile, the debt-to-GDP ratios of Spain and Ireland stood at 42,3% and 26,1%, which were much lower than the 67% of Germany and 49,8 of the Netherlands. However, in the aftermath of the GFC, debts levels started to mount and in 2013, Portugal, Spain and Ireland's debt levels also surpassed the threshold of 100% of GDP. The public debt level in Greece had risen up to 180% of the Greek GDP in 2013 and maintained around this level until 2017.

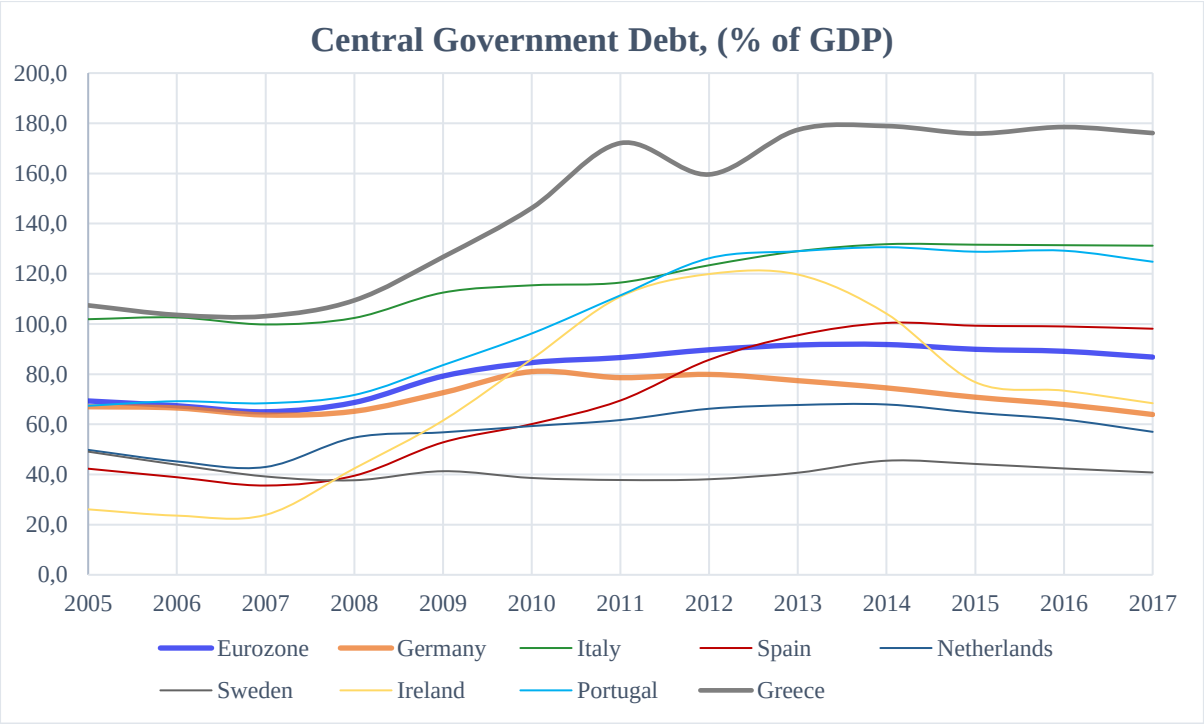


Figure 9 Central Government Debt-to-GDP Ratio (Eurostat, 2018)

Germany's debt-to-GDP ratio, on the other hand, only marginally increased after the GFC to about 80% in 2010; it recovered promptly after the crisis and did not demonstrate sharp fluctuations during the sovereign crisis. Other account surplus countries in the EMU such as the Netherlands and Sweden both shared similar trends, without drastic fluctuations as witnessed by the account deficit countries.

The overall debt level of the Eurozone since the GFC has increased, particularly in the southern European countries and an apparent disparity between the "core" and "periphery" can be noticed with the core countries having much less pressure. 2014 was the first year for the Eurozone under a negative environment, and in January 2015, the ECB pumped about 1.1 trillion into the economy via its long-term refinancing operations, which is an unprecedented unconventional monetary policy test Europe. Nevertheless, during this period from 2014 to 2017, the debt-to-GDP ratios in Germany, the Netherlands, Ireland, Sweden showed a slight decline, but no distinct changes were observed from the current account deficit countries.

4.5 Concluding Remarks

The ultra-low and negative interest rates implemented by the ECB aimed at stimulating the inflation and promoting economic recovery by lowering the benchmark interest rate in the money market. The ECB carried out the NIRP through the Interest Rate Corridor framework that the central bank sets the floor and ceiling of policy rate to influence the interbank rate.

The distinction between various types of monetary easing programmes is crucial for the identification of NIRP's effects as these programmes are carried out around the same time with the interest rate adjustment. These programmes provided excessive liquidity to the Eurozone money market via MRO, LTRO and APP, with the intention to encourage bank lending in order to repair the transmission channel of monetary policy and boost inflation. It is essential to consider the excessive liquidity generated by these programmes while conducting the empirical test in the next Chapter, as the fluctuations of the time series of the macroeconomic objectives could come from either interest rate and liquidity injection

The overview of the time series of the macroeconomic indicators demonstrates the current economic predicament in Europe. The unique constitutional design of the EMU has led to difficulties in the implementation of the quantitative easing programmes. Monetary policy needs to coordinate with fiscal policy to achieve the optimal macroeconomic regulation and control. However, the Eurozone has a unified monetary union with each member state having their own fiscal policies. In addition, strict financial and deficit constraints have been imposed on the EMU member states, hindering the member states from taking advantage of the historically low sovereign bond yields to increase leverage and increase spending.

The effects of the NIRP and quantitative easing policies remain largely uncertain and are required to be empirically tested within a systematic model. The HICP has risen, and it seems that monetary policies have fulfilled its responsibility of stabilising prices. However, the macroeconomy in Europe still faces severe challenges including heavily indebted governments, high unemployment rate, accumulation of deficits and weakened industrial output. These problems are mostly underscored in the southern states such as Greece and Italy rather than in the current account surplus countries such as Germany and the Netherlands, indicating the divergence of the economic development within the EMU. It is difficult to identify the causal mechanisms between ECB's monetary policies and macroeconomic performance. Therefore, it is necessary to empirically examine the causal relationships through a reliable econometric model.

5 Research Methodology and Data

Chapter 4 discusses two categories of the monetary policies implemented by the ECB to overcome the economic predicament - the Interest Rate Corridor (IRC) framework and different types of quantitative easing programmes, that inject excessive liquidity into the market. The discourse follows by scanning through the evolvement of five macroeconomic indicators which were discussed in the Theoretical Framework to measure the effectivenss the monetary policy. However, since the two unconventional monetary policies were carried out parallel to each other, and countries with deficits reveal disparate movements compared to countries with surpluses, it is difficult to draw conclusions simply directly from time series and separate the effects of interest rate adjustment and NIRP.

Hence, this chapter brings the monetary policies and macroeconomic time series into an empirical test by introducing the empirical development of the VAR and PVAR models. Some of the most compelling advantages of the PVAR models in this research in comparison with other econometric method are reviewed. Then the operationalisation of the theoretical concepts is carried out, and the underlying reasons behind the selection and computational method of indicators are also elucidated in this chapter.

5.1 Development of Vector Autoregressive Model in Econometrics

5.1.1 Vector Auto-Regressive Model

Econometric models are designed to estimate economic relationships, testing economic theories and assessing the effectiveness of policies (Wooldrige, 2016). Traditional econometric methods such as multiple linear regression models and simultaneous equation models explain the simple relationships between variables and artificially determine the endogeneity or exogeneity of certain variables. To overcome these shortcomings, as one of the winners of the 2011 Nobel Price in Economics, Sims (1980) criticised the large-scale macro-econometric models and emphasised the dynamic nature of the relationship between macroeconomic variables (Sims, 1980). This was later known as Sims' Critique, and he (1980) proposed Reduced-Form VAR model in his seminal paper Macroeconomics and Reality with Sargent, which allows macroeconomic modelling without imposing significant restrictions (Sargent & Sims, 1977).

VAR models are multivariate linear time-series models designed to capture the joint dynamics of multiple time series, and it offers a flexible alternative to the traditional econometric models. A VAR model contains a set of linear dynamic equations where each variable is specified as a function of an equal number of lags of itself and all the variables in the system, and all variables are considered endogenous. Hence, the VAR model does not require the distinction between endogenous and exogenous models as it excludes the concerns about the direction of causation (Sims, 1980). Another

advantage of this model is that OLS equations can simply be employed provided that there are no contemporaneous terms on the right-hand side of the equations.

Nevertheless, it is difficult to explain the coefficients from the estimation of parameters, because VAR model is "atheoretical[4]", which implies that the model simply extracts the information from the data without consideration of economic theories. On the other hand, if the lag period is longer, more parameters are needed to be estimated, requiring a large length of the data sample. In addition, the number of variables is limited, and the simple VAR model does not account for individual and time effects.

5.1.2 Panel VAR

In order to overcome the limitations of data volume and spatial heterogeneity of the VAR model, Panel-Vector Autoregressive Model (PVARs) was developed and refined by macroeconomists and financial economists who deal with data across many countries.

The PVAR model was firstly introduced by Holtz-Eakin et al. (1988). Later papers from Pesaran and Smith (1995), Canova and Ciccarelli (2009) and Koop & Korobilis (2014) have improved and optimised the model, reconfirming PVAR as an appropriate way to measure the shocks transmitted across countries.

PVAR inherits the advantages using the traditional VAR model, treating all variables as endogenous variables and not being restricted by traditional economic theories. On the other hand, it has its own innovations. For instance, the length requirements are reduced that parameters of the equation can be estimated as long as T>l+2 (T is the length of the time series, l is the order of the lag term). Furthermore, PVAR model controls unobservable individual heterogeneity due to spatial variation, individual fixed effects allow unobservable country-specific differences, and time fixed effects capture the common shocks that individuals may experience in cross-section time series. These innovations free the VAR model from the dependence of simple individual time series data and further expands into the spatial measurement, constructing a flexible analytical framework for macroeconomic research.

5.2 Data Selection

5.2.1 Country Group

The European Central Bank (ECB) was formally established on July 1, 1998, in Frankfurt under the provisions of the Maastricht Treaty of 1992. France, Italy, the Netherlands, Belgium, Luxembourg, Ireland, Spain, Portugal, Austria and Finland were the first countries to adopt the euro and the first

[4] Atheoretical: independent of established economic theories

governments to give up their power in formulating monetary policies. In 2001, Greece became the 12th country to enter the Eurozone. As of the end of 2018, there were 19 official member states in the Eurozone, and all of them are members of the European Union. Figure 10 indicates these 19 Eurozone countries with light blue shades; the countries that are member states of the EU but have not adopted the Euro currency are marked with dark blue shades.

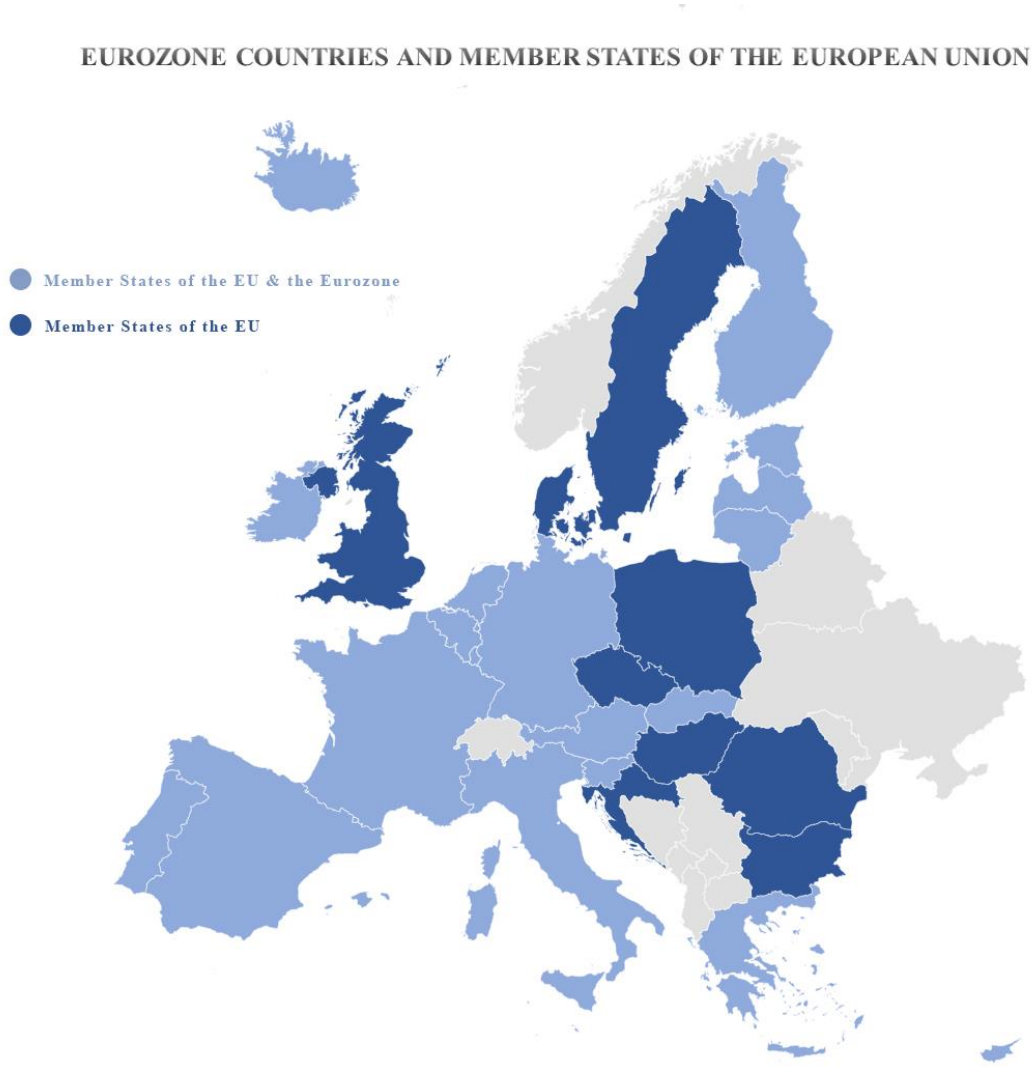


Figure 10 Eurozone Countries and the Member States of the European Union

This empirical analysis employs the data from an unbalanced panel of 14 selected countries – Germany, the United Kingdom, France, Italy, Spain, the Netherlands, Switzerland, Sweden, Poland, Belgium, Austria, Ireland, Portugal and Greece. The nine countries that lay the foundation of the Eurozone and Greece are first included because the data of these countries is consistent and complete. This avoids the abnormal effects of short-term fluctuations on the transmission effect of ECB's monetary policy. The next country that joined the Eurozone after Greece was Slovenia in 2007 the length of the data of these later joined countries tends to be incomplete.

