Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Economics

Master's Thesis

External shocks and central banks' policy

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

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Economics and Management

Thesis title

External shocks and central banks' policy

Objectives of thesis

The purpose of the thesis is to determine how central banks respond to external shocks and to evaluate the efficiency of their policies.

The sub-objectives of the study are to determine which central banks' tools are the most important and efficient on the period studied ; and to find out if central banks are facing limits that prevent them from reacting effectively to shocks.

Methodology

The practical part of the research uses multiple-criteria decision analysis to compare the effects and the importance of different monetary policies.

The data come from the European Central Bank and the Norges bank publications, released between 2000 and 2021.

The proposed extent of the thesis

60 – 80

Keywords

External shocks, monetary policies, central banks, crises, interest rates

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Recommended information sources

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Expected date of thesis defence

2021/22 SS – FEM

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Electronic approval: 4. 3. 2022

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Prague on 10. 03. 2022

Declaration

I declare that I have worked on my master's thesis titled *External shocks and central banks' policy* by myself and I have used only the sources mentioned at the end of the thesis. As the author of the master's thesis, I declare that the thesis does not break any copyrights.

In Prague on March 31st, 2022 _____

Acknowledgement

I would like to thank Professor Karel Malec for his time, his help, and his valuable advice during my work on this thesis.

External shocks and central banks' policy

Abstract

This research focuses on the central bank's response to external shocks. The purpose of it is to determine which of the monetary policy tools studied is the more effective. It was chosen to study the European Central Bank and the Norges Bank over two periods during which they reacted to major external shocks, the subprime mortgage crisis and the COVID-19 pandemic. Three different types of monetary policy tools that they used in response to these shocks were identified : key interest rates, asset purchase programs and funding for lending program. The effectiveness of these instruments was estimated on the four macroeconomic indicators of the magic square of Kaldor, that is on the inflation, the GDP, the unemployment, and the current account, thanks to a VAR-X model. Then, a Multicriteria Decision Analysis (MCDA) was used to get a ranking of the instruments based on the previous macroeconomic criteria and on criteria related to the implementation of the instruments by central banks. As a result, the policy interest rate is the best instrument available to central banks in response to a shock. Asset purchase programmes are the second effective instrument, ahead of funding for lending programmes. This top ranking for the reduction of the key interest rate is due to its effectiveness regarding macroeconomic criteria. The difficulty of implementing it in zero lower bound situation mitigates this position and highlights the importance for central banks to increase key interest rates during expansion periods to be able to react to a futur external shock.

Keywords: Monetary policy, central bank, external shock, supply shock, demand shock, crises, key interest rate, unemployment, inflation, Gross Domestic Product, current account.

Vnější šoky a politika centrálních bank

Abstrakt

Táto práce se zaměřuje na reakci centrálních bank na vnější šoky. Jeho účelem je určit, který ze zkoumaných nástrojů měnové politiky je nejúčinnější. Rozhodli jsme se prostudovat Evropskou centrální banku a Norskou banku ve dvou obdobích, během nichž reagovaly na velké vnější šoky, krizi rizikových hypoték a pandemii COVID-19. Identifikovali jsme tři různé typy nástrojů měnové politiky, které použily v reakci na tyto šoky: klíčové úrokové sazby, programy nákupu aktiv a financování programu půjček. Efektivita těchto nástrojů byla odhadnuta na čtyřech makroekonomických ukazatelích Kaldorova magického čtverce, tedy na inflaci, HDP, nezaměstnanosti a běžném účtu, díky modelu VAR-X. Poté jsme pomocí Multicriteria Decision Analysis (MCDA) získali pořadí nástrojů na základě předchozích makroekonomických kritérií a kritérií souvisejících s implementací nástrojů centrálními bankami. V důsledku toho je základní úroková sazba nejlepším nástrojem, který mají centrální banky k dispozici v reakci na šok. Programy nákupu aktiv jsou druhým účinným nástrojem před financováním úvěrových programů. Toto nejvyšší umístění ve snižování základní úrokové sazby je dáno její efektivitou vůči makroekonomickým kritériím. Obtížnost jeho implementace v situaci nulové dolní meze tuto pozici zmírňuje a zdůrazňuje, že je důležité, aby centrální banky zvýšily klíčové úrokové sazby během období expanze, aby byly schopny reagovat na vnější šok.

Klíčová slova: měnová politika, centrální banka, vnější šok, nabídkový šok, poptávkový šok, krize, klíčová úroková sazba, nezaměstnanost, inflace, hrubý domácí produkt, běžný účet.

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1. Introduction

The subprime mortgage crisis and more recently the COVID-19 pandemic have shown that external shocks can cause deep recessions. In such moments of crisis, it is the role of central banks to use monetary policy to stabilize the economy. This key role of monetary policy in times of crisis made interesting to study its effectiveness. In particular, to compare the effect of different monetary policy tools used by central banks in response to shocks during the 21st century on macroeconomic indicators. The impact of the different monetary policy instruments on macroeconomic indicators, such as those established by Kaldor with the magic square, has been little studied.

The ambition of the study is twofold as it is planned to take into account the implementation processes of monetary policy tools in the analysis. The aim is to find out if central banks are facing new limits that prevent them from reacting effectively to shocks with the appropriate tool.

The structure of this thesis is as follows:

In the first part, the objectives and the methodology to achieve them will be presented. The vector autoregression model that was used and the multicriteria decision analysis that allowed us to reach the conclusions will be introduced.

Then, the existing literature on the topics of monetary policy and external shocks will be studied.

In the third part, the practical aspect of the study will be presented, the models will be developed in order to get the results.

In the fourth part, the results will be presented and discussed in the light of other studies related to this one.

Finally, the conclusion will give a complete overview of the work.

2. Objectives and Methodology

2.1 Objectives

The purpose of the research is to evaluate the efficiency of central banks monetary policy tools in response to external shocks and to determine which central banks' tools are the most important and effective. The sub-objective of the study is to find out if central banks are facing limits that prevent them from reacting effectively to shocks with the appropriate tool.

2.2 Methodology

2.2.1 Population and periods

The study focuses on European Union and Norway over two periods. The period 1 corresponds to the subprime mortgage crisis, the selected start of which is 2007 quarter 4, when the shock started to be felt in Europe and the central banks set up their first policies in response to it. The selected end of it is 2010 quarter 2 because it is considered that from this date the European Central Bank responds to the sovereign debt crisis (Fontan, 2014). The period 2 is the COVID-19 pandemic, with a start date in 2019 quarter 4, when the COVID-19 appeared. This corresponds to a date slightly anterior to the reaction of central banks. This choice was made to ensure consistent results with the VAR-X model which requires a minimum number of observations.

It was chosen to study European Union and Norway because their central banks, respectively the European Central Bank and the Norges Bank, opt for different monetary policy instruments which allowed us to study a sufficient number of them for comparison.

The selected periods are the subprime mortgage crisis and the COVID-19 pandemic because they are the two most important external shocks to which these central banks had to respond in the 21st century. Moreover, these two periods are spaced out in time and therefore the monetary policies implemented are not necessarily the same, as is the macroeconomic environment. The shock of the COVID-19 pandemic allows us to have a current vision of monetary policy, put in perspective by what it was twelve years earlier.

2.2.2 Data

All the data are in quarters. Data of macroeconomic indicators were collected from 2000 to 2021 for eurozone and from 2003 to 2021 for Norway. Quarterly inflation data were not available before 2003 on the Norwegian statistical institute website. Macroeconomic data have been collected over a long period of time because the Vector autoregression analysis requires a significant number of observations. Data of monetary policy were taken only during the two "response to shock" periods detailed earlier.

The data on the eurozone and the monetary policies set up by the European Central Bank have all been collected via the ECB website and its database. The data about Norges Bank's measures come from its own website. Finally, the data about Norway's macroeconomic indicators come from its national statistical institute, called Statistisk sentralbyrå or Statistics Norway and is abbreviated as SSB.