The non-Eurozone countries which nonetheless had strong economic ties with the Eurozone, the United Kingdom, Poland, Sweden and Switzerland, are added to the sample country group. The inclusion of these four countries takes into consideration the spill-over effects of the monetary policy of the ECB to the countries that are economically connected with the Eurozone

Furthermore, these countries represent the largest economies in Europe. The research using data of these countries to study the transmission mechanisms of the ECB's monetary policy delivers more credible and persuasive results.

Figure 7 displays all selected countries in the empirical analysis with labels of their current account balance conditions. The average of these European countries is -0,5 (%), although the range between the country with the most surplus and the country with the most deficit is 16,7(%). This means that there is large disparity in terms of the balance of payments in the Eurozone as well as in Europe.

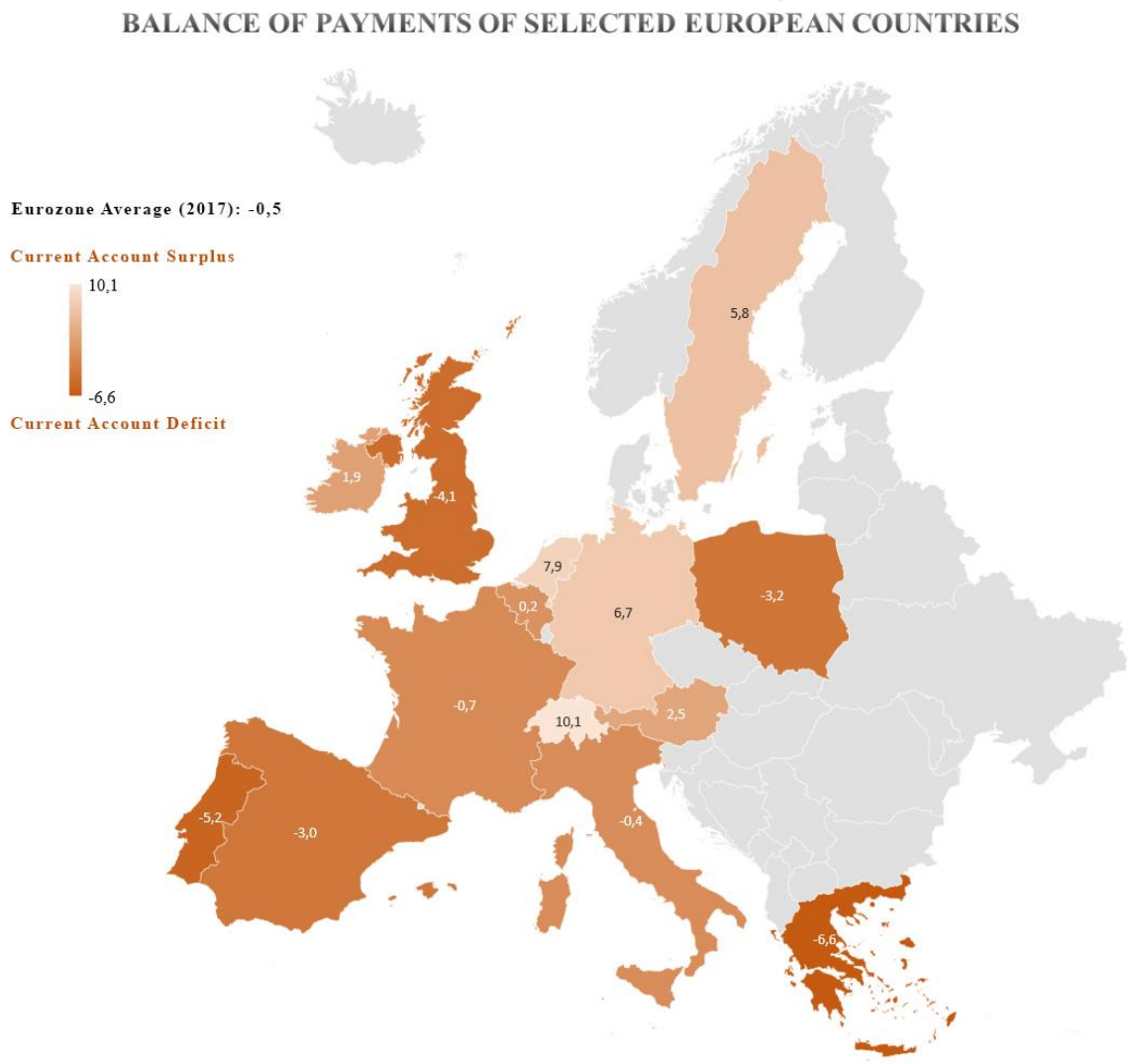


Figure 11 Balance of Payments of Selected European Countries

Besides the Eurozone countries, data from the United Kingdom, Sweden, Poland and Switzerland are also added to the panel. Despite being at the edge of Brexit, the United Kingdom remains to be the second largest economy in the European Union and the financial centre of the world. The inclusion of the data from the UK may detect some of the underlying effects of European monetary policy on the British economy.

On the other hand, Sweden and Poland are the largest economies in Scandinavia and Central Eastern Europe (CEE) respectively, and Switzerland is a financial and industrial hub that is closely connected with the EU. The currencies of these countries are to some extent pegged into the euro. Therefore, the data from these two countries help to trace the spill-over effects of EU's monetary policies on the rest of Europe.

5.2.2 Selection of Time Span

The dataset contains annual indices for variables of ECB interest rate, monetary easing, economic recovery, employment, price level, country's account balance and financial stability from the abovementioned 14 countries over the period from 2005 to 2017, covering the pre-GFC course, the time span during the GFC and the ensuing sovereign debt crisis as well as the recent slow economic recovery. The ECB firstly introduced the NIRP in June 2014. If one only analyses the data characteristics since the implementation of the NIRP, it would be difficult to sufficiently draw solid and convincing results due to the extremely short time span. As a result, this paper puts the NIRP time span into a complete economic circle and use a unified model to explain the effectiveness over a period covering the whole period of interest rate adjustment from high to low, two crisis, and different levels of liquidity adjustments (LTRO & APP).

For the purpose data consistency of the empirical analysis, data sources used in the empirical test of this thesis come from the Statistical Data Warehouse[5] and Eurostat[6]. The former is the European Central Bank's official online platform for data publications for statistics mostly within the Eurozone; the latter is a Directorate-General of the European Commission aiming for the provision of statistics across the entire EU. A combination of these two sources provides the basis of a reliable estimation of NIRP's effectiveness in and outside the Eurozone.

[5] Statistical Data Warehouse: https://sdw.ecb.europa.eu/

[6] Eurostat: https://ec.europa.eu/eurostat

5.3 Selection and Operationalisation of Variables

As reported in Table 1, the dataset for the empirical analysis contains one explanatory variable, one control variable and five dependent variables. Additionally, column 2 and column 3 report the operationalisation and sources of the variables. Highlighted in bold, the ECB's monetary policies are mainly divided into two categories: interest rate adjustment and liquidity injection.

Instead of the official deposit facility rates as used in most empirical research on this topic, the main explanatory variable used in this thesis is the real (effective) interest rates of each sample country, which is the nominal interest rate adjusted by the inflation. The selection of variables are justified by the fact that the ECB can only adjust the nominal interest rate, but the actual interest rate is affected by the inflation level of the real economy (Hegedorn, 2008).

Table 1 Operationalisation of Main Variables

Variables	Operationalisation	Source
Nominal Interest Rate	Deposit Facility Rate published by the ECB	Statistical Data Warehouse
Real Interest Rate (Explanatory Variable)	The effective interest rate that has been adjusted to inflation, calculated by subtracting the HICP from the nominal interest rate	Statistical Data Warehouse
Liquidity Injection (Control Variable)	Additional liquidity released through the ECB's calculated by adding the total amount of assets acquired by the ECB through the QE programmes represented by MRO, LTRO and APP	Statistical Data Warehouse
HICP	Harmonised Index of Consumer Prices - measuring the shifts in prices of goods and services consumed by households	Eurostat
Unemployment Rate	The unemployed individuals between the ages of 15 and 75 who 1) are able and ready to work within two weeks 2) actively look for work as a percentage of GDP	Eurostat
Industrial Output	Industrial Production Index - annual change in price-adjusted industrial output	Eurostat
Balance of Payments	Annual current account balance as a percentage of GDP	Eurostat
Debt-to-GDP Ratio	Government debt as a percentage of GDP	Eurostat
Dummy Variable[7]	1 = Current Account Surplus Countries 0 = Current Account Surplus Countries	

[7] The country is considered to be a consistent current account surplus country when the average current account balance from 2005 to 2017 is positive, and vice versa.

Since the ECB has implemented three monetary easing programmes alongside the NIRP, it is crucial to consider this excessive liquidity made available by ECB as a control variable – Liquidity Injection, highlighted in bold. The data is acquired from the annual consolidated balance sheet of the ECB published by the ECB on 31 December 2017. (See Section 4.2 for detailed information) The aggregate assets value of MRO and LTR on the balance sheet represent the total endogenous cash flow provided by ECB's cheap loan schemes. With respect to the Asset Purchase Programme (APP), four programmes - CBPP1, CBPP2, ABSPP, CSPP (see 4.3.3) construct the liquidity shock through direct engagement of the central bank in purchasing large amount of assets in the Eurozone. This is represented by the item "Securities Held for Monetary Policy Purposes (SHMPP)" on the balance sheet (Lewis & Roth, 2017). Hence, the control variable is calculated as:

$$Liquidity\ Injection = MRO + LTR + SHMPP$$

The variable liquidity injection takes the sum value of the allotment of MRO & LTRO and APP programme to show the adjustments of excessive liquidity injected by the ECB into the economy.

Following the discussion in *3.4 Effectiveness Demarcation*, the five objectives are price stability, full employment, economic growth, current account balance, and financial stability. These five objectives are measured by the Harmonised Index of Consumer Prices (HICP), the Industrial Production Index (IPI), unemployment rate and Balance of Payments (BOP).

It is of which noteworthy that THE Industrial Production Index (IPI), instead of GDP growth rate, was employed to measure economic output. IPI covers industrial production volume sold of a country in a variety of fields including manufacturing, electricity, gas, mining, quarrying, air conditioning supply and construction (Eurostat, 2018). Measuring industrial output excludes the potential effect that the freed liquidity and cheaper loans flow into the financial market or real estate instead of the industries and SMEs. When interest is low, the excessive liquidity is less likely to flow into the manufacturing sector, industries, and SMEs if financial market and real estate industry have a higher return on investment. Hence, measuring real industrial output is a more accurate indicator in measuring the effects of interest rates on real economy particularly in this case.

Lastly, there is a dummy variable *bal* that indicates whether the target country belongs to the current account surplus or deficit group. It is computed based on the average of the country's balance of payments over the period from 2005 to 2017. "1" is assigned to countries that have a positive average of the balance of payments, and "0" is assigned the countries with a minus average. The country is considered to be a consistent current account surplus country if the average current account balance from 2005 to 2017 is positive, and vice versa.

5.4 Concluding Remarks

The PVAR approach combines the classic VAR model developed by Sims, treating all variables in the equation as endogenous, and the model used for panel data, taking account the unobserved individual heterogeneity by introducing individual and time fixed effects. PVAR is an ideal model for assessing the transmission of macroeconomic shocks, which is also the reason why this paper employs this approach to examine the effectiveness of monetary policies on macroeconomic indicators.

The empirical analysis employs one independent variable, one control variable and five independent variables to measure the effectiveness of the NIRP on macroeconomic indicators in some of the most representative economies within and out the Eurozone over a complete economic cycle. The control variable controls for the liquidity adjustment caused by ECB's monetary easing programmes in order to isolate the effects of NIRP.

6 Data Analysis

The Panel-Vector Autoregressive Model (PVAR) is selected as the econometric model of this thesis as it is able to examine the variations in both time and space dimensions without confronting with the problem of exogeneity. The data used in the empirical analysis encompasses the measurements of the unconventional monetary policies adopted by the ECB (NIRP and monetary easing) and macroeconomic indicators from 14 major economies in Europe from 2003 to 2016.

This chapter carries out the PVAR to test the dynamic relationship between the NIRP & monetary easing programmes and analyse the regional variations in the effectiveness of the NIRP. The first step is to construct the mechanism of the PVAR model in the form of equations and summarise the statistics. PVAR model requires a stationary series and LLC IPS and Fisher-type unit root tests are performed to guarantee the stationarity of all variables in the empirical analysis.

Since the variables appeared to be nonstable that the null hypothesis cannot be rejected, the region-specific effect is removed by taking first differences. The optimal lag length is selected based on Andrew and Lu's information criteria. The estimations are executed independently of the individual fixed effects using the Helmert procedure with equation-by-equation ordinary least squares (OLS). Granger-Causality tests are then performed to detect the causal relationships between the variables.

Resting on the obtained results, impulse-response analysis (IRF) is derived to observe how a variable respond to the shocks in the monetary policy holding other changes constant. In support of the results from the IRF analysis, forecast-error decomposition analysis shows how much the independent variable contributes to the change in macroeconomic indicators

6.1 PVAR Modelling

There are major differences between countries in Europe in terms of overall economic policy (fiscal and monetary) orientation. Moreover, living standards of residents and levels of development are also various and fluctuate over time. Hence, individual fixed effects and time fixed effects are included in the model.

The following model is established:

$$Y_{it} = A_{t1}\, Y_{i,t-1} + \cdots + A_{tp} Y_{i,t-p} + d_i + \gamma_t + e_{it}$$

Y_{it} represents a vector of five endogenous variables (unemployment rate, the balance of payments, debt-to-GDP ratio, HICP and industrial output). Subscripts i and t refer to specific country and time, d_i and γ_t denote the fixed effects. Y_{it-p} is a vector of lagged dependent variables, containing the main explanatory variable – shift in interest rate, the control variable - liquidity injection (control) and five macroeconomic indicators. e_{it} represents the vector of residuals. p represents the number of lags , the

t implies the years from 2005 to 2017. $t - p$ indicates the number of observations that can be used in the estimation of the PVAR model.

6.2 Descriptive Statistics

Table 2 shows the descriptive statistics of the explanatory and control variables. The interest rate represents the real/effective interest adjusted by inflation instead of the nominal interest rates itself. The indicator of liquidity injection is made into a log value as the data obtained from the ECB's consolidated balance sheet are too large compared to other variables and the logarithms help in scaling down the large values.

Table 2 Explanatory Variables - Descriptive Statistics

Independent Variable		Mean	Std, Dev,	Min	Max	Observations
Interest Rate	overall	-0,87	1,21	-4,2	2,2	N = 195
	between		0,49	-1,67	0,38	n = 15
	within		1,12	-4,08	1,53	T = 13
Liquidity Injection	overall	13,78	0,56	12,92	14,96	N = 195
	between		0	13,78	13,78	n = 15
	within		0,56	12,92	14,96	T = 13

Table 3 shows the descriptive statistics of 5 dependent variables. The industrial output is also converted to a derivative of a log variable to show the percentage change.

Table 3 Dependent Variables – Descriptive Statistics

Dependent Variable		Mean	Std Dev	Min	Max	Observations
HICP	overall	1,56	1,33	-1,7	4,7	N = 194
	between		0,5	0,24	2,35	n = 15
	within		1,24	-1,52	4,58	T = 12,93
Unemployment Rate	overall	9,08	5,02	2,58	27,5	N = 195
	between		4,06	3,14	17,75	n = 15
	within		3,12	-0,47	19,36	T = 13
Industrial Output	overall	4,62	0,17	4,12	5,17	N = 182
	between		0,13	4,33	4,84	n = 14
	within		0,12	4,29	4,95	T = 13
Balance of Payments	overall	0,75	5,76	-14,48	1,49	N = 195
	between		5,02	-6,59	1,01	n = 15
	within		3,08	-7,14	1,17	T = 13
Debt-to-GDP Ratio	overall	81,79	32,23	23,6	178,9	N = 182
	between		27,74	41,48	147,3	n = 14
	within		17,91	33,34	129,64	T = 13

6.3 Unit Root Test – Stationarity

Before the panel VAR analysis is started, the unit root test needs to be performed on the variables of the empirical analysis to ensure the stationarity of the test and refrain from the "spurious regressions" (Abrigo & Love, 2016). LLC, IPS and Fisher-type statistical hypothesis tests are adopted to check the stationarity of the data by checking the unit roots of the data. A stationary time series has the property that its mean, variance and autocorrelation are constant and consistent over time.

It is risky to extrapolate econometric models fitted to a dataset that is not stationary. In particular, macroeconomic time series data are hardly stationary in their original formats since they usually suffer from the influence of economic cycles and trends. The panel data unit root tests applied in this chapter include LLC test (Levin-Lin-Chu), IPS test (Im-Pesaran-Shin) and Fisher-type. The unit root tests with both panel means & time trends and with only panel means are performed respectively, and the results are shown in Table 4.

Table 4 Unit Root Tests

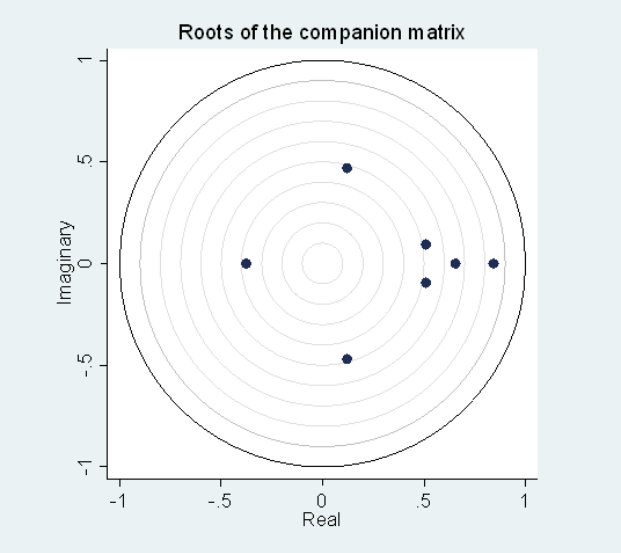
Variables	LLC	LPS	Fisher	LLC	LPS	Fisher
	Panel means & time trend included		Panel means & time trend included but drift term not included	Panel Means included but time trend excluded		Panel means and drifts term included, but time trend not included
Stats	T-value	W-t-bar	Pm	T-value	W-t-bar	Pm
Interest Rate	-8,8015***	-3,1006***	3,1587***	-7,8984***	-4,1743***	10,1723***
HICP	-8,7972***	-4,1739***	3,1518***	-3,1518***	0,8995***	10,1713***
Unemployment Rate	-4,7027***	-1,5091***	-0,2086	-2,6035***	0,402***	8,5242***
Industrial Output	-4,0049***	0,4020***	1,1969	-10,2853***	-1,6528***	7,0425***
Balance of Payments	-7,6858***	-3,4055***	2,7349***	-2,5818***	1,0502	-5,1941***
Debt-to-GDP Ratio	-3,3288***	0,3138	0,4837	-1,7459***	-0,5106	6,6284***

*** p<0.01, ** p<0.05, * p<0.1

Based on the results of unit root tests shown in Table 4, the null hypothesis at the 1% level of statistical significance $\rho = 0$ cannot be rejected as there are likely to be unit roots in the panels under the provided test conditions (Kunst, 2011). For instance, three out of six unit root test for the variable *Debt-to-GDP Ratio* yield insignificant results. The only variables that demonstrate strong statistical significance are *Interest Rate* and *HICP* that the null hypothesis can be rejected here.

Therefore, the differencing approach is adapted to stabilise the panel data of variables unemployment rate, industrial output, balance of payments, debt-to-GDP ratio by removing alterations in the level of

the time series, reducing trend and seasonality. The differenced series represents the shift between consecutive observations in the original, which can be denoted as the following equation:



$$Y_{it} - Y_{i,t-1} = \varepsilon_{it} + c$$

ε_{it} denotes the white noise and c is the average of the changes between consecutive observations. After having taken the first difference of the four probable nonstationary variables, the PVAR unit root tests with all seven variables are within the unit circle, meaning that the stationarity conditions require by the PVAR model are satisfied, and the selection of the optimal lag length and Granger Causality Test can be continued.

Figure 12 Unit Root Test for the Stationarity of all endogenous variables

6.4 Selection of the Lag Order

The lag length determines how far back the time should go. The determination of an optimal lag length is essential since too many lags come at the cost of the degree of freedom and two few lags could also result in autocorrelation. Andrew and Lu (Andrew & Lu, 2001) introduced a consistent moment and model selection criteria (MMSC) for GMM models based on Hansen's (1982) J statistic of over-identifying restrictions. When selecting the lag order, it is necessary to consider that the selected lag can reflect the dynamic characteristics of the model, and accounts for the relationship between the estimated parameters and the degrees of freedom of the model (Abrigo & Love, 2016). Weighing the balance between the lag number and degree of freedom, this paper selects the optimal lag number based on AIC, BIC and HQ model selection criteria.

Table 5 Determination of the optimal lag order based on the information criteria

lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	0,9833383	94,5119	0,0001022	-142,4659	-3,488099	-59,95043
2	0.9992569	.	.	.	.	.

Table 5 shows that lag=1 is the optimal lag order determined by the standard information criteria for GMM estimation MBIC, MAIC and MQIC by Andrews and Lu (2001). The sample data set of the empirical analysis is T=13, superfluous lags are thus not conducive to explaining the relationship between the independent and dependent variables. Hence, the adopted model in the consecutive analysis is the first-order PVAR.

6.5 PVAR Model Estimation

This chapter has hitherto constructed the PVAR model and performed stationarity tests. After having selected the optimal lag order in the previous section, the analysis now proceeds to the estimation of parameters in the PVAR model. It is worth reminding that the impulse response functions in the next chapter will interpret the substantive significance of the estimates. The estimation of parameters in this section gives a preliminary understanding of the causal relationships between variables.

The fixed effects contained in this model allow for region-specific heterogeneity, but they are also correlated with the regressors because of the lags of the dependent variables. The Helmert transformation, also known as forward mean-differencing (FOD), is used to remove the means of the available future observations; this procedure preserves the orthogonality between transformed variables and explanatory variables (Abrigo & Love, 2016). This paper follows the standard panel GMM that as many instruments as endogenous variables are adopted to assure the consistency of the estimated coefficients.

Table 6 presents estimation of three PVAR models; it first presents the overall estimates in column 3 and then shows how the outcomes differs the current account surplus and current account deficit countries to control for region-specific effects in column 4 and 5. The first column shows the five macroeconomic indicators as dependent variables: HICP, unemployment rate, industrial output, balance of payments and debt-to-GDP ratio. The second column lists the main explanatory variable and the control variable with one lag which is determined in the last section.

According to Table 6, interest rate adjustment does not have significant influence on unemployment rate but has minor influence on the HICP (0,288) and balance of payments (-0,373), both at the 5% confidence interval. Interest rate shift generates highly significant effects on industrial output (-0,0147) and debt-to-GDP ratio (2,290) at 0,1% confidence interval. With respect to the liquidity injection, highly significant coefficients are found on industrial output (-0,0666) and unemployment rate (1,625) at 0,1% confidence level, but liquidity injection does not yield significant results in the HICP and the debt-to-GDP ratio.

In the current account surplus countries, most results appear to be insignificant. However, the coefficient of liquidity injection on unemployment is highly significant (1,066) and this high significance also applies to the current account deficit countries but with a larger coefficient (2,049). Additionally, both interest rate adjustment and liquidity injection produce significant results on the debt-to GDP ratio with large coefficients of 2,594 and 6,849.

In account deficit countries, both the explanatory and the control variables yield negative coefficients at 1% confidence level on industrial output. The change of the HICP caused by interest rate adjustment

has weak significance as in all sample countries. Moreover, liquidity injection leads to a highly significant change in balance of payments (2,204)

Table 6 PVAR Model Estimation

(1)	(2)	(3)	(4)	(5)
Dependent Variables	Independent Variables (with one lag)	All Sample Countries	Current Account Surplus Countries	Current Account Deficit Countries
HICP	Interest Rate	0,288*	0,224	0,382*
		[0,1346]	[0,1788]	[0,1945]
	Liquidity Injection	-0,256	0,0652	0,259
		[0,3670]	[0,4617]	[0,5396]
Unemployment Rate	Interest Rate	0,156	0,143	0,171
		[0,0911]	[0,1246]	[0,1302]
	Liquidity Injection	1,625***	1,066***	2,049***
		[0,2907]	[0,3043]	[0,3663]
Industrial Output	Interest Rate	-0,0147***	0,0121	-0,0155**
		[0,0044]	[0,0070]	[0,0051]
	Liquidity Injection	-0,0666***	-0,0761**	-0,0561**
		[0,0156]	[0,0270]	[0,0185]
Balance of Payments	Interest Rate	-0,373*	0,308	0,205
		[0,1451]	[0,2309]	[0,1957]
	Liquidity Injection	1,464**	0,548	2,204***
		[0,5496]	[0,8817]	[0,6450]
Debt-to-GDP Ratio	Interest Rate	2,290***	2,594***	1,500**
		[0,5604]	[0,7110]	[0,5603]
	Liquidity Injection	3.556	6,849**	0,204
		[2,7509]	[2,4060]	[3,9913]
Observations		140	60	80

Standard Errors in Brackets

* p<0,05, ** p<0,01, *** p<0,001

From the PVAR estimation of parameters above, it can be seen that interest adjustment and liquidity injection have varying effects on different macroeconomic indicators, and these effects are again different in current account surplus and current account deficit countries. The interpretation validates the proposal of this thesis that the distinction between countries with consistent surplus and deficits is crucial to the understanding of the policy effectiveness.

It is noteworthy that, as indicated in *Section 5.1.1*, the PVAR model is atheoretical, so that the interpretation of the coefficients is indubitably limited. Sections 6.7 and 6.8 will further examine the causal mechanisms using impulse response functions and variance decomposition.

6.6 Granger Causality Test

The PVAR estimation of parameters in 6.6 indicates that the relationships between the independent/control variables and dependent variables are intertwined and complex. In order to clarify the causal mechanisms between the explanatory/control variable and the dependent variables, this section performs the Granger Causality Test, thereby excluding the non-causal equations from the following impulse response functions.

The Granger Causality test was initiated by Clive W. J. Granger, winner of the 2003 Nobel Prize in Economics. His hypothesis test is used to analyse the causal relationship between economic variables in time series, and it does not rely on a priori specification of a structural model, but instead is a method for quantifying the usefulness of the past results in forecasting (Granger, 1969). The intuition of Granger Causality is that the future events will not have a causal effect on the present and the past, and not vice versa.

This research observes whether the interest rate drop, and monetary easing programmes of the ECB can cause changes in changes in price levels, unemployment rate, industrial output, the balance of payments and debt levels. This section adopts this approach to investigate the causal relationships between dependent and independent variables. The equations that have limited explanatory power will be excluded from impulse response and variance decomposition analysis.