The macroeconomic data on which it is planned to analyse the effects of monetary policy are those of Kaldor's magic square, i.e. unemployment, inflation, the growth domestic product (GDP) and the current account.

To study monetary policy, some of the quantifiable tools used by central banks in response to shocks have been selected.

There is one instrument of conventional monetary policy:

- Key interest rates : used by Norges Bank in both periods and by the ECB in response to the shock of the subprime crisis. The key interest rate of the European Central Bank taken into consideration is the marginal lending facility; that of Norges Bank is called interest rate on banks' overnight deposits.

And two unconventional monetary policy tools:

- Asset Purchase programmes : used by ECB in both periods. In response to the subprimes crisis, the central bank set up a Covered Bond Purchase Programme (CBPP) and to the COVID-19 shock a Pandemic Emergency Purchase Programme (PEPP).

- Funding for lending programmes: used by ECB during the period 2, under the name of Long Term Refinancing Operations III (LTROIII).

The ECB's key interest rate is studied only in response to the subprime crisis because, although this rate still exists in the second period, it has remained unchanged. Similarly, only the key interest rate is analysed for Norges Bank's monetary policy because this is the instrument it has prioritised. In addition, Norges Bank limits its use of tools like asset purchases. The Norvegian central bank still uses unconventional monetary policy tools but these are more difficult or impossible to quantify, such as forward guidance. Indeed, it considers that it is not a suitable tool in the case of its economy.

For the purpose of clarity, it was decided to use only the generic names of the monetary policy tools when presenting the data and results. Thus, for the rest of the thesis there are :

- NB key interest rate period 1, designating the interest rate on banks' overnight deposits of Norges Bank during the subprime mortgage crisis.
- NB key interest rate period 2, designating the interest rate on banks' overnight deposits of Norges Bank during the COVID-19 pandemic.
- ECB key interest rate period 1, designating the marginal lending facility that the European Central Bank manipulated during the subprime mortgage crisis.
- ECB asset purchase period 1, designating the CBPP set up by the European Central Bank during the subprime mortgage crisis.
- ECB asset purchase period 2, designating the PEPP set up by the European Central Bank during the COVID-19 pandemic.
- ECB funding for lending period 2, designating the LTROIII set up by the European Central Bank during the COVID-19 pandemic.

The tables containing the data information can be found in the appendix.

2.2.3 VAR-X model

To analyse the relationships between the data previously presented, and particularly the impact of decreasing the key interest rate, setting up asset purchase programmes and implementing funding for lending programmes on inflation, unemployment, GDP growth and the current account, a Vector Autoregression model was used. In this model, monetary

policy was treated as exogenous because they are only included in the response to shocks phases and not over the whole period when macroeconomic data were collected.

The Vector Autoregressive model (VAR) is a statistical model developed by Christopher Sims in the 1980s. It is used to capture the interdependencies between several time series. A VAR model with exogenous variables is called VAR-X.

A. Representation of the VAR-X model

The independent variables are :

- Key interest rate (%) : ***Kint***
- Asset purchase program (million EUR) : ***APP***
- Funding for lending program (million EUR) : ***FFL***

The dependent variables are:

- Consumer price index growth rate (%) : $\Delta \boldsymbol{Inf}$
- Gross domestic product growth rate (%) : $\Delta \boldsymbol{GDP}$
- Unemployment rate (%) : ***Unemp***
- Current account (million EUR) (million NOK) : ***CA***

And :

- a = constant
- ε = innovations

The number of lags chosen is 1 because of the small number of observations.

a. Matrix of the VAR-X model

$$\begin{pmatrix} \Delta inf_t \\ \Delta GDP_t \\ unemp_t \\ CA_t \end{pmatrix} =$$

$$\begin{pmatrix} a_{0,\Delta inf} \\ a_{0,\Delta GDP} \\ a_{0,unemp} \\ a_{0,CA} \end{pmatrix} + \begin{pmatrix} a^1_{\Delta inf,\Delta inf} & a^1_{\Delta inf,\Delta GDP} & a^1_{\Delta inf,unemp} & a^1_{\Delta inf,CA} \\ a^1_{GDP,\Delta inf} & a^1_{\Delta GDP,\Delta GDP} & a^1_{\Delta GDP,unemp} & a^1_{\Delta GDP,CA} \\ a^1_{unemp,\Delta inf} & a^1_{unemp,\Delta GDP} & a^1_{unemp,unemp} & a^1_{unemp,CA} \\ a^1_{CA,\Delta inf} & a^1_{CA,\Delta GDP} & a^1_{CA,unemp} & a^1_{CA,CA} \end{pmatrix} \begin{pmatrix} \Delta inf_{t-1} \\ \Delta GDP_{t-1} \\ unemp_{t-1} \\ CA_{t-1} \\ Mpol_{t-1} \end{pmatrix}$$

$$+ \begin{pmatrix} a^1_{\Delta inf,Kint} & a^1_{\Delta inf,APP} & a^1_{\Delta inf,FFL} \\ a^1_{\Delta GDP,Kint} & a^1_{\Delta GDP,APP} & a^1_{\Delta GDP,FFL} \\ a^1_{unemp,Kint} & a^1_{unemp,APP} & a^1_{unemp,FFL} \\ a^1_{CA,Kint} & a^1_{CA,APP} & a^1_{CA,FFL} \end{pmatrix} \begin{pmatrix} Kint_{t-1} \\ APP \\ FFL \end{pmatrix} + \begin{pmatrix} \varepsilon_{\Delta inf,t} \\ \varepsilon_{GDP,t} \\ \varepsilon_{unemp,t} \\ \varepsilon_{CA,t} \end{pmatrix}$$

b. Equations of the VAR-X model

The equations of the VAR-X are as follow :

Equation 1. $\Delta \boldsymbol{GDP_t} = a_{0,\Delta GDP} + a_{\Delta GDP,\Delta inf}\Delta inf_{t-1} + a_{\Delta GDP,\Delta GDP}\Delta GDP_{t-1} + a_{\Delta GDP,unemp}unemp_{t-1} + a_{\Delta GDP,CA}CA_{t-1} + a_{\Delta GDP,Kint}Kint_{t-1} + a_{\Delta GDP,APP}APP_{t-1} + a_{\Delta GDP,FFL}FFL_{t-1} + \varepsilon_{\Delta GDP,t}$

Equation 2. $\boldsymbol{unemp_t} = a_{0,unemp} + a_{unemp,inf}\Delta inf_{t-1} + a_{unemp,GDP}\Delta GDP_{t-1} + a_{Unemp,unemp}unemp_{t-1} + a_{unemp,CA}CA_{t-1} + a_{unemp,Kint}Kint_{t-1} + a_{unemp,APP}APP_{t-1} + a_{unemp,FFL}FFL_{t-1} + \varepsilon_{unemp,t}$

Equation 3. $\Delta \boldsymbol{inf_t} = a_{0,\Delta inf} + a_{\Delta inf,\Delta inf}\Delta inf_{t-1} + a_{\Delta inf,GDP}GDP_{t-1} + a_{\Delta inf,unemp}unemp_{t-1} + a_{\Delta inf,CA}CA_{t-1} + a_{\Delta inf,Kint}Kint_{t-1} + a_{\Delta inf,APP}APP_{t-1} + a_{\Delta inf,FFL}FFL_{t-1} + \varepsilon_{\Delta inf,t}$

Equation 4. $\boldsymbol{CA_t} = a_{0,CA} + a_{CA,\Delta inf}\Delta inf_{t-1} + a_{CA,\Delta GDP}GDP_{t-1} + a_{CA,unemp}unemp_{t-1} + a_{CA,CA}CA_{t-1} + a_{CA,Kint}Kint_{t-1} + a_{CA,APP}APP_{t-1} + a_{CA,FFL}FFL_{t-1} + \varepsilon_{CA,t}$

2.2.4 Development steps of VAR-X model

To estimate the model, the software gretl was used. Here are the steps to implement it.

A. Stationarity of time series

First, to estimate a VAR model, the time series must be stationary. Their stationarity was tested using the Dickey-Fuller augmented test.