Table 7 Granger Causality Test

	(1)	(2)	(3)	(4)	(5)
Variables	HICP	Unemployment Rate	Industrial Output	Balance Payments	Debt-to-GDP Ratio
Interest Rate	**0.382****	0.171	**-0.0155*****	-0.205	**1.500*****
	(0.195)	(0.130)	**(0.00515)**	(0.196)	**(0.560)**
Liquidity Injection	-0.259	**2.049*****	**-0.0561*****	**2.204*****	0.204
	(0.540)	**(0.366)**	**(0.0185)**	**(0.645)**	(3.991)
Observations	80	80	80	80	80

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Granger Causality test results presented in Table 7 suggest that the coefficients of the HICP, industrial output and debt-to-GDP ratio are at 1% confidence level, meaning that the null hypothesis that the non-Granger-cause variables are excluded should be rejected. The interest rate variable is thus a Granger cause for these three macroeconomic indicators. However, the log interest rate does not show explanatory power on the unemployment rate and balance payments, so that the null hypothesis is accepted in these two cases.

With regards to the control variable (liquidity injection), Table 7 shows that liquidity injection's causal effects on the unemployment rate, industrial output and balance of payments passed the Granger Causality test, which can, therefore, be kept for the following analysis. However, liquidity injection does not have explanatory power on price levels and debt levels, and therefore these equations should also be excluded.

Both the explanatory and control variables are Granger-causes of industrial output: interest rate adjustment and liquidity injection are mutually complementary and reinforcing in explaining the causal relationship between unconventional monetary policies and macroeconomic indicators.

6.7 Impulse Response Analysis

6.7.1 Why IRF

In the previous section, the stationarity adjustment of the PVAR model has been performed by taking the first difference of nonstationary variables. Then, the optimal lag was selected based on the information criteria, and Granger Causality Test confirms the causal relationships between endogenous variables.

In a (P)VAR model, the estimated coefficients are difficult to interpret as these autoregressive models include several endogenous variables with lags. Since all variables are treated the same as endogenous in an auto-regressive system, there are no evident dynamics between targeted variables. Conclusions that are drawn solely based on the estimations of coefficients are largely limited and cannot represent the entire and dynamic causal path.

In order to solve this disadvantage, this section 6.7 aims to explore the impulse response relationship between the explanatory and dependent variables in a dynamic and dimensional system. The assumption here will be that when there is a response of an endogenous variable to an impulse in another variable, the latter is regarded as causal for the former.

The Impulse Response Function (IRF) is the main workhorse in a VAR model and also an essential tool to examine dynamic relationships/path in empirical causal analysis and policy effectiveness analysis. IRF is derived to demonstrate how an endogenous variable reacts to a unit innovation in the explanatory

variables as disturbance, holding all other shocks constant. IRF is also used in explaining the degree a which the changes in one variable is passed to other variables at different stages either directly or indirectly.

The following sections (6.7.2, 6.7.3, 6.7.4) presents the Impulse Response Functions of the overall impact in the Eurozone and beyond, in the account surplus countries and account deficit countries respectively. The estimated coefficients presented in Table 6 are in line with the results. The confidence bands in the IRF graphs are produced by 300 Monte Carlo iterations.

6.7.2 IRF for All Selected Countries in Europe

Based on the results shown in the Granger-Causality test, the equations without strong explanatory power are excluded from the impulse response analysis. Hence, the relationships between interest rate adjustment, unemployment and balance of payments as well as the relationships between the liquidity injection, the HICP and the debt-to-GDP ratio are excluded from the impulse-response analysis.

Figure 13 captures the overall impact of the interest rate adjustment on all sample countries. The three functions illustrate the response of Debt-to-GDP ratio, the HICP and industrial output to a shock in the one-lag PVAR model. It can be observed that a one standard deviation interest rate shock results in less than 1unit of debt increase after the first five periods, despite a temporary slow-down in the second year.

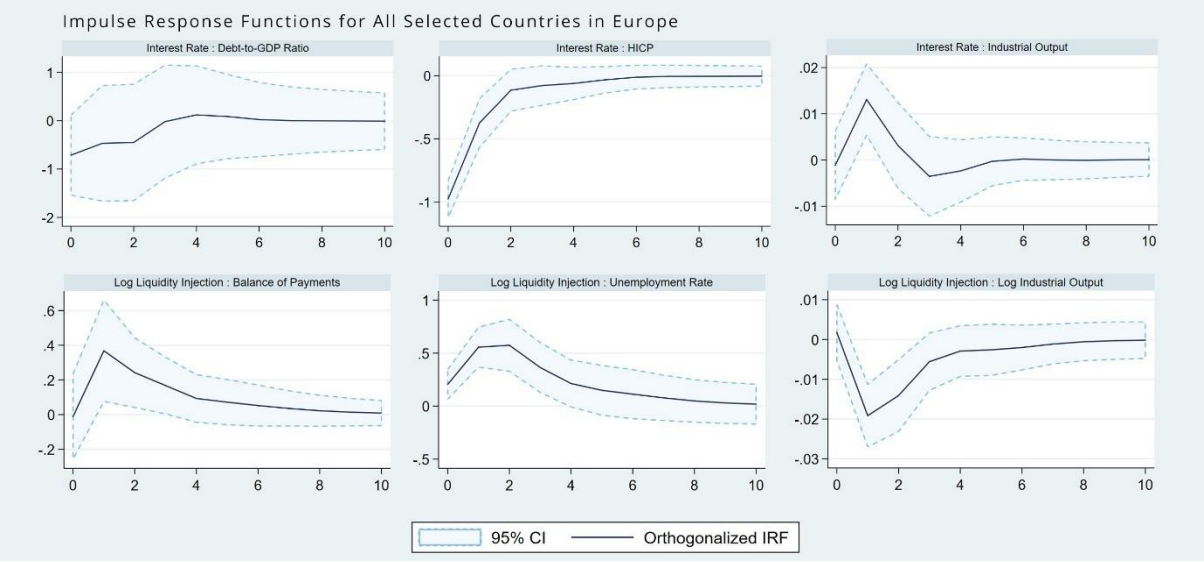


Figure 13 IRF Impulse Response for all sample Countries

With regards to the price level, there has been a sharp increase of the HICP in the first two periods given a shock of one standard deviation change in interest rate, but the influence diminishes immediately entering the third period, implying that the interest rate's noticeable impact on the price level only exists in the short term. Industrial output's growth initially soares but quickly plunges into the negative territory and then returns to the zero lines in the fifth period.

Figure 13 also plots the impulse response functions for the balance of payments, unemployment rate and industrial output responding to a one standard deviation shock of the interest rate adjustment. It shows that the current account balance condition of the sample countries improves as a 0.4 increase in the balance of payments is witnessed. However, one unit change in interest rate leads to rising unemployment and shrinking industrial output in the first period, even though the effects are muted after the third period.

As a small concluding remark, NIRP and ultra-low interest rates have a short-term upward influence on the inflation level, and its impact on industrial output fluctuates over time in the Eurozone. On the other hand, liquidity injection contributes to the short-term balance of payments but in the meanwhile causing a reduction in industrial output and rising unemployment.

6.7.3 IRF for Current Account Surplus Countries

The impulse response functions for the account surplus countries shown in Figure 14 paints a slightly different picture as Figure 13. The Debt-to-GDP ratio is impervious to a one standard deviation shock in interest rate throughout all periods in account surplus countries. The variation in price levels (the HICP) while receiving a one standard deviation shock is similar to the overall trend on the EU level that interest rate shock has a noticeable impact on the HICP in the first two periods and immediately flattens out when passing the second year.

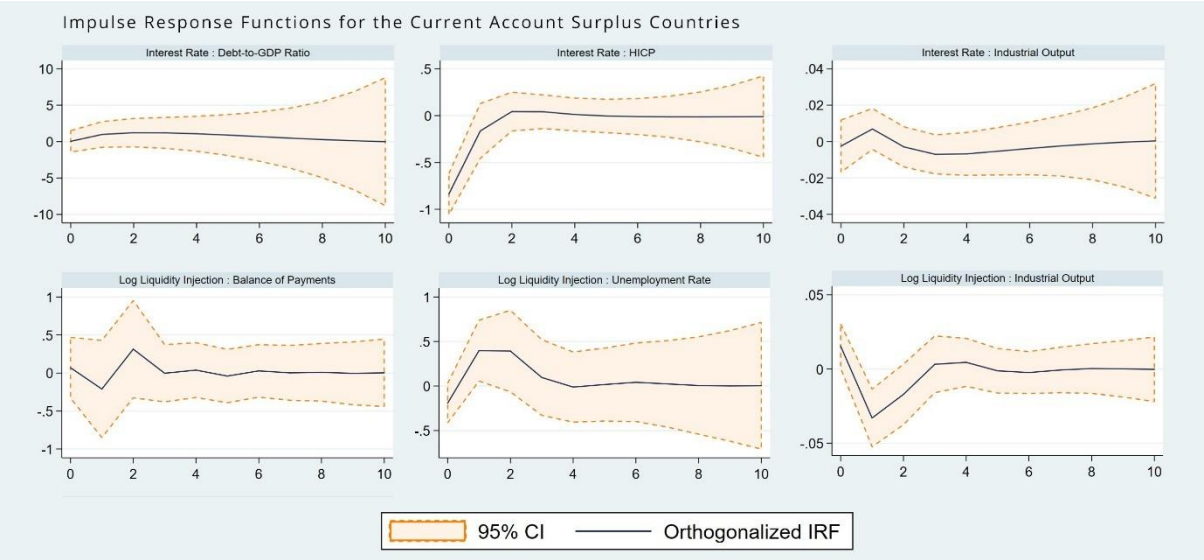


Figure 14 IRF for Current Account Surplus Countries

Furthermore, the balance of payments in account surplus countries reacts to one standard deviation shock in liquidity injection initially drives the savings of the account surplus countries into the negative realm but then rebounds after the first period. After having peaked in the second year, it returns back to zero and then mildly fluctuates around zero. With respect to the unemployment rate, liquidity shock

initially drives up the unemployment rate in the first two years until point 0.5 and then gradually comes back to the zero in the fourth year. In addition, industrial output also responds to the liquidity shock with a sharp within the first year, but it then gradually recuperates and stabilises around the zero line in about the fourth period.

With regards to the account surplus countries as a whole, most responses of the macroeconomic indicators, following the shocks of interest rate change and liquidity injection, are in accordance with the results on the overall level in Europe presented in 6.7.2. Only differences are that the string of perverse effects brought by these two monetary policies is on a stronger amplitude in the current account deficit countries (peripheral countries) than the EMU + Switzerland average.

6.7.4 IRF for Current Account Deficit Countries

As for the account deficit countries in Europe, the results from Figure 15 left little room for optimism. One standard deviation shock of interest rate cut gives rise to short- to middle-term debt accumulation. Although the inflation gradually recovers, industrial output rose in the first period and then gradually fell below zero until the 7th period.

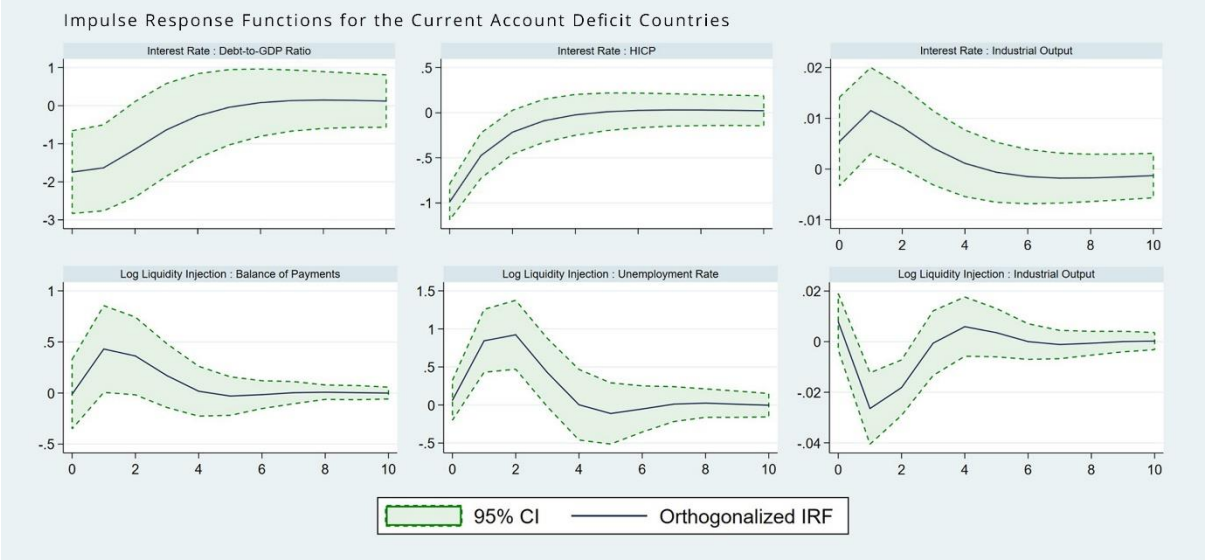


Figure 15 IRF for Current Account Surplus Countries

Liquidity shock has a more significant influence than slashing interest rates on the account surplus countries. The response of the balance of payments to a liquidity shock is an instantaneous increase in the short-run and gradually diminishing effect in the long-run. Unemployment rises sharply reacting to the liquidity shock and industrial output declines with a stronger amplitude in the first period than in account surplus countries.

6.7.5 IRF Results

To sum up the Impulse Response Analysis, a few points can be made. First of all, the results of the impulse response functions are more comprehensive and integrated than the estimation of coefficients. Second, ultra-low interest rates and the NIRP contribute to the increase of price level in the Eurozone and beyond, but they are likely to result in rising debt levels and declining industrial output, with even relatively higher amplitude in the account deficit countries.

The impulse response functions shown in the previous sections once again confirms that the inclusion of the control variable – liquidity injection, is crucial. In a broader sense, liquidity injection carried out by monetary easing programmes triggers higher unemployment and lower industrial output despite the lenient borrowing conditions and excessive liquidity on the market. The scale of the adverse effect on unemployment in account surplus countries is significantly smaller than in account deficit countries. Regarding the balance of payments, the IRF results demonstrate the redistribution in the Eurozone that account surplus countries transfer to account deficit countries via purchase programmes.