The results for eurozone are :

- The time series of the GDP growth rate is stationary.
- The time serie of the inflation is not stationary. It becomes stationary in the first difference.
- The time serie of nemployment growth rates are not stationary. It becomes stationary in the first difference.
- The current account time series is not stationary. It is not stationary in the first difference either.

The results for Norway are :

- The time series of GDP growth rate stationary.
- The time serie of CPI growth rate is stationary.
- The time serie of unemployment is stationary.
- The current account time series is not stationary. It is not stationary in the first difference either.

To make the time series stationary, the differencing method was used. It was chosen that the two current account series would be left in first difference to avoid over-differencing.

B. Lag determination

The lag is the optimal shift of the model. In view of the small number of observations, especially for monetary policy, a lag of 1 was selected.

C. Validity of the model

For the model to be unbiased, certain conditions must be fulfilled. These conditions are related to the residuals. Indeed, the normality, absence of autocorrelation and homoscedasticity of the residuals must be ensured. To deal with the possibility of non-normality, heteroskedasticity and autocorrelation and ensure an unbiased model, the "heteroskedasticity-robust standard errors" was used.

2.2.5 Multicriteria Decision Analysis

Multi-criteria Decision Analysis (MCDA) enable a choice to be made between several solutions through the use of a multi-criteria analysis grid. Thus, as its name suggests, it is often used ex ante to make decisions. In the present case, the MCDA is applied in ex-post evaluation, which is consistent with the objective of judging monetary policy instruments according to different criteria, after they were used.

A. Options of the Multicriteria Decision Analysis

The identified options are the monetary policy instruments studied, i.e. key interest rate, asset purchases programmes and funding for lending programmes.

B. Criteria of the Multicriteria Decision Analysis

The criteria for arbitrating between these options are of two types : macroeconomic and related to the implementation of the instruments.

The macroeconomic criteria correspond to the impact on the endogenous variables of the VAR-X model, i.e. on the growth rate of GDP, the inflation, the unemployment rate and the current account.

Other criteria were added to decide between the monetary policy instruments. Indeed, it seemed important in this study to also base the analysis on a more technical aspect of the implementation of these tools by central banks. These criteria are the speed of implementation, the feasibility and the absence of negative consequences. The speed of implementation is to be taken into account when choosing the emergency monetary policy because even in the short term a shock has an impact on the economy, so it requires a fast response. Feasibility means that the instrument can be set up currently, it is an essential criterion because not all tools are possible to implement depending on the context. Finally,

some tools may have, in addition to their beneficial effect, a negative effect later on; this is something that must be kept in mind when judging monetary policy.

C. Order of importance and weight of the criteria

MCDA makes possible to give an order of importance to the criteria by giving them a weight. Here it has been established :

Table 1. MCDA : Order of importance of macroeconomic criteria.

	Order	Weight
Unemployment	1	50
Inflation	2	40
Economic growth	3	20
Current account	4	10

Source : author, 2022

The table 1 shows the macroeconomic criteria ranked in order of importance, respectively the unemployment, the inflation, the economic growth and the current account. Unemployment is placed first because it was established in the literature review that it has a detrimental effect both economically and socially. The impact on inflation was placed second in view of the importance given to inflation targeting by central banks. The economic growth was placed next because although it is a sign of a healthy economy and brings many benefits related to development of countries, in the light of current issues, mainly related to the environment, it is less and less an end in itself.. The lightest weight is given to the effect on the current account because although a trade surplus suggests a healthy and competitive country or area, a deficit is not necessarily bad.

Table 2. MCDA : Order of importance of implementation criteria.

	Order	Weight
Feasability	1	50
Speed	2	30
Absence of negative consequences	3	20

Source : author, 2022

In table 2, the criteria for the implementation of monetary policy instruments were ordered as follows: first feasibility, followed by speed and finally the absence of negative consequences. Feasibility is the most important criterion as it can be a blocking factor. Speed of implementation is placed second because a shock needs to be responded to as quickly as possible to limit its devastating effects. Finally, the absence of negative consequences was placed last because it is a bonus.

D. Rating of options

The next step in the MCDA is to score the options according to their performance on the selected criteria. Thus, on the one hand, the key interest rate, the asset purchase programmes and the funding for lending programme are evaluated according to their impact on the macroeconomic indicators in the two periods, so, according to the results obtained by the VAR-X model. On the other hand, they are rated according to their implementation advantages.

For the effectiveness on macroeconomic indicators, the rates given vary from 0 to 4. A rate of 0 means that the instrument has no effect on the criterion, a rate of 1 means that the tool has a small effect on the criterion, a rate of 2 means a moderate impact, a rate of 3 means a strong impact and a rate of 4 means a very strong impact.

To decide on these ratesthe results of the VAR-X model were used. The VAR-X showed when monetary policy instruments had an impact on macroeconomic indicators and of what degree. When the p-value, given by gretl when displaying the results of the VAR-X model, is less than 0.05 that means that the result is statistically significant and that the tool has an impact on the indicator. An instrument that has no impact on a criterion for all periods and areas in which it appears receives a rate of 0 for its effectiveness on that criterion. Then it was dediced according to the amount of the coefficient: the further from 0 the more impactful the tool was. If the instrument had an impact one or more times but in minimal proportions, i.e. with two or more decimal places equal to 0, it is given a rate of 1. Similarly, if an instrument had an impact on a criterion but in opposite ways in the two periods or between the two countries, it is given a rate of 1 on the criterion. If a tool has significantly impacted a criterion but only once, it is given a rate of 2 for the criterion. If the instrument has been impactful more than once and one of the times is significant but the other is weaker, it is

given a score of 3 for the criterion corresponding. If a tool has impacted on a criterion each time it has appeared and in significant proportions, it is given a rate of 4 for the criterion.

For the effectiveness on the implementation criteria, the rates given also vary from 0 to 4. They were awarded on the basis of on knowledge highlighted in the literature review, knowledge about the processes of central banks to set up monetary policies and new information that come from reports published by central banks or organisations, as the OECD, which highlight the positive and negative aspects of monetary policy tools. If a tool fulfils the criterion perfectly it is given a rate of 4, if it does not fulfil the criterion at all it is given a rate of 0. If a tool fulfils the criterion with difficulty, it is given a rate of 1. If it is considered to fulfil the criterion halfway it is given a rate of 2. If it is considered that it meets the criterion to a large extent but not perfectly, i.e., it can at least be given one criticism, it is given a score of 3.

E. Scoring of options

In this study, the term rating is clearly distinguished from scoring. Rating is attributed to giving one rate to an instrument on one given criterion. Scoring refers to the final score obtained by the instruments, which is an aggregation of the rates.

To obtain the total score for each instrument, its score was first calculated according to the macroeconomic criteria and according to the implementation criteria. This is done by multiplying the score for each criterion by the weight assigned to that criterion earlier. The two scores are then added together to find the total score for each tool. These final scores allow us to rank the monetary policy instruments.

It is important to calculate and keep the score of the macroeconomic criteria and the one related to the implementation of the instruments as they allow to highlight where the strengths and weaknesses of each instrument come from.

3. Literature Review

3.1 Central banks

Central banks are public institutions that administer the currency of countries or currency areas and regulate the money supply.

3.1.1 Structure and independence of central banks

Central banks of most of the industrialized countries have a decentralized structure. This structure is interesting to know to understand how and by whom the monetary decisions are taken. In his book, Mishkin (2010) revealed the structure and level of independence of several of them.

A. The Federal Reserve System

The Fed is composed of five entities: the Board of Governors of the Federal Reserve System, the Federal Reserve Banks, the Federal Open Market Committee, the Federal Advisory Council and about 2,900 commercial bank members.

The US central bank seems to have a lot of freedom from government intervention. However, the President of the United States does have some influence on it, as he nominates the members of the Board of Governors. This influence is limited, though, because the term of the Chairman of the Board of Governors does not always coincide with that of the President of the United States, and thus a President may face a Chairman of the Board of Governors appointed by a previous government. History shows that the Fed, although very independent, can be subject to certain pressures, including public support.