However, IRF analysis is unable to quantify how much the explanatory and control variables contribute to each dependent variable respectively. The following section solves the issue by introducing the Forecast-Error Variance Decomposition.

6.8 Forecast-Error Variance Decomposition

6.8.1 Why FEVD?

The previous section presents the effects of shocks in interest rate and liquidity injection on the five macroeconomic indicators. However, it does not demonstrate how vital these shocks are in explaining the variations in other variables, In this section, the forecast-error variance decomposition (FEVD) is employed to evaluate the importance of shocks in interest rate and liquidity injection in explaining the fluctuations in macroeconomic indicators.

The FEVD expresses the magnitude of the effect of orthogonal shocks by determining the proportion of variation, shock or innovation of every dependent variable caused by each of the explanatory variables. It not only demonstrates the economic significance of the econometric model but also determines how much of the variability in the dependent variable is caused by its own variance.

In addition, since we have one explanatory (interest rate shock) and one control variable (liquidity shock) in the empirical analysis, the FEVD identifies which one of the two is “stronger” in explaining the variability in the dependent variables over time, in this case, five macroeconomic indicators in 14 European countries from 2005 to 2017.

6.8.2 FEVD Results

Table 8 shows the FEVD results which are derived from the orthogonalised impulse-response functions. The variables on the first row are explained by the variables on the column. Since the analysis contains ten periods, only three periods (period 2, 5, 10) were selected to represent the short-term, medium-term and long-term contribution. The FEVD analysis with full periods is reported in Appendix C.

Table 8 Forecast-Error Variance Decomposition (FEVD) Results

Response Variable	Period	Impulse Variables						
		Interest Rate	**Liquidity Injection**	HICP	Unemployment Rate	Industrial Output	Balance of Payments	Debt-to-GDP Ratio
HICP	2	**61,7%**	1,9%	34,2%	0,1%	1,1%	0,0%	1,1%
	5	**55,0%**	2,0%	39,0%	1,0%	1,0%	0,0%	1,0%
	10	**50,0%**	2,0%	44,0%	1,0%	1,0%	0,0%	1,0%
Unemployment Rate	2	16,6%	**21,4%**	11,5%	45,9%	4,0%	0,0%	0,6%
	5	15,0%	**29,0%**	19,0%	31,0%	3,0%	0,0%	4,0%
	10	12,0%	**25,0%**	31,0%	26,0%	3,0%	0,0%	4,0%
Industrial Output	2	**5,8%**	**12,5%**	24,4%	5,8%	47,8%	0,0%	3,7%
	5	**5,0%**	**15,0%**	31,0%	6,0%	37,0%	0,0%	6,0%
	10	**4,0%**	**14,0%**	38,0%	5,0%	33,0%	0,0%	6,0%
Balance of Payments	2	3,7%	**4,7%**	7,8%	6,0%	8,9%	67,3%	1,6%
	5	4,0%	**7,0%**	7,0%	7,0%	8,0%	63,0%	3,0%
	10	4,0%	**8,0%**	8,0%	7,0%	8,0%	62,0%	3,0%
Debt-to-GDP Ratio	2	**2,0%**	4,8%	6,0%	5,8%	15,3%	4,2%	61,9%
	5	**2,0%**	13,0%	18,0%	8,0%	11,0%	3,0%	46,0%
	10	**1,0%**	11,0%	32,0%	7,0%	9,0%	2,0%	37,0%

Based on the results from the Granger-Causality Tests from Table 8, the HICP and debt levels are caused by interest rate adjustment whereas liquidity injection has explanatory power in changes in unemployment rate and balance of payments. In addition, both interest rate and liquidity injection are the Granger-causes of the changes the industrial output. The key numbers in the graph have been made

bold to show the relevance of explanatory and control variable. Since PVAR treats all variables in the model as endogenous, all five dependent variables are also included in this table in order to have a full understanding of the magnitude of each endogenous variable.

In the short run, when all shocks of endogenous variables hit, the impulse to interest rate accounts for 61,7% variation of the fluctuation in the HICP, comparing to only 34,2% of the HICP's own shock. In the long run, the contribution of the interest rate to change in the HICP remains above 50%, indicating that interest rate change is the primary driver of the slowly climbing interest rate of the Eurozone. Interest rate shocks, by contrast, are only responsible for 2,0% of the variance in the second and fifth period and it expresses tendency of decline in the long-run until, in 10th period, the contribution only accounts for 1,0% of this variation.

Furthermore, both interest rate and liquidity shocks have explanatory power in the industrial output of selected countries based on the results from Granger-Causality test. It is conspicuous from Table 9 that the fluctuations of the industrial output are primarily driven by its own shock rather shocks coming from other variables. However, liquidity shock has much larger economic significance than interest rate shock, and it represents respectively 12,5%, 15,0% and 14% of the variation in the second, fifth, and tenth period comparing to the 5,8%, 5,0% and 4,0% variation from the interest rate shock.

In respect of the liquidity injection, its shock is responsible for 21,4% of the unemployment change in the first period, but the shock is coming from the unemployment rate itself is doubles this number. However, interest rate's importance increases over time, and it peaked in the 5th period, with 29,0% of the contribution to the variation of the unemployment rate, which is already closed to the declining impact from the dependent variable's own fluctuations. In the last period, the interest rate shock's impact slightly decreased to 25% in explaining the movements of the unemployment rate.

Regarding the balance of payments, shock in liquidity injection is not the most important factor in the determination of current account balance, and the largest contributor to the change of balance of payments comes from the variable per.se. Nevertheless, its impact maintained consistent growth, and it starts from 4,7% in the second period to about 8% in the last period.

6.8.3 Summary of the FEVD Outcomes

In summary, the forecast-error variance decomposition analysis answers the question raised by the impulse response analysis: how much of the fluctuation in the five macroeconomic indicators over different periods is explained by each of the two shocks (interest rate and liquidity) in the PVAR model. It finds evidence that the interest rate shock is the main contributor to the slow growth of price levels, even though its scale of impact on the debt levels is limited since it only explains a small portion of the change in the debt levels.

Both liquidity and interest rate shock are correlated with fluctuations in the industrial output of a certain country; the former has more economic significance than the latter in explaining this relationship. Although liquidity shock plays a role in the convergence of the balance of payments within the Eurozone, it also is the main driver in rising unemployment in Europe.

7. Summary and Interpretation of the Empirical Results

This chapter rounds off the empirical analysis by summarising main statistical outcomes in a non-technical manner. Subsequently, section 7.2 attempts to explain possible underlying reasons and transmission mechanisms behind the empirical results, preparing for the conclusion and policy recommendations.

7.1 Review of results

The PVAR model consists of one explanatory variable to measure the adjustments in real/effective interest rates and one control variable to assess the monetary easing programmes that are carried out alongside the ultra-low and negative interest rate policies. The effectiveness is reflected in five economic indicators as presented in the previous chapters – HICP, unemployment rate, industrial output, the balance of payments and debt levels.

The empirical analysis commences with setting up the PVAR model and descriptive statistics. The prerequisites of a reliable PVAR model requires the stationarity of the data and the determination of the optimal lag order. Three types of unit root tests were performed and the non-stationary time series were taken the first difference. The optimal lag order, based on the information criteria MBIC, MAIC and MQIC, is chosen to be one lag. The estimation of parameters in the PVAR model is then performed, and the coefficients indicate that the drawbacks of both unconventional policies tend to outweigh their contributions to the recovery of the macroeconomy. Additionally, there tend to be large differences regarding effectiveness in account surplus and deficit countries in Europe. In order to have a more in-depth understanding of the relationships, impulse response analysis and variance decomposition are adopted.

The last step before the impulse-response function analysis is the Grange-Causality test; the result shows that neither interest rate adjustment nor liquidity injection is the causes of variations in all variables; instead, interest rate is correlated with the HICP, and debt levels and liquidity injection is correlated with the unemployment rate and balance of payments; both variables are Granger-causes of industrial output. Hence, the following analysis excludes those equations that fail to pass the Granger-Causality tests and those with causal relationships are taken into consideration.

By combining the results from the main workhorses of the model impulse response function and the variance decomposition function, the following conclusions are drawn. From a broader perspective, interest rate downward adjustment leads to upward movement in price levels, mirrored by the slowly rising the HICP. Since the interest rate shock is the largest contributor to the variation in the HICP, it is thus a cogent argument that ECB's NIRP achieves its overriding objective in driving up the inflation rate to just below 2%. However, this impact is very short-term, and it vanishes after the 2nd year in the

future. This effect shows high consistency across the Eurozone in both account surplus and deficit countries.

The interest rate adjustment, however, facilitates the debt growth in a small amplitude. Comparison between figure 7 and 8 implies that this small amplitude is derived only from the account deficit countries. Comparing to its short-term effect on core countries with surpluses, interest rate adjustment has a short- to mid-term impact on the upward movement of the debt levels in current account deficit countries.

Although both the interest rate cut and liquidity injection are Granger-causes of industrial output, they move in opposite directions. In the first period, the interest rate shock leads to a sharp increase in industrial output but then falls below the zero lines entering the second year. Meanwhile, the liquidity injection results in a dramatic decline at the beginning of the first period but then recovers back to the zero lines in about the third period. Both variables have short-term, but conflicting effects on industrial output and these trends are unaltered in account surplus and deficit countries.

The excessive liquidity generated by the unconventional monetary easing programmes by the ECB also leads to a short-term rise in unemployment rate in both country groups, but with a much stronger amplitude in account deficit countries. Liquidity shift is responsible for a large proportion of the rise in unemployment rate.

Finally, liquidity injection urges the short-term convergence of the balance of payments between account surplus and deficit countries in the short-term. The economic significance in the first periods is weak but tends to grow over time. The surplus countries' balance sheets witness a decline in savings in the first period, and in the meantime, an adverse effect is observed in the deficit countries that their deficits have been shrunk. Nevertheless, in the second period, the void between the account surplus and deficit countries is again enlarged as the former's surplus rises before hitting back the zero line, and the latter's short-term positive outlook of account balance wears off. This implies that the liquidity injection solves the short term unequal distribution of wealth, but it is unable to justify that the current account deficit countries are unencumbered in the long-term.

7.2 Interpretation of the Results and Discussion

Having established the empirical results, this sub-section attempts to critically interpret the underlying reasons and transmission mechanism of these results. Based on the empirical results, interest rate adjustment have a significant impact on inflation, industrial output and debt level; the liquidity injection leads to changes in unemployment industrial output and balance of payments. Also, the impact varies greatly depending on whether the country has consistent current account surpluses or deficits. The empirical test puts emphasis on the causal relationships between monetary policies and

economic variables but does not explore the transmission mechanism between them. Therefore, this section ventures to interpret how the monetary policy has caused changes in each economic variable as summarised in the previous section.

7.2.1 Interest Rate Adjustment on Inflation Rate: Is Forward Guidance still Relevant?

Price stability is the most critical monetary objective of the ECB. The central bank's interest rate adjustment has a short-term and robust impact on the upward movement of the interest rate. On the other hand, the ECB has conducted several quantitative easing programmes, engaging in large-scale purchases of assets and increasing the bank's balance sheet to an unprecedented level. Nevertheless, the released liquidity is not significantly associated with the shifts of slowly rising inflation levels.

As demonstrated in Appendix D, by the end of 2017, the average inflation rate of the Eurozone had reached 1,5%, thanks to radical interest rate cuts. To some extent, the outcomes imply that an ultra-low interest environment has ultimately facilitated the growth of aggregate demand, which is reflected in the gradually rising HICP level.

However, the ECB's quantitative definition of inflation targeting is relatively ambiguous. Canada, Sweden or the UK all have clear inflation targets. Australia and New Zealand have clear inflation targeting ranges, with clearly defined upper and lower bounds (Loayza & Soto, 2002). The 2% of the ECB's monetary objective is not a target value; the inflation level needs to be close to 2%, but the lower bound is not specified (Surico, 2003). Additionally, as discussed before, the "medium-term orientation" has not been clearly defined.

The ECB's inflation target is the central bank's commitment to the market. It means that if the actual inflation is above (below) the target, the central bank will tighten (loose) its monetary policy (Svensson, 2010). Due to this commitment, citizens can have stable expectations and arrange their own consumption and saving plans, companies are able to follow their production plans and make investments accordingly, and the financial markets can understand risks better. Without this commitment, consumers might only have a limited understanding of the future. Thus, they do not know how much they should spend and how much they need to save. As for companies, they are not able to assess the demand for consumption and identify moments to lay off.

If the expectations of the future prices are negative or minorly positive, it is unlikely that low-interest rates above the zero bound will promote consumption (Schäfer, Stephan, & Hoang, 2017). The NIRP, despite the slow progress, has ultimately brought the deflated economies out of the predicament. Even though central banks kept insisting upon their price stability target, the applicability of the inflation targeting of the ECB is highly disputable (Blau, 2017).

Given the growing influence of E-commerce and recent advancements in the field of automation and AI, the production process has become increasingly efficient, and costs have shrunk as much as they

could (Sánchez & Kim, 2018). After years of quantitative easing programmes, the HICP has risen, but the ECB or Bank of Japan are still struggling to deal with a sluggish economy (Appendix 5). At a time when the price sensitivity is higher than ever before (Robel & Rahman, 2014), central banks that live on forward guidance are advised to rethink the compatibility of the 2% target and the relationship of the expected inflation rate and economic growth.

7.2.2 Rising Unemployment triggered by Liquidity Injection

Structural unemployment is persistent and long-term unemployment caused by a sustained shock, which restricts people pursuing employment (Restrepo, 2015). It can either be caused by an economic cycle or a technological upgrade. These shocks occur abruptly, and the damage is substantial, but adapting to these shocks would lead to long periods of the rising unemployment rates since the economy needs time to restructure. In recent decades, in addition to the collapse of oil prices, the deindustrialisation, globalisation, and developments of information and technology required the EU to carry out economic restructuring.