B. The European Central Bank

The European Central Bank, created in 1999, modelled these institutions on the Federal Reserve, as the central banks of each country have a similar role to that of the Federal Reserve banks. The European Central Bank and the national central banks of the countries that have adopted the euro are called the Eurosystem. The Eurosystem is different from the European System of Central Banks, which refers to the European Central Bank and the national central banks of the European Union member countries. The European Central Bank has an Executive Board with a structure close to the Federal Reserve Board of Governors,

consisting of the President, the Vice-President and four other members, who are nominated for a non-renewable term of eight years. The Governing Council, which includes the Executive Board and the presidents of the national central banks, is similar to the Federal Open Market Committee and decides on monetary policy. The presidents of the national central banks are chosen by their own governments, while the members of the Executive Board are appointed by a committee composed of the heads of state of all the countries of the European Monetary Union.

Despite the fact that the structure of the Eurosystem is similar to that of the Federal Reserve System, there are significant differences between the two. First, the budgets of the Federal Reserve Banks are controlled by the Governing Council, while the national central banks control their own budgets and the one of the ECB. Secondly, the monetary operations of the Eurosystem are conducted by the national central banks of each country, so the monetary operations are decentralised, unlike those of the Federal Reserve. Finally, it is the countries of the European Monetary Union that supervise and regulate financial institutions and not the ECB.

The European Central Bank is the most independent central bank in the world. The members of the Executive Board have eight-year terms, while the heads of national central banks are subject to terms of at least five years. Like the Fed, the ECB sets its own budget, and national governments are not allowed to give it instructions. This independence is ensured by the Maastricht Treaty, which stipulates that the ECB's primary objective is price stability, which means that the Eurosystem's objective is more explicitly stated than that of the Federal Reserve System. Finally, the last element that ensures the independence of the ECB is that the Eurosystem Charter cannot be amended except by a revision of the Maastricht Treaty, which would be difficult to implement as all signatories of the Treat must approve each proposed modification.

3.2 Monetary Policy

Monetary Policy refers to all the means used by the monetary authorities, often central banks, to stabilize the economy via the money supply. It differs from fiscal policy, which is controlled by the government through its budget.

Its usefulness and its role have been debated for decades, which is reflected in the evolution of its use. Until the end of the 1970s, monetary policy was generally used as an instrument

of circumstantial regulation, in particular to fight unemployment. Since the beginning of the 1980s, central banks, which became more independent from the States, have been conducting structural monetary policies especially aimed at price stability.

3.2.1 Monetary Policy objectives

A. In theory

The objectives of economic policies, and more particularly of monetary policies, have been much discussed by economists. The main opposing views are Monetarism and Keynesianism.

a) Friedman

Friedman (1968) explains that monetary policy cannot target an interest rate through money creation. This relationship only works in the short run, because afterwards the effect is reversed, due to the induced increase in demand for loans and the decrease in the value of money. He then argues that monetary policy cannot target a defined level of unemployment below the natural rate of unemployment. He justifies again this impossibility by the difference between the immediate and long-term consequences of such a monetary policy. Indeed, during an expansionary monetary policy, unemployment tends to decrease at the beginning, but once inflation has reached a high level, unemployment tends to increase. Targeting the natural rate of unemployment is also impossible, as this rate is not known. Thus, for Friedman, monetary policy should pursue a steady growth of the money stock to ensure price stability and stable economic activity.

b) Kaldor

In an article (1971), Kaldor notes that in the post-war years, governments are given the task of managing the economy to make it prosperous. He explains that this success is given by the achievement of four objectives that an economic policy should pursue. These goals are full employment, stability of prices, economic growth and equilibrium in the balance of payments.

Kaldor places these objectives on a graph, and calls this representation Magic Square, with each of the four corners of the square corresponding to an objective. These objectives thus extend on the graph in four opposite directions along the x-axis and the y-axis. Positive on

the y-axis is economic growth. It represents the positive change in the production of goods and services over a given period and is expressed as a percentage of GDP. On the other side, negative on the y-axis, is price stability expressed by the inflation rate, which by convention ranges from 0% to 10%. The trade balance is positive on the x-axis, the more positive this balance is, the higher the monetary value of exports. Finally, on the other side of the x-axis is unemployment, which should be as close to zero as possible. The wider the square, the better the economic situation.

However, these objectives are difficult to achieve together because they depend on different or even contradictory factors which poses a challenge to pursue these objectives in practice.

B. In practice

In practice, the monetary policy objectives set by central banks are correlated with the theories that have been presented above. The US Federal Reserve has three main stated objectives: price stability, maximum employment, and low interest rates (Federal Reserve Act, 1913). Furthermore, financial stability has been added to these goals after the Subprime mortgage crisis (Dodd-Frank Wall Street Reform and Consumer Protection Act, 2010). The European Central Bank has only one official objective, prices stability (Treaty on the Functioning of the European Union 1957).

a) Price stability

The objective of price stability is common for the two central banks, with a 2% inflation targeting for both. Therefore, inflation is clearly focused on by these policies, limiting it to a low level.

Targeting inflation and announcing officially what level of inflation is planned to be effective in the future is important for economic actors because it permits to avoid uncertainty. Uncertainty leads companies to wait to make investment, households to consume less, lenders to be more cautious and ask for higher compensation, so it slows down the entire economic activity.

Furthermore, there are four main reasons for targeting a small positive rate of inflation (Otmar Issing, 2000).

- The first one is the argument of the seigniorage. The seigniorage is the profit obtained by the issuer of a currency. It is equal to the value of the money created, minus its manufacturing, circulation, and maintenance costs. Inflation would lead the financial authorities to create more money and to raise their revenues. However, for developed countries this argument is not their first motivation source to target inflation because it is not the most efficient way to maximize their revenues.
- The second one is related to the Phillips curve which could be conclusive in a low inflation case because of nominal wage floors that can appear as a constraint. Indeed, there is a nominal rigidity in wages, but inflation makes reducing the real wages easier. Furthermore, based on the model of Akerlof (1996), it is considered that, if there is wage-stickiness, a change to zero inflation would raise the level of unemployment equilibrium.
- The third reason is that a negative real interest rate can be needed to respond to large shocks. The real interest rate refers to the nominal interest rate minus inflation. Yet, nominal interest rate cannot be negative (Summers, 1991). So, some inflation is necessary.
- The last argument is that inflation can be overestimated by conventional price analysis. So, targeting a zero inflation and not a low inflation can cause, in fact, a deflation. Deflation appears as harmful for the economy because it can lead to a deflationary spiral that is a vicious cercle between decreases in prices, decreases in production and decreases in wages so in demand.

a) Maximum employment

Maximum employment is one of the main goals of the Federal Reserve. The American monetary authority defines it as the lowest unemployment rate an economy can experience in the long run while keeping inflation stable. This objective was set up in 1946 with the Employment Act signed by Harry.S Truman. Even if the Federal Reserve pursues other objectives maximum employment and price stability are seen as its “dual mandate”. The main reason is that these two first goals can set up a favourable environment that will naturally leads to the third one.

This dual mandate has been criticized and the question to change it and focus only on inflation has been asked several times. However, the Federal Reserve has kept the maximum

employment goal as one of its main and different reasons can explain this decision (Thorbecke, 2002).

- First, with this strategy, the United States were facing low unemployment and low inflation, while other countries, whose central banks were only focused on inflation, had higher unemployment rates. This comparison is still true in 2022.
- The second reason is the obvious harmful consequences of unemployment, compared to those of moderate inflation. Indeed, unemployment causes a loss in revenues, a cost to the government and the society in general, but also have social negative effects at the individual level. Indeed, unemployment can jeopardize self-esteem and cause mental and physical illnesses.
- Third, central bankers tend to focus only on inflation and need to be pushed to pursue other objectives.
- The fourth argument against focusing solely on price stability is that it would aggravate the unemployment raise caused by a supply shock. Indeed, a supply shock often results in higher inflation and unemployment. Following a negative supply shock, real wages should be allowed to decrease to protect employment. As it is difficult to reduce absolute wages of workers, an increase in the price level is necessary to reduce real wages and minimize unemployment raise. However, if central banks only aim at price stability, the price level would be frozen, and a negative supply shock would increase unemployment.

b) Moderate long-term interest rates

The objective of moderate long-term interest rates is close to the price stability one. They are sometimes seen as one goal, which again explains the name “dual-mandate” given to the Federal Reserve policy. This proximity is due to the fact that long-term nominal rates are decided based on expected inflation. If prices are stable, long-term interest rates will remain at moderate levels.

Setting moderate interest rate is beneficial for the economy because the price of borrowing will be moderate. So, businesses and individuals will be interested in borrowing, which will promote employment and consumption.

a) Financial stability

The objective of price stability was set up for the Federal Reserve by the Dodd-Frank Wall Street Reform and Consumer Protection Act in 2010. This act was written in response to the financial crisis of 2007–2008. The document designates the Federal Reserve as in charge of the supervision of important financial institutions. Furthermore, the central bank officiates as "consolidated supervisor" of nonbank financial companies that are considered by the Financial Stability Oversight Council as organizations whose collapse could threaten the stability of the US financial system. More generally, the Federal Reserve is mandated to measure and analyse the risks of financial instability in order to pursue policies that will permit to avoid them.

Ensuring financial stability goes together with the other objectives of the Federal Reserve. Indeed, a properly functioning financial system leads to an adequate allocation of saving and investment, that will support economic growth and employment.

3.2.2 Monetary Policy tools

To achieve their objectives, central banks use several instruments. The choice of instrument varies according to the needs of the economy but also according to the possibilities available to central banks. Where possible, they use conventional monetary policy instruments, mainly interest rates. But if these instruments cannot be used, central banks resort to unconventional monetary policy tools.

A. Conventional monetary policy tools

There are three instruments of conventional monetary policy (Bindseil, 2021) :

- Open Market Operations : Open market operations are financial transactions between the central bank and commercial banks. These transactions are initiated by the central bank. They are divided into two categories: outright purchases or sales of assets and lending. The loans can be granted in a "fixed rate tender", where the central bank decides on the interest rate and time frame at which it will grant the credit, or in a "variable rate tender", where banks can submit offers at different interest rates.
- Reserve Requirement : Reserve requirements force banks to store a given level of demand deposits on their account in the central bank for a defined time. Checks are made on end-of-day data. The amount of a given bank's reserve requirement is set

according to its balance sheet liabilities, which must be provided monthly. The European Central Bank, for example, has decided to set it at 1% of the bank's liabilities to non-bank actors with a maturity shorter than two years. In the case of zero reserve requirements, banks are not allowed to have a negative balance at the end of the day on their account in the central bank.

- Standing facilities : Standing facilities are financial operations that the central bank realizes for commercial banks. Currently, they are provided in two different types. The first is the "overnight facility", which allows banks to borrow whenever they want, at the rate set by the central bank, with an overnight maturity. In this way, the central bank determines the upper limit of the interbank rate, as no bank would have an incentive to borrow at a higher rate. The second is a "deposit facility" that enables banks to deposit money whenever they want on a central bank's account where they earn a certain amount of interest. It sets the lower limit for the interbank rate because no bank would lend at a lower rate than the one safely insured by the central bank.

B. Unconventional monetary policy tools

When conventional monetary policies are seen as less effective to face certain situations, as for example during and after the subprime crisis, central banks are led to use non-standard monetary tools. In more precise terms, conventional monetary policies are mainly based on the variation of the nominal interest rate, and they may reach the zero lower bound on interest rates. In that case, a central bank can no longer boost demand by lowering interest rates and has to recourse to unconventional monetary policies (Bernanke, 2004).

More recently, Bernanke (2020) highlighted five unconventional monetary policy tools, that have been widely used in recent years and are mainly aimed to reach employment and inflation objectives, two key goals for central banks as it has been seen previously. These tools are, quantitative easing, forward guidance, funding-for-lending programs, yield curve control and negative interest rate.

- Quantitative easing, also named Central Bank Asset Purchases, refers to the purchase of assets by central banks to expand their balance sheet. These assets are often debt securities. It permits to the banks and more widely the market to receive liquidity.

This tool was first used by the Bank of Japan in the 1990s to manage the severe deflation that has affected the country. (Joyce, 2012)

- The forward guidance tool was also introduced during the 1990s. However, it has become an essential part of the policy after 2008. This practice consists in sharing the information with the public about central banks future policies, especially on the interest rate. This transparency is indeed a tool for the monetary policy because this information can dynamize markets, decrease uncertainty and stabilize interest rate. Forward guidance is efficient under certain conditions. First, central banks have to show that they will follow the announced policy (and people must trust their statement); secondly, they have to communicate clearly and explicitly about their operations; and finally, they must ensure that the information is understood by people in the way they want it to be. (Filardo, 2014).
- Funding-for-lending programs are used to motivate banks to lend more to households and compagnies. To do this, central banks offer funds to the banks at under-market rates. The Bank of England launched this program in 2012. The central bank calculates the terms of the loans according to the bank's contribution to lending to the real economy (Bank of England, 2012).
- Yield curve control is the purchase by the central bank of an infinite number of long-term debt securities in order to set the interest rate at desired maturity. This method can be very beneficial in combination with other unconventional measures. To ensure its success, the central bank must be taken seriously when it declares to buy an unlimited number of long-term bonds. If investors believe this statement, the actual purchase by the central bank may finally be low. This tool also needs to be used for a sufficiently long period during an effective lower bound event to be efficient (Bank of Finland, 2020).
- Negative interest rate : With inflation falling and short-term policy rates close to zero, it became more difficult for monetary policies to lower real interest rates while keeping inflation stable and output at its peak. Thus, from 2014 onwards, negative interest rates policies started to be popular among central banks. This tool allowed the ECB to ensure its forward guidance and, with the help of other easing measures, to drive inflation towards its 2% medium-term objective. Some central banks have implemented a negative interest rate policy to increase low inflation, others have used it to mitigate the unwanted effects of unconventional monetary policies measures and

to counter currency appreciation pressures. At the same time, most central banks have introduced a tiered deposit rate aimed at reducing the cost of carrying excess reserves for banks while allowing a smooth but efficient transmission to money markets (IMF, 2016).

C. Best monetary policy tool

Among all these tools, central banks must select the most effective and most appropriate to the situation of their country or economic area. Atkeson (2007) analysed what is the best choice of monetary policy tool. He chose to focus on three options, interest rates, exchange rates, and money growth rates. He notes that in general the preferred instrument of developed countries is the interest rate. This tool is hardly used in developing countries which do not have a very active financial market.
Using a simple monetary model, he determined that the optimal choice of monetary policy depends on the tightness and transparency of the instruments but also on the commitment of the policymaker to future decisions. Thus, the interest rate is the best instrument because it is naturally tight and has good transparency. The exchange rate comes second in his ranking because it is more transparent than money growth rate.

Rosenberg (2019), has also established that the interest rate is the most impactful monetary policy tool. He analysed how different types of monetary policy have affected house prices in Finland using a Bayesian vector autoregression model. He chose to compare two types of monetary policy, conventional policy with interest rate manipulation and unconventional monetary policy with balance sheet shocks such as asset purchase programmes. The results show that both a monetary policy interest rate shock and a balance sheet shock have a positive and temporary impact on house prices in Finland. However, the response to a balance sheet shock is weaker and has a shorter duration. He then put these Finland specific results into perspective with the euro area as a whole. He found that the peak of the effect of a policy rate shock on house prices in Finland occurs more quickly than in the euro area as a whole, but the magnitudes of the peak impact are similar. The effect of a balance sheet shock on house prices is not significantly different in Finland than in the euro area as a whole. In concludes by suggesting that, in general, the conventional monetary policy of manipulating the policy interest rate may have a larger and longer-lasting effect on key economic indicators than the unconventional monetary policy on monetary unions.