The decline in the labour participation rate and the high proportion of structural unemployment are challenges for sustainable growth and recovery in the European case (Boeri & Jimeno, 2015). Although current unemployment rate in Europe has hit a low record since the financial crisis, the labour participation rate in the EU is still low comparing to other major economies such as the United States (shown in Appendix E: Labour Force Participation Rate of Major World Economies**).** Ten years after the GFC, the labour participation rate has not improved and has hovered at a level of 57,3% in 2017, in comparison with the 68,9% of China, the 60,2% of Japan and the 61,9% of the United States.

An explanation of the causal effect between liquidity injection and rising unemployment thus starts from the key factor limiting the labour participation rate, which is labour compensation (Boeri & Jimeno, 2015). The excessive liquidity caused by consecutive rounds of QE diminishes the real purchasing power of employees and job seekers and significantly increases risks for industries and SMEs[8], thereby discouraging full-time employment and wage increase. The unconventional monetary policies prevented a deflationary spiral, but the unaltered wage level has not been able to adapt to full employment. This led to structural unemployment and fiscal deficits, which are primarily felt in southern European countries.

7.2.3 Weakening Industrial Output

Theoretically, in a low-interest rate environment, the cost of corporate lending is lower. The corporations are able to borrow more and thus increase investment in the industrial sector. As a result,

[8] SMEs : Small and Medium Sized Enterprises

the industries and associated service providers are able to access more financing and increase output. Empirical results have accepted this assumption in both account surplus and deficit countries in the sampled countries in Europe that interest rate adjustment can boost industrial output. However, factoring in the excessive liquidity that commercial banks possess, the industrial output exhibits a significant sign of decline which is stronger than the output increase led by interest rate cuts.

OECD economist William White indicates that when companies consider whether or not to increase their investments, the costs of borrowing and the availability of liquidity are just two of many factors that come into consideration (Evans-Pritchard, 2018). When the investors are concerned with the undue sensitivity of the industrial sector during a recession, they are unlikely to invest in the industrial sector if there are other assets with much higher return on investment, e.g. the real estate industry.

The low costs of borrowing are also likely to finance the insolvent zombie companies at stake. 9% of the STOXX 600 companies in Europe belong to so-called zombie companies[9]. They were able to survive by relying on low-interest rates and credit degradation (McGowan, Andrews, & Millot, 2017). However, if the ECB takes immediate austerity measures, these companies will immediately face risks of default and the "Lehman Moment". These large international companies tend to receive government subsidies, especially during recession periods, because national governments are inclined to fend off the unemployment risks led by the bankruptcy. The crowd-out effect distorts the allocation of financing resources, inhibiting potential output growth.

The main findings of the report are that the increase in the proportion of zombie companies is closely related to the investment and employment reduction of non-zombie companies across sectors (McGowan, Andrews, & Millot, 2017). On average, an increase in the proportion of zombie companies amongst all OECD countries has resulted in a 2% cumulative investment loss and a 0.7% loss in employment compared to the pre-crisis period. This is a particularly severe issue in Europe, which had the highest proportion of zombie companies, as shown in Appendix F (Proportion of Zombie Companies to Non-Zombie Companies in the OECD Member States) as the countries.

The second figure in Appendix G (Proportion of Cash Spent by STOXX Europe 600 non-financials for Invest for Growth and Return to Investors) illustrates the investments of the STOXX 600 non-bank companies over the past 20 years. Despite the continuous reduction of interest rates by the ECB in the past 15 years, the investments of these European companies have been declining (the dark blue line). Meanwhile, these companies have been increasingly involved in stock share buybacks and dividend payouts (ECB, 2007). The earnings per share have risen and is reflected in the booming stock market.

[9] Zombie Companies: Companies that do not make enough profits over a prolonged period of time to repay their debt servicing costs(Caballero et al, 2008). This term was firstly used for Japanese companies during the "lost decade", but has recently gained increasing attention amongst academics.

Hence, the theoretical assumption of the transmission mechanism is hampered by multifarious obstacles in practice. Neither the low-interest rates nor the liquidity injection were guided to follow into the real industries but to the financial market and real estate, which are reflected on the asset bubbles and booming stock prices.

7.2.4 Debt Accumulation under the NIRP

Eight years of zero or negative interest rates have lured the current account deficit countries (periphery) into deeper debt dependency while leaving current account surplus countries(core) unaffected. In a low-interest environment, governments with deficits are able to maintain the living standards and social welfare of their citizens by borrowing more, leading to accumulation of debts. If the production increase, reflected in the GDP, does not follow up with the debt growth, the result will be a higher debt-to-GDP ratio. This ratio in the Eurozone has increased from the pre-crisis 65% to about 87% in 2017 (Figure 9).

The risks involved are likely to be blurred by lenient credit. However, when interest rate rises, high debt levels will make businesses and households more vulnerable to unexpected saltation in the financial market, accelerating capital flight in the peripheral countries and undermining the debt sustainability.

Speculations started to spread when the 10-year Treasury yield hit the “psychologically important” 3% level (Amaro, 2018) in April 2018. Soon after, the interest rate in the US rose and hit 2.25% at the end of 20018. As a result, investors began to expect an interest rate hike of central banks worldwide. The ECB also announced that the interest rates would gradually increase starting from 2019, leading to the potential rise of borrowing costs, which might discourage multinational corporations from investing in assets overseas (Domm, 2018). Based upon the current debt level (See Appendix H: Global Debt Level of the Fourth Quarter of 2017) at a record $237 trillion which is approximately 317.8% of the global aggregate GDP, the financial stability is likely to be threatened if these investments are withdrawn depending on how fast the interest rate is going to grow (Budimir, 2017). Particularly in the emerging economies where the debts have expanded in an unprecedented rate, there is a substantial likelihood of defaults in scale, leading to another outbreak of debt crisis (Trade and Development Board, 2018).

7.2.5 Convergence of Balance of Payments

Finally, liquidity injection urges the short-term convergence of the balance of payments between account surplus and deficit countries in the short-term. The economic significance in the first periods is weak but tends to grow over time. The surplus countries' balance sheets witness a decline in savings in the first period. In the meantime, an adverse effect is observed in deficit countries whose deficits have shrunk. Nevertheless, in the second period, the gap between the account surplus and deficit countries is again enlarged as the former's surplus rises before hitting back the zero line, and the latter's short-term positive outlook of account balance wears off. This means that the liquidity injection has been conducive to the short term unequal distribution of wealth in Europe, but it is unable to prevent current account deficit countries from long-term deficit pressure.

The national fiscal policy and unified monetary policy between peripheral countries and core countries appear to be incompatible. The Eurozone cannot meet the different monetary policy preferences of its member states while the peripheral countries are unable to reduce deficits against the core and increase competitiveness through currency depreciation.

The divergence between the periphery and the core is manifested through the accumulation of deficits by peripheral countries. The liquidity injection, executed by refinancing operations and purchasing assets, aims to increase the money supply and depreciates the currency. Depreciation will promote exports and curb imports, which generate higher income and expenditure.

The special characteristic of the QE in Europe is that the ECB, which is financed by the core countries (ECB, 2019), engages in purchasing a large amount of sovereign bonds from member states in a quagmire, thereby lowering bond yields and alleviating the government's default risks (Appendix I: European Governments' Bond Yields). Although the QE does not directly purchase corporate bonds, a large amount of funds are squeezed out to the corporate bond market as a direct outcome of lowering the government bond yields.

The alleviation of default risks allows the governments of the peripheral countries undergoing austerity measures to access financing from countries with surpluses and collect more taxation from corporates. Hence, the deficits are shrunk in the short-term. In the long-run, the QE programmes are less likely to conceal the institutional shortcoming of the EMU and mute existing structral poblems. Effective fiscal policy requires a compatible monetary policy. Under a system with uniformity of monetary policy and dscretionary fiscal policies, national monetary objectives do not always coincide with the ECB's chief objective in price stabilty. Hence, this conflict gradually leads to accerbation of fiscal conditions in peripheral countries.

7.2.6 Interpretation Outcomes

This sub-section has attempted to interpret the causal relationships identified in the empirical analysis. The ECB's interest adjustment has contributed to realisation of its chief target – price stability, but this target appears to be ambiguous and outdated. The rising debt levels in current account deficit countries and short-term convergence of balance of apyments are related to the issues of constitutional design of the EMU that a monetary union is established without the consolidation of fiscal policies. Moreover, the rise of unemployment rate and weakened industrial output indicate the structural problem in Europe. These insights help to formulate policy recommendations in the later chapter.

8 Conclusion, Limitations and Policy Recommendations

Chapter 8 consists of three sections: conclusions, limitations and policy recommendations. First, the conclusion provides the reader with an overview of the main discussion and critical findings from empirical research. It also looks back at the hypotheses mentioned in Chapter 3 and justifies whether these hypotheses are accepted. Subsequently, the second section presents the potential shortcomings of this paper and room for future research. In the end, policy recommendations are devised based on *7.2 Interpretation of the Results and Discussion*.

8.1 Conclusion

The Negative Interest Rate Policy (NIRP) is a highly controversial policy instrument in both theory and practice. Its implementation has overcome the zero lower bound (ZLB), and a new effective lower bound remains to be explored. From a theoretical perspective, the NIRP decrease costs of borrowing for corporate and household, thereby stimulating consumption and investment. In practice, the unintended drawbacks of this policy tend to outweigh its advantages. This is particularly noticeable for current account deficit countries in Europe.

This paper attempts to critically examine the effectiveness of the European Central Bank's interest rate adjustment in promoting macroeconomic recovery in Europe, further observing variation in effectiveness in current account surplus (core) and deficit (periphery) countries. The empirical analysis employs a Panel Vector Autoregressive Model (PVAR), taking into account annual data of 13 EMU member states and Switzerland from 2005 to 2017. The effectiveness of the ultra-low and negative interest rates is measured by five indicators, which represent the 5 macroeconomic objectives discussed in the literature review: price stability, full employment, economic growth, balance of payments and financial stability.

The PVAR model in this paper also controls for the quantitative easing programmes that were carried out alongside the downward adjustment of interest rates by measuring the amount of asset expansion on the ECB's consolidated balance sheet. In addition, the model also considers the interaction effect by dividing the sample countries into current account surplus (core) and current account deficit countries (periphery). With respect to the empirical results, the PVAR analysis yields a significant effect of ECB's interest rate adjustment on rising inflation. This indicates that the ultra-low interest rates and negative rates have contributed to the realisation of ECB's overriding monetary objective – inflation targeting at below 2%. Nevertheless, this has come at the cost of exacerbation of the indebtedness in the peripheral countries. Under such a low-interest rate environment, the industrial output of both country groups has slightly increased, indicating that there are evidence corporates and the industries were incentivised to borrow more.

In contrast, the analysis reveals a more significant and negative effect of liquidity injection on industrial output. This indicates that excessive liquidity has not flown to the real economy. The unemployment rate rose, driven by excessive liquidity. Structural unemployment remains a substantial issue. Additionally, regarding the account balance, evidence brings to the light short-term signs of converging of the balance of payments between the core and peripheral countries.

Four years into the experiment, it is still in an inchoate phase to proclaim that the NIRP has been a success and contributed to the macroeconomic recovery in Europe, even though the ECB has repetitively emphasised that the policy has achieved the price stability objective. Therefore, the first hypothesis is rejected that the ECB has not fulfilled its role in maintaining price stability, despite slow progress. The second hypothesis is accepted as slashing interest rates has not resulted in an overall economic recovery in sample countries. However, it is worth mentioning that perverse effects of the ultra-low interest rates are not as significant as the perverse effects of liquidity injection. Furthermore, the empirical results justify the third hypothesis that the NIRP has a more significant impact on the current account deficit countries (core) than the current account surplus countries (periphery). These effects are both positive and negative.

Tracing back to Chapter 1, the question of whether the zero lower bound (ZLB) can be breached is raised. Based on the interpretation of the empirical results, this thesis agrees with the rationale of classic economics theory that the ZLB should not be breached, in the case of the ECB.

Lastly, the empirical analysis also affirms the importance of the inclusion of liquidity injection as a measurement tool for ECB's quantitative easing programmes. The results reveal that quantitative easing programmes have more significant but adverse effects than interest rate cuts in the sampled countries

8.2 Limitations and Room for Future Research

Having concluded the findings of this thesis, reminding the major limitations of this paper is relevant. First of all, the study cannot be extrapolated to any other countries that have adopted the NIRP such as Japan as the circumstances are distinct in Europe due to the unique institutional design of the EMU. Second, it is hard to ascertain the transmission time of interest rate to variations in any of the dependent variables. The empirical analysis employs one lag for all dependent variables. In reality, however, the transmission time for different variables is different.

Subject to the short implementation time of the ultra-low interest rates and data inconsistency, smaller economies such as Iceland or countries in the Central and Eastern Europe (CEE) were not included in the dataset, despite being members of the EMU. There is possibility that the addition of data from these economies could affect the PVAR results obtained. Also, in order to ensure the stationarity of the data,

the first differences have been taken for the variables with unit roots; it has resulted in a number of missing values. Given the small dataset, this could lead to a validity issue.

Another limitation is that this research does not distinguish between the periods when the interest rates were above zero, at the zero line and negative, but rather as an overall downward adjustment process. The interest rates in different ranges could bring about altered results. For example, the interest rate at 0,0% could have disparate effects on the macroeconomic indicators than the interest rate at -0,4%.

Following the last limitation, future research can focus on whether different ranges of interest rates lead to different effects on economic variables. Furthermore, it would be interesting to focus the analysis on the transmission mechanisms of monetary policies. This thesis only explores the policy impact on the ultimate economic performance but does not consider how the policy has been passed onto the macroeconomic indicators.

8.3 Policy Recommendations

Having concluded the empirical analysis and discussed the limitations, this section rounds off this thesis with policy recommendations. Based on what has been discussed in *7.2 Interpretation of the Results and Discussion*, the recommendations are directed towards monetary authorities, policymakers, and academics.