3.2.3 Monetary policy in time of crisis

A. Central banks role in time of crisis

In times of crisis, especially in financial markets, central banks face challenges, such as stabilising rates in the interbank market and finding the right way to respond to the potential macroeconomic consequences of the crisis through monetary policy. Mishkin (2010) points out that in times of crisis, central banks act primarily in a lending role.

Indeed, in time of crisis central banks can act as lenders of last resort. Loans of last resort are a particularly effective way of providing reserves to the banking system during a crisis, as reserves are immediately redirected to the banks that need them most. This assistance is an excellent way to avoid financial panics and is a condition for successful monetary policy. Central banks can also play the role of lender of last resort for the whole financial system and boost the overall liquidity of the system or macro liquidity. Thus, during financial market disturbances, central banks turn to discretionary liquidity operations, with a maturity that depends on their objective.

B. The importance of asset purchases in time of crisis

In a speech for the European Central Bank, Schnabel (2021), points out that the pandemic has shown that asset purchases are an indispensable monetary policy instrument in times of market stress and economic slowdown. She highlights that asset purchases are considered to support economic growth and inflation in three main ways: first, through the market stabilisation channel, by providing liquidity; second, through the portfolio rebalancing channel, by reducing the overall amount of duration risk to be held by price-sensitive investors and inducing a shift to other, riskier assets to support their value; and, third, through the signalling channel, by signalling central banks' intention to keep policy rates low for longer. She uses the example of the Pandemic Emergency Purchase Programme (PEPP) launched in response to the COVID-19 shock. This programme prevented the collapse of the financial system when the pandemic shock hit the European economy. It allowed the ECB to have a strong presence in the market and to be flexible when making purchases, enabling stabilisation and the return of confidence.

3.2.4 Challenges and limits of monetary policy

Pollin (2020) notes that financial liberalisation brings new challenges to central banks. The 2008 crisis brought the objective of financial stability back to the forefront of central bank concerns. This objective poses several dilemmas for central banks. Firstly, this objective calls into question the independence of central banks. Indeed, to achieve it, coordination with fiscal policy would have to be implemented. Another option is to give the task of achieving the financial stability objective to a committee composed of representatives of the central bank, but also of the supervisory authorities as well as the political power, which would undoubtedly reduce the independence of the central bank. Furthermore, the financial stability objective challenges the freedom of capital movement because this freedom exposes economies to external shocks. Indeed, in a world where the economy and finance are globalised, interdependencies between the banking systems of different countries have been observed and run the risk of contagion of financial instability from one economy to another. However, it is impossible to completely dispense with the free movement of capital, so new instruments and constraints to secure financial stability are needed.

Another challenge for central banks is that after more than ten years of unconventional monetary policy, a return to the usual policy may no longer be possible. This would require many adjustments in their operations. This is what Couppey-Soubeyran (2019) suggests. According to her, a return to conventional monetary policy is not an option, especially as the real interest rate and the natural interest rate will tend to remain structurally low, as will nominal rates. This expectation extends at least until 2030. Therefore, a new monetary policy standard must be set, based on the unconventional. Low interest rates should force quantitative easing to become a permanent instrument and push banks to make greater use of negative interest rates. However, conventional monetary policy must not be too accommodating to avoid financial instability. The challenge for central banks is to combine monetary policy with other monetary policies, the so-called policy mix. In particular, it points the finger at the eurozone for its lack of coordination between the single monetary policy and the fiscal policies of each member country, which makes its monetary policy less effective.

3.3 External shocks

The International Monetary Fund (2003) defines an external or exogenous shock as "a sudden event beyond the control of the authorities that has a significant negative impact on the economy. Such shocks can include terms-of-trade shocks, natural disasters, shocks to the supply of goods for domestic consumption or export, shocks to demand for exports, shocks to the availability of finance, and shocks caused by conflict and civil unrest."

3.3.1 Nature of external shocks

A. Supply shocks

Blinder and Rudd (2010) define supply supply shocks as events that affect the ability of firms to produce. Thus, they have an effect on the prices or quantities of inputs, or even on the technology of production. In addition, demand shocks affect household, business and government spending because they affect their earning. Supply shocks are events that move the price level and real output in opposite directions. Note, for example, that a negative shock results in higher prices and lower output. To explain his second definition, he uses the supply-side diagram, in which an upwardly directed aggregate supply curve moves inwards along a fixed aggregate demand curve, thereby simultaneously raising the price level and reducing output. Creating what is known as stagflation.

A supply shock is positive if it increases the quantities produced and therefore the supply. A supply shock is negative if it leads to a reduction in supply. Here the study is only interested in negative shocks because they represent situations that can endanger the economy, thus requiring the implementation of monetary policies to support it.

B. Demand shocks

A demand shock is an unexpected, sudden, and temporary change in the aggregate demand for products or services. An external demand shock is a change in an exogenous variable, which affects aggregate demand. The impact of demand shocks is mainly felt in the short term, as confirmed by Hénin (1994), who nevertheless points out that these shocks are not neutral in the long term either.

A demand shock is positive if it leads consumers to buy more, and thus increase aggregate demand. A supply shock is negative if it leads to a reduction in consumption and therefore a decrease in aggregate demand. Again, here the study will focus only on negative shocks in order to analyse the responses of the monetary authorities to counter them.

It is important to note that events can create both a supply and demand shock, thus affecting the economy at different levels.

C. Financial shocks

Jermann and Quadrini (2012) explain that the subprime crisis revealed that the financial market is an important source of destabilisation of the economy. Economists, who until then were studying the financial sector as a vector for the transmission of shocks driven by other sectors, started to focus on disturbances that emanate directly from the financial markets.These financial shocks have an important impact on the macroeconomy, and can jeopardise the health of GDP and employment, as happened in 2008.

3.3.2 Impact of external shocks

A. Consequences of external shocks in general

In the same paper as previously, the International Monetary Fund presents various economic consequences of negative external shocks. The magnitude of the impact varies according to the nature of the shock, its size and duration, and the structure of the affected economy.

These consequences can be direct but also indirect. First, exogenous shocks can negatively affect growth. Natural disasters, for example, can lower production and income, and can destroy infrastructures. If these direct problems are not addressed, they can cause further problems in the medium to long term. Another example is trade-related shocks. They directly reduce real income and jeopardize investment and consumption. External shocks can also harm the economic health of governments. Indeed, their revenues can drop because of negative trade shocks if the export products concerned are an important source of tax revenues. Finally, exogenous shocks can worsen poverty by destroying the assets of the population or by causing direct income losses, inflation, and lower government social expenditures.

B. Studies about the impact of external shocks on eurozone

The impact of external shocks on euro zone has been studied at various levels.

Hahn (2003) analysed the consequences of external shocks on prices in the eurozone since the establishment of the European Monetary Union. He was interested in three different types of shocks : oil price shocks, exchange rate shocks, and non-oil import price shocks. Thanks to a Vector Autoregression model, he found that exogenous shocks are significantly responsible for the fluctuation in prices, and it appeared that they were the source of most of the inflation the area has experienced.
Furthermore, the use of impulse responses enabled him to rank the three categories of shocks he had identified according to the size and speed at which the shocks crossed the economy. Thus, the first in terms of size and speed are the non-oil import price shocks, the second are exchange rate shocks and oil price shocks are the last. Finally, he tested the reliability of his results by simulating the model over various periods and through several identification schemes.

Goux (2006) used a structural Vector Autoregression model to identify the nature of shocks. Thanks to this method, he identified seven categories : external shocks, supply shocks, price shocks, money supply shocks, interest rate shocks and exchange rate shocks. To calculate the impact of these shocks, he then used a Vector Moving Average model.
The external shock simulates a transmission of US monetary policy shocks. As a result, economic activity in the euro area gradually and permanently declines. The consequences are noteworthy on inflation but also on interest rates. However, the euro-dollar exchange rate is only slightly affected and only in the short term.
In general terms, the euro zone is particularly sensitive to shocks that result in changes in monetary conditions, whether via the interest rate or the exchange rate. However, Goux states that the interest rate remains a more important determinant than the exchange rate.

Gossé and Guillaumin (2010) studied the impact of exogenous shocks on the current account of eurozone but also on economic growth and exchanges rates from the 2000s. They chose to deal with four shocks, the rise in the price of oil, the decrease in the Fed Funds rate, the increase in the SP500 index and the accumulation of global imbalances. To conduct their study, they used the methodology of Structural Vector Autoregressive models. Their analysis reveals that the four shocks have implied a loss of growth for the euro area countries. In the

zone, external shocks are the cause of about one third of the changes in the growth differential and the real effective exchange rate, while they explain only 15% of the changes in the current account.

C. Studies about the impact of external shocks on US economy

Forni and Gambetti (2010) analysed shocks and their impact on different aspects of the US economy by studying data from 1959 to 2007. They started by searching how many types of shocks impact the US economy. Thanks to a factor model, they found that these shocks are between two and six. They chose to focus on four of them, and two of which are of interest here : supply and demand shocks.

Their model enabled them to establish that supply shocks are responsible for more than half of the changes in GDP. They also cause substantial changes in inflation, but to a lesser extent. Forni and Gambetti also noted that supply shocks have a massive and lasting impact on output.

According to their findings, demand shocks have no significant effect on long-term GDP but have an important impact on employment and other related variables. They also have a large impact on inflation, especially in the long term. Finally, for investment and its unpredictable variations, demand shocks are the determining factor.

Kilian and Vigfusson (2016) studied the impact of oil price shocks on the US economy, by searching a causal relationship between these shocks and recession. Their work showed that there isn't an automatic correlation between net oil price increases and recessions, so the time factor must be considered.

However, using the net oil price increase method, a relationship between oil price shocks and recession has been identified. For example, they found that the oil shock was responsible for a 3% decrease of real GDP two years after the Islamic Revolution in Iran in 1979, a decline of the same amount two years after the Iraq invaded Kuwait in 1990 and 5% drop two years after the oil shock of 2007-2008.

Nevertheless, these results should be treated cautiously, as an alternative method, the linear model, shows different results, with a much lower correlation. Other factors were added by Kilian and Vigfusson, such as consumer confidence, to correct this gap between the two methods without completely succeeding.

These studies have shown that external shocks are likely to harm the economy if they are not counterbalanced by economic policies. This is precisely the role of central banks to counterbalance their effects, to keep the economy stable and growing when these shocks occur. However, despite the use of unconventional monetary policies, central banks have less and less room to manoeuvre to counteract shocks.

4. Practical Part

4.1 Overview of the monetary policy response to the subprime mortgage crisis

The financial market started to experience turmoil in August 2007. The shock started in the US market and spread globally because of the interdependence of financial markets. After the failure of Lehman Brothers in September 2008, the financial system was even more weakened, making central banks' actions even more essential (Norges Bank,2009).

In response to this financial shock, the ECB used conventional monetary policy, by intensifying open market operations and then gradually manipulating its key interest rates. Thus, the interest rate on the main refinancing operations, the interest rate on the marginal lending facility and the deposit facility fell respectively from 4.00% to 1.00%, from 5.00% to 1.75%, and from 3.00% to 0.25% between July 2007 and May 2009. To provide even more support, the central bank launched various fixed-rate tender procedures to provide refinancing operations but also to offer dollar funding. At the same time, the ECB used unconventional monetary policy. Indeed, it implemented a series of exceptional measures aimed at temporarily broadening the list of its assets, especially via the Covered Bond Purchase Programme (CBPP).

Similarly, Norges Bank was first involved in providing sufficient liquidity to the banks through fixed-rate loans (F-loans). Through the swap market, it provided the banks with US dollars. It also made available as much Norwegian kroner as needed in the foreign exchange swap market for US dollars and euros. In addition, it lowered its key interest rate several times from 5.75% to 1.25 between 2008 and 2009.

4.2 Overview of the monetary policy response to the COVID-19 pandemic

The coronavirus emerged in November 2019 in China before spreading to Europe in January 2020. In March 2020, the World Health Organisation declared COVID-19 a pandemic. Containment measures were put in place across Europe from February. This situation led to both a negative supply and demand shock (Soltani, 2021). Indeed, a negative supply shock due to the stoppage of the Chinese economy, which is a major international producer, but

also due to the fact that, deprived of their production factor, companies have had to reduce or even totally stop their activity. And a negative demand shock as domestic and international consumers locked in their homes have changed their consumption habits, mainly downwards. To counterbalance the effects of these shocks, central banks quickly put in place multiple measures.

The ECB's conventional monetary policy was rather limited in responding to the Covid shock as key interest rates were already at their lowest. Thus, the ECB reacted mostly with unconventional monetary policy instruments. Firstly, in order to reduce borrowing costs and increase lending in the euro area, the ECB launched the Pandemic Emergency Purchase Programme, PEPP, to the amount of EUR 1 850 billion. Then, to facilitate access to credit for companies and households, the ECB launched in September 2019, loans with a maturity of three years: TLTRO III. These loans are also part of the unconventional monetary policy, because banks can borrow funds from the ECB at a favourable rate as low as -1% only if they keep lending to businesses and households. This is what was presented earlier under the name "funding for lending".

Norges Bank had the possibility to manipulate its interest rate on banks' overnight deposits because at the beginning of the crisis it stood at 1.50%. This rate was reduced to 0.00% from May to September 2020 and then raised to 0.25%. In March 2020, the Norwegian central bank launched "extraordinary F-Loans", they are called extraordinary because the quantities given to the banks were those desired, the central bank did not issue any refusals.

4.3 VAR-X results : Eurozone

Table 3. VAR-X result : impact on eurozone's GDP growth rate.

```
Equation 1: GDPgrowth_rate
Heteroskedasticity-robust standard errors, variant HC1

                      coefficient   std. error   t-ratio  p-value
  ------------------------------------------------------------------
  const                0.00634711   0.00539883    1.176   0.2434
  GDPgrowth_rate_1     0.438300     0.291583      1.503   0.1369
  d_Unemployment~_1   -1.06230      2.15706      -0.4925  0.6238
  d_Inflation_1        1.54949      1.06632       1.453   0.1503
  d_Current_Acco~_1    1.37327e-07  1.36539e-07   1.006   0.3177
  ECBKeyIntPl_1       -0.283922     0.125465     -2.263   0.0265  **
  ECBAssPurchPl_1      4.71469e-07  5.31370e-07   0.8873  0.3777
  ECBAssPurchP2_1      1.27727e-07  1.21520e-07   1.051   0.2965
  ECBFundLendP2_1     -6.00241e-05  4.02579e-05  -1.491   0.1401
```

Source : author, gretl, 2022

On the table 3, thanks to the p-values it can be seen that only the policy rate has had a significant impact on the GDP growth rate. An increase in the policy interest rate is correlated with an increase in the GDP growth rate. Thus, the policy of lowering the policy interest rate is correlated with an increase in the GDP growth rate.

Table 4. VAR-X result : impact on eurozone's unemployment rate.

```
Equation 2: d_Unemployment_rate
Heteroskedasticity-robust standard errors, variant HC1

                      coefficient   std. error   t-ratio  p-value
  ------------------------------------------------------------------
  const                0.000167948  0.000213286   0.7874  0.4334
  GDPgrowth_rate_1    -0.0258218    0.00786546   -3.283   0.0015   ***
  d_Unemployment~_1    0.569504     0.105033      5.422   6.55e-07 ***
  d_Inflation_1       -0.0319425    0.0524631    -0.6089  0.5444
  d_Current_Acco~_1    6.72608e-09  5.57323e-09   1.207   0.2312
  ECBKeyIntPl_1        0.0342112    0.0165244     2.070   0.0418   **
  ECBAssPurchPl_1     -7.93416e-08  3.23352e-08  -2.454   0.0164   **
  ECBAssPurchP2_1      7.27777e-09  3.21507e-09   2.264   0.0264   **
  ECBFundLendP2_1     -8.44104e-06  1.23042e-06  -6.860   1.53e-09 ***
```

Source : author, gretl, 2022

On the table 4, thanks to the p-values, it is shown that all monetary instruments had an impact on the unemployment rate. The coefficients enable us to establish that an increase in the policy interest rate leads to an increase in the unemployment rate. The funding for lending

tool had a slight negative effect on the unemployment rate in period 2. In both periods, the asset purchase programmes CBPP (period 1) and PEPP (period 2) had opposite effects on the unemployment rate. In the first period the asset purchase led to a small decrease in the unemployment rate but in the second period it led to a small increase in the unemployment rate.