8.3.1 Reorientation of Monetary Objectives

Policymakers at the ECB are advised to reconsider the approximate 2% monetary objective in the medium-term as the overriding monetary objective. Although this target ensures that the EMU casts off the deflation spiral, it is difficult to guarantee a consistent range of inflation rates amongst the member states due to the Balassa-Samuelson effects[10]. In principle, the relevance of the medium-term inflation targeting in an era with technical innovations and globalisation is questionable. The price level is depressed by globalisation and lower production costs, catalysing asset bubbles. The ECB needs to restrict the co-occurrence of low inflation and asset bubbles and conduct a mix of long-term monetary policies that allow for fluctuations within the economic cycles.

Additionally, the credibility and legitimacy of the Frankfurt-based monetary authority do not solely rest upon the narrowly defined inflation targeting rate. The objective of the ECB's policy mix should aim at facilitating the economic recovery in a comprehensive sense.

[10] Balassa-Samuelson effects: optimal inflation level for the developed economies are lower than the less developed/developing economies.

8.3.2 Exit from the NIRP and Reduction of Operating Costs

In a low interest rate environment, it is difficult to monitor the flow of liquidity released by the QE programmes; it is unlikely that it will flow into the industrial sector. Instead it flows towards sectors with a higher return on investment, such as the real estate industry. The univocal approach to redirect the liquidity to the productive sectors in need of financing is to raise the interest rate but reduce the tax burden and operating costs for the companies. In other words, the expected return on investment for the industrial sector needs to be higher than the expected return on investment of the financial assets.

A higher interest rate can effectively suppress the escalation of asset prices, but at the same time, it results in higher costs of borrowing for the companies (Kent & Lowe, 1997). Hence, it is essential to reduce costs for the companies in the industrial sector. This can be achieved through subsidies and a reduction of taxation for the industrial sector, even more so for the ones operating in the manufacturing sector. The exit from the NIRP needs to be carefully monitored and accompanied by a reduction of the costs. The process can be measured by the growth of corporate taxation revenue on the national governments' balance sheets, which needs to be lower than the national GDP growth. In other words, if the growth of corporate taxation is higher than the GDP growth of a particular country, it is unlikely that the liquidity released by the QE programmes will flow into the productive sector.

8.3.3 Need for Structural Reform

On an ending note, both quantitative easing and interest rate cuts are aimed at solving issues of low inflation and sluggish economic performances. The NIRP, as an extension of the low-interest rate policy, is not the exclusive solution to all structural problems in the economy, and in the case of the ECB, long-term reliance on ultra-low interest rates have produced undesirable side effects. Policymakers should place greater emphasis on the institutional and structural deficiencies of the European integration process, as the lack of a unified fiscal alliance led to current account imbalances. Peripheral countries such as Greece, were able to access inexpensive financing at the cost of debt accumulation, while the productivity remained low and welfare retrenchment was not conducted due to public pressure. Loose monetary policy mutes the current issues and wins time for structural reforms, but the policymakers tend to overlook the necessity and urgency of these reforms.

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Appendix

Appendix A

Annual Consolidated Balance Sheet of the Euro system in 2016 and 2017

Link back to Section 4.2.3 – Asset Purchase Programme (APP)

Annual consolidated balance sheet of the Eurosystem

(in EUR millions)

Assets	**Balance as at 31 December 2016**	**Balance as at 31 December 2017**
1 Gold and gold receivables	**382.061**	**376.300**
2 Claims on non-euro area residents denominated in foreign currency	**327.859**	**296.201**
2.1 Receivables from the IMF	78.752	70.214
2.2 Balances with banks and security investments, external loans and other external assets	249.107	225.987
3 Claims on euro area residents denominated in foreign currency	**30.719**	**38.079**
4 Claims on non-euro area residents denominated in euro	**19.082**	**19.364**
4.1 Balances with banks, security investments and loans	19.082	19.364
4.2 Claims arising from the credit facility under ERM II	0	0
5 Lending to euro area credit institutions related to monetary policy operations denominated in euro	**595.873**	**764.310**
5.1 Main refinancing operations	**39.131**	**3.372**
5.2 Longer-term refinancing operations	**556.570**	**760.639**
5.3 Fine-tuning reverse operations	0	0
5.4 Structural reverse operations	0	0
5.5 Marginal lending facility	172	299
5.6 Credits related to margin calls	0	0
6 Other claims on euro area credit institutions denominated in euro	**69.134**	**37.563**
7 Securities of euro area residents denominated in euro	**1.974.866**	**2.660.726**
7.1 Securities held for monetary policy purposes	**1.653.995**	**2.386.012**
7.2 Other securities	320.870	274.714
8 General government debt denominated in euro	**26.460**	**25.015**
9 Other assets	**235.368**	**250.052**
Total assets	**3.661.423**	**4.467.611**
Liabilities		
1 Banknotes in circulation	**1.126.215**	**1.170.716**
2 Liabilities to euro area credit institutions related to monetary policy operations denominated in euro	**1.313.264**	**1.881.596**
2.1 Current accounts (covering the minimum reserve system)	888.988	1.185.792
2.2 Deposit facility	424.208	695.801
2.3 Fixed-term deposits	0	0
2.4 Fine-tuning reverse operations	0	0
2.5 Deposits related to margin calls	69	2
3 Other liabilities to euro area credit institutions denominated in euro	**9.427**	**20.984**
4 Debt certificates issued	**0**	**0**
5 Liabilities to other euro area residents denominated in euro	**220.760**	**286.371**
5.1 General government	114.887	168.457
5.2 Other liabilities	105.873	117.913
6 Liabilities to non-euro area residents denominated in euro	**205.678**	**355.900**
7 Liabilities to euro area residents denominated in foreign currency	**3.644**	**3.831**
8 Liabilities to non-euro area residents denominated in foreign currency	**9.301**	**11.254**
8.1 Deposits, balances and other liabilities	9.301	11.254
8.2 Liabilities arising from the credit facility under ERM II	0	0
9 Counterpart of special drawing rights allocated by the IMF	**59.263**	**55.218**
10 Other liabilities	**218.927**	**221.212**
11 Revaluation accounts	**394.357**	**357.862**
12 Capital and reserves	**100.587**	**102.667**
Total liabilities	**3.661.423**	**4.467.611**

Appendix B

Contribution of the National Central Banks to the Capital of the ECB

Link back to Section 4.2.3 – Asset Purchase Programme (APP)

National Central Banks	Capital key %	Paid-up capital (€)
Nationale Bank van België/Banque Nationale de Belgique (Belgium)	25.280	273,656,178.72
Deutsche Bundesbank (Germany)	183.670	1,988,229,048.48
Eesti Pank (Estonia)	0.1968	21,303,613.91
Central Bank of Ireland (Ireland)	11.754	127,237,133.10
Bank of Greece (Greece)	17.292	187,186,022.25
Banco de España (Spain)	83.391	902,708,164.54
Banque de France (France)	142.061	1,537,811,329.32
Banca d'Italia (Italy)	118.023	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)	40.677	440,328,812.57
Oesterreichische Nationalbank (Austria)	20.325	220,018,268.69
Banco de Portugal (Portugal)	16.367	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)	12.708	137,564,189.84
Total	**696.176**	**7,536,110,121.69**

(ECB, 2019)

Appendix C

Forecast-Error Variance Decomposition – All Variables

Link back to Section 6.8 Forecast-Error Variance Decomposition

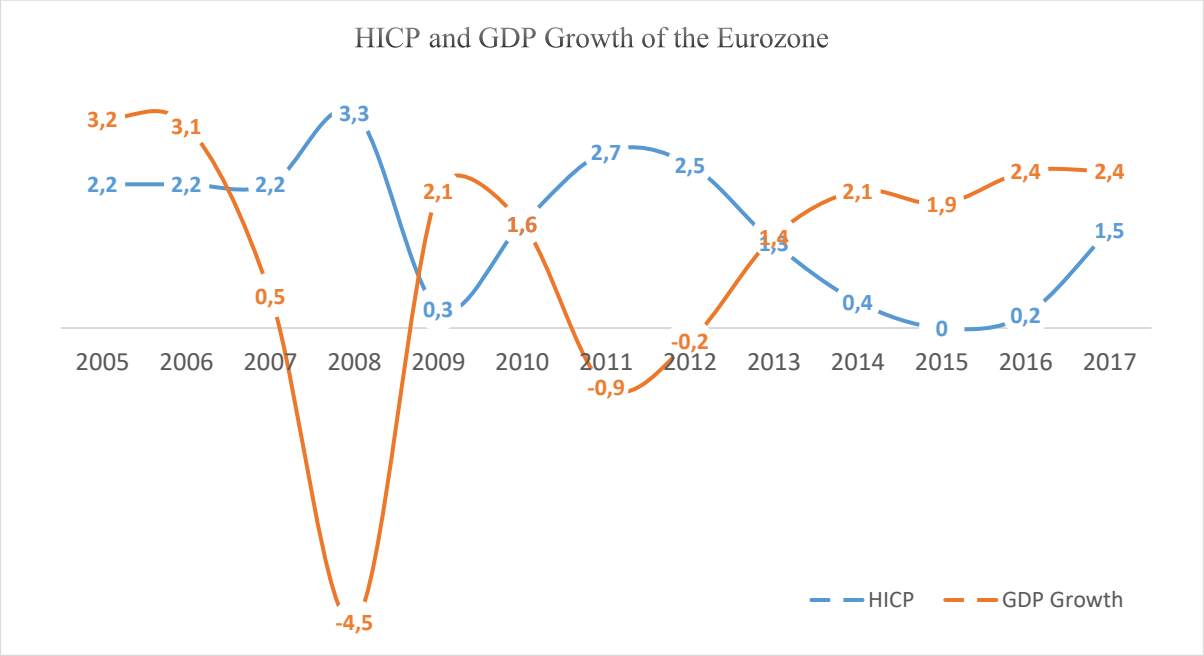
Response\Impulse Variable	**Periods**	**Interest Rate**	**Liquidity Injection**	**HICP**	**Unemployment Rate**	**Industrial Output**	**Balance of Payments**	**Debt-to-GDP Ratio**
HICP	1	0,69	0,02	0,29	0,00	0,00	0,00	0,00
HICP	2	0,62	0,02	0,34	0,00	0,01	0,00	0,01
HICP	3	0,59	0,02	0,36	0,01	0,01	0,00	0,01
HICP	4	0,57	0,02	0,38	0,01	0,01	0,00	0,01
HICP	5	0,55	0,02	0,39	0,01	0,01	0,00	0,01
HICP	6	0,54	0,02	0,40	0,01	0,01	0,00	0,01
HICP	7	0,53	0,02	0,42	0,01	0,01	0,00	0,01
HICP	8	0,52	0,02	0,42	0,01	0,01	0,00	0,01
HICP	9	0,51	0,02	0,43	0,01	0,01	0,00	0,01
HICP	10	0,50	0,02	0,44	0,01	0,01	0,00	0,01
Unemployment Rate	1	0,02	0,05	0,24	0,69	0,00	0,00	0,00
Unemployment Rate	2	0,17	0,21	0,12	0,46	0,04	0,00	0,01
Unemployment Rate	3	0,18	0,29	0,12	0,36	0,03	0,00	0,03
Unemployment Rate	4	0,16	0,29	0,15	0,32	0,03	0,00	0,04
Unemployment Rate	5	0,15	0,29	0,19	0,31	0,03	0,00	0,04
Unemployment Rate	6	0,14	0,28	0,22	0,30	0,03	0,00	0,04
Unemployment Rate	7	0,13	0,27	0,25	0,29	0,03	0,00	0,03
Unemployment Rate	8	0,13	0,26	0,27	0,28	0,03	0,00	0,03
Unemployment Rate	9	0,12	0,25	0,29	0,27	0,03	0,00	0,03
Unemployment Rate	10	0,12	0,25	0,31	0,26	0,03	0,00	0,04
Industrial Output	1	0,00	0,00	0,33	0,06	0,60	0,00	0,00
Industrial Output	2	0,06	0,12	0,24	0,06	0,48	0,00	0,04
Industrial Output	3	0,05	0,16	0,26	0,05	0,41	0,00	0,06
Industrial Output	4	0,05	0,16	0,29	0,06	0,38	0,00	0,06
Industrial Output	5	0,05	0,15	0,31	0,06	0,37	0,00	0,06
Industrial Output	6	0,05	0,15	0,33	0,06	0,35	0,00	0,06
Industrial Output	7	0,05	0,15	0,35	0,06	0,34	0,00	0,06
Industrial Output	8	0,05	0,14	0,36	0,06	0,34	0,00	0,06
Industrial Output	9	0,05	0,14	0,37	0,05	0,33	0,00	0,06

Industrial Output	10	0,04	0,14	0,38	0,05	0,33	0,00	0,06
Balance of Payments	1	0,01	0,00	0,07	0,07	0,07	0,79	0,00
Balance of Payments	2	0,04	0,05	0,08	0,06	0,09	0,67	0,02
Balance of Payments	3	0,04	0,06	0,07	0,06	0,09	0,65	0,03
Balance of Payments	4	0,04	0,07	0,07	0,06	0,08	0,64	0,03
Balance of Payments	5	0,04	0,07	0,07	0,07	0,08	0,63	0,03
Balance of Payments	6	0,04	0,08	0,07	0,07	0,08	0,63	0,03
Balance of Payments	7	0,04	0,08	0,08	0,07	0,08	0,63	0,03
Balance of Payments	8	0,04	0,08	0,08	0,07	0,08	0,63	0,03
Balance of Payments	9	0,04	0,08	0,08	0,07	0,08	0,62	0,03
Balance of Payments	10	0,04	0,08	0,08	0,07	0,08	0,62	0,03
Debt-to-GDP Ratio	1	0,02	0,00	0,08	0,02	0,17	0,03	0,68
Debt-to-GDP Ratio	2	0,02	0,05	0,06	0,06	0,15	0,04	0,62
Debt-to-GDP Ratio	3	0,02	0,11	0,08	0,07	0,13	0,04	0,55
Debt-to-GDP Ratio	4	0,02	0,13	0,13	0,08	0,12	0,03	0,50
Debt-to-GDP Ratio	5	0,02	0,13	0,18	0,08	0,11	0,03	0,46
Debt-to-GDP Ratio	6	0,02	0,13	0,22	0,08	0,10	0,03	0,43
Debt-to-GDP Ratio	7	0,02	0,12	0,26	0,08	0,10	0,03	0,40
Debt-to-GDP Ratio	8	0,01	0,12	0,29	0,07	0,09	0,03	0,39
Debt-to-GDP Ratio	9	0,01	0,11	0,31	0,07	0,09	0,03	0,38
Debt-to-GDP Ratio	10	0,01	0,11	0,32	0,07	0,09	0,02	0,37

Appendix D

HICP and GDP Growth of the Eurozone

Link back to Section 7.2.1 Interest Rate Adjustment on Inflation Rate: Is forward guidance still relevant?

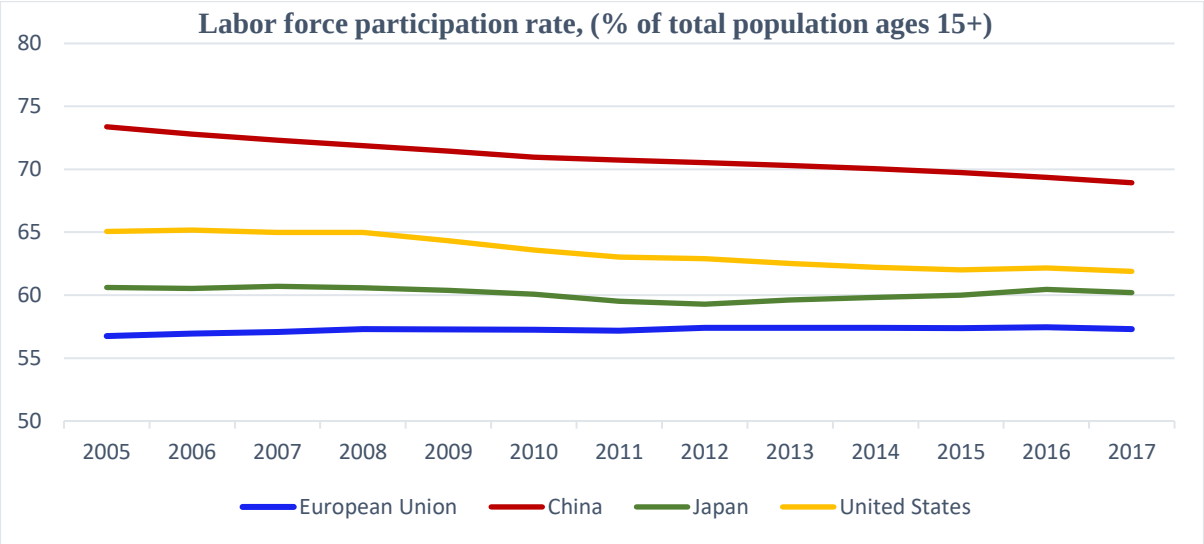


Source: Eurostat

Appendix E

Labour Force Participation Rate of Major World Economies

Link back to Section 7.2.2 Unemployment Rate triggered by Liquidity

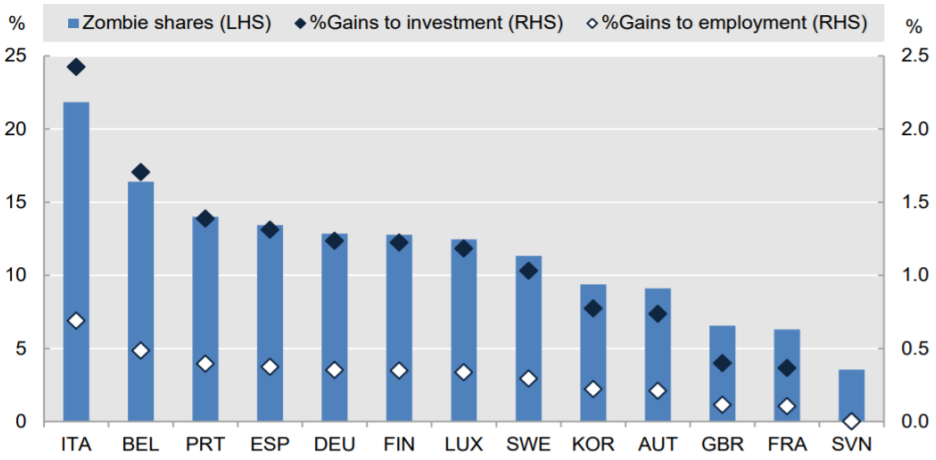


Source: The World Bank Database

Appendix F

Proportion of Zombie Companies to Non-Zombie Companies in the OECD Member States

Link back to Section 7.2.3 Weakening Industrial Output



Note: This figure shows the counterfactual gains to investment and employment of a typical non-zombie firm from reducing the share of zombies to the sample minimum level (i.e. Slovenia in 2013). Zombie shares refer to the share of capital sunk in zombie firms, defined as firms aged ≥10 years and with an interest coverage ratio<1 over three consecutive years.

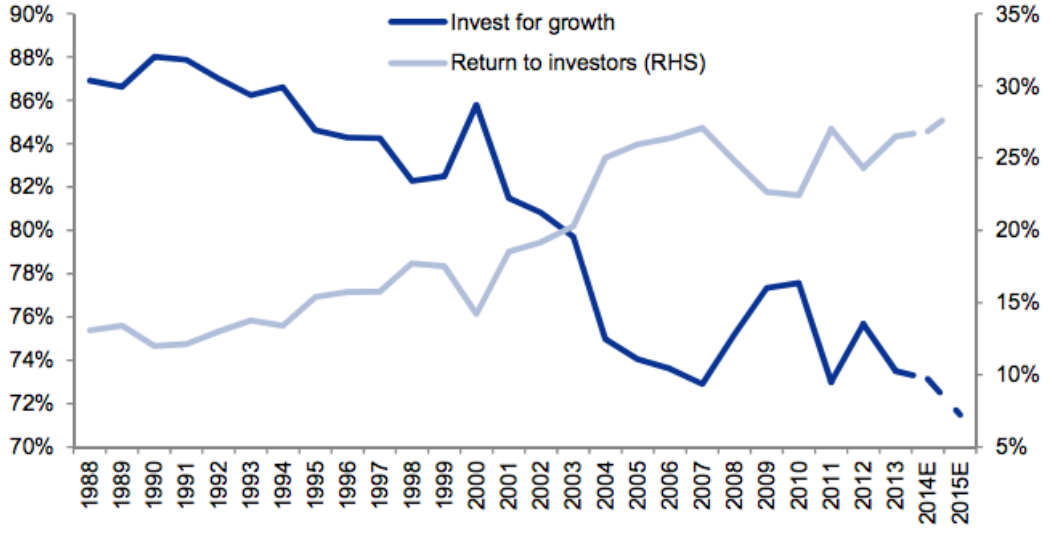
Source: OECD calculations based on ORBIS.

Appendix G

Proportion of Cash Spent by STOXX Europe 600 non-financials for Invest for Growth and Return to Investors

Link back to Section 7.2.3 Weakening Industrial Output

Exhibit 9: Companies are spending less on investment, returning more cash to shareholders
Proportion of cash spent by STOXX Europe 600 non-financials

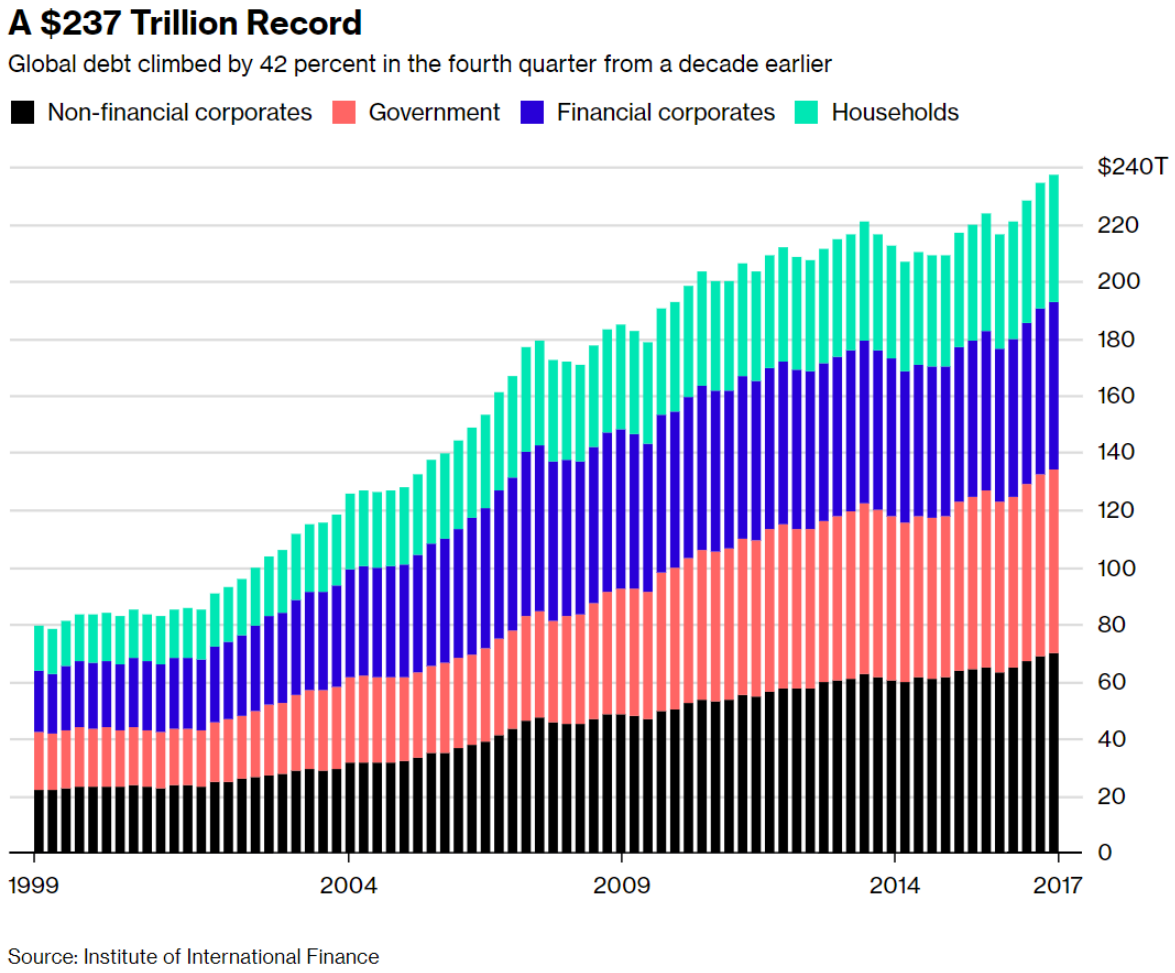


Source: Factset, Worldscope, Goldman Sachs Global Investment Research.

Appendix H

Global Debt Level of the Fourth Quarter of 2017

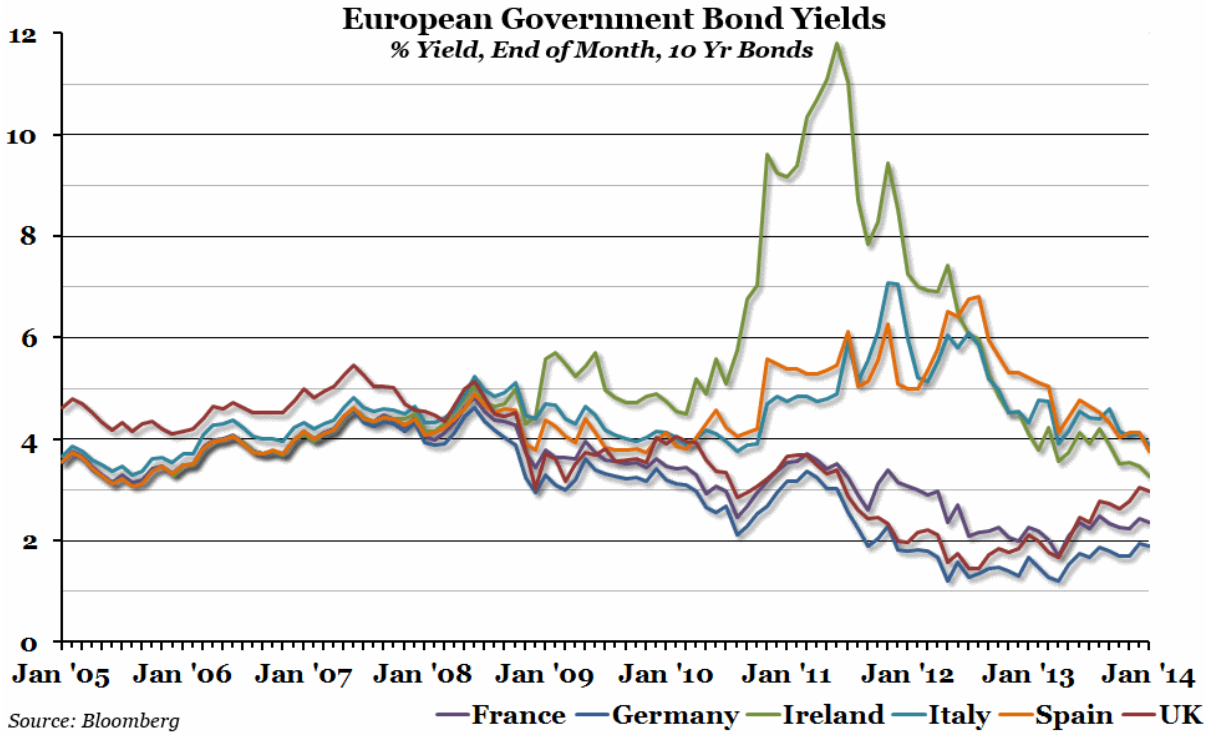
Link back to Section 7.2.4 Global Debt Level of the fourth quarter of 2017



Appendix I

European Government Bond Yields

Link back to Section 7.4.5 Convergence of Balance of Payments



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