Table 5. VAR-X result : impact on eurozone's inflation.

```
Equation 3: d_Inflation
Heteroskedasticity-robust standard errors, variant HC1

                      coefficient   std. error   t-ratio   p-value
  ---------------------------------------------------------------
  const               -0.00129307   0.000553570  -2.336    0.0221  **
  GDPgrowth_rate_1     0.0514208    0.0274996     1.870    0.0653  *
  d_Unemployment~_1   -0.426858     0.277033     -1.541    0.1275
  d_Inflation_1        0.0667454    0.134970      0.4945   0.6223
  d_Current_Acco~_1    9.24323e-09  1.40586e-08   0.6575   0.5128
  ECBKeyIntP1_1       -0.00155933   0.0669521    -0.02329  0.9815
  ECBAssPurchP1_1      5.09720e-07  1.79831e-07   2.834    0.0059  ***
  ECBAssPurchP2_1      4.17393e-08  1.22359e-08   3.411    0.0010  ***
  ECBFundLendP2_1     -4.40332e-06  2.75678e-06  -1.597    0.1143
```

Source : author, gretl, 2022

The table 5 shows that asset purchase programmes had an impact on inflation during both periods because the two p-values corresponding are smaller than 5%. The coefficients shows that these programmes had a slight positive impact on inflation during both periods.

Table 6. VAR-X result : impact on eurozone's current account.

```
Equation 4: d_Current_Account
Heteroskedasticity-robust standard errors, variant HC1

                      coefficient      std. error     t-ratio   p-value
  ------------------------------------------------------------------------
  const                 1770.77        3948.19         0.4485   0.6551
  GDPgrowth_rate_1     -81690.6       121288          -0.6735   0.5026
  d_Unemployment~_1   -495332           1.99458e+06   -0.2483   0.8045
  d_Inflation_1       -943623         915488          -1.031    0.3059
  d_Current_Acco~_1       -0.240052      0.134447      -1.785    0.0781  *
  ECBKeyIntP1_1       -100811         229341          -0.4396   0.6615
  ECBAssPurchP1_1          0.0828425     0.828938      0.09994  0.9207
  ECBAssPurchP2_1          0.0654278     0.0548039     1.194    0.2362
  ECBFundLendP2_1          6.56167      17.2447        0.3805   0.7046
```

Source : author, gretl, 2022

On the table 6, it can be observed that none of the three monetary policy tools had an impact on current account. Indeed, all of the p-values corresponding are greater than 5%.

4.4 VAR-X results : Norway

Table 7. VAR-X result : impact on Norway's GDP growth rate.

Equation 1: GDP_growth_rate
Heteroskedasticity-robust standard errors, variant HC1

	coefficient	std. error	t-ratio	p-value	
const	-0.000963947	0.00973869	-0.09898	0.9214	
GDP_growth_rate_1	-0.339883	0.162609	-2.090	0.0404	**
Inflation_1	0.248129	0.608172	0.4080	0.6846	
Unemployment_r~_1	0.212280	0.263544	0.8055	0.4234	
d_Current_Acco~_1	8.51613e-08	5.62307e-08	1.514	0.1346	
NB_KeyIntP1_1	-0.186837	0.105251	-1.775	0.0804	*
NB_KeyIntP2_1	-2.37016	0.949773	-2.495	0.0150	**

Source : author, gretl, 2022

The p-values in the table 7 indicate that the key interest rate of Norges Bank had an impact on the GDP growth rate. The coefficients show that decreasing the key interest rate had a significant positive impact on GDP growth rate for both periods, but even greater in period 2.

Table 8. VAR-X result : impact on Norway's inflation.

Equation 2: Inflation
Heteroskedasticity-robust standard errors, variant HC1

	coefficient	std. error	t-ratio	p-value
const	-0.000772561	0.00177711	-0.4347	0.6652
GDP_growth_rate_1	-0.0269368	0.0227422	-1.184	0.2404
Inflation_1	-0.112957	0.151830	-0.7440	0.4595
Unemployment_r~_1	0.0688342	0.0468186	1.470	0.1462
d_Current_Acco~_1	1.54889e-08	1.54198e-08	1.004	0.3188
NB_KeyIntP1_1	0.0366775	0.0362136	1.013	0.3148
NB_KeyIntP2_1	-0.0197164	0.107996	-0.1826	0.8557

Source : author, gretl, 2022

The p-values concerning the NB key interest rate in table 8 are greater than 5%, which indicated that the tool didn't have an impact on inflation.

Table 9. VAR-X result : impact on Norway's unemployment rate.

```
Equation 3: Unemployment_rate
Heteroskedasticity-robust standard errors, variant HC1

                      coefficient   std. error   t-ratio    p-value
  ------------------------------------------------------------------
  const                0.00328087   0.00248421    1.321     0.1911
  GDP_growth_rate_1   -0.0715104    0.0275545    -2.595     0.0116    **
  Inflation_1          0.0106415    0.128327      0.08293   0.9342
  Unemployment_r~_1    0.916874     0.0648653    14.14      8.80e-022 ***
  d_Current_Acco~_1   -1.95437e-08  1.91358e-08  -1.021     0.3108
  NB_KeyIntP1_1        0.00228683   0.0223984     0.1021    0.9190
  NB_KeyIntP2_1        0.224064     0.314841      0.7117    0.4791
```

Source : author, gretl, 2022

The p-values corresponding to the NB key interest rate in table 9 are greater than 5%, which indicated that the tool didn't have an impact on the unemployment rate.

Table 10. VAR-X result : impact on Norway's current account.

```
Equation 4: d_Current_Account
Heteroskedasticity-robust standard errors, variant HC1

                       coefficient        std. error     t-ratio   p-value
  ------------------------------------------------------------------------
  const                -24898.9           21704.3        -1.147    0.2554
  GDP_growth_rate_1     31106.9          247036           0.1259   0.9002
  Inflation_1               1.41224e+06      1.61929e+06   0.8721   0.3863
  Unemployment_r~_1    672612            560256           1.201    0.2342
  d_Current_Acco~_1         0.239713         0.195217      1.228    0.2238
  NB_KeyIntP1_1         7089.33          242410           0.02925  0.9768
  NB_KeyIntP2_1            -1.74117e+06  370671          -4.697    1.35e-05 ***
```

Source : author, gretl, 2022

In table 10, it is observed thanks to the p-value and the value of the coefficient that NB key interest had a significant impact on Norway's current account in period 2. Decreasing the interest rate has led to an increase in the current account.

4.5 Multicriteria Decision Analysis

4.5.1 Rate of the monetary policy instruments

Table 11. MCDA : rating of instrument according to their effectiveness on macroeconomic criteria.

	Inflation	Unemployment	Economic growth	Current account
Decrease key int rates	0	2	4	2
Asset purchases	1	1	0	0
Funding for lending	0	1	0	0

4 = extremely (effective); 3 = very (effective); 2 = moderately (effective); 1 = slighty (effective); 0 = not (effective) at all
Source : author, 2022

In the table 11 monetary policy instruments were rated according to their effectiveness on the four macroeconomic indicators established by the previous VAR-X model. O is the lowest rate and 4 the highest.

The decrease of the interest rate did not appear to have an impact on inflation, which explains the rate of 0. It had a significant impact on the unemployment rate but only once out of the three times it was tested, which justifies the score of 2. The effect of the fall in the interest rate on the GDP growth rate has been significant in every period in which it has been in operation. It was therefore given a score of 4 on the economic growth criterion. The key interest rate had a significant impact on the current account but only once out of the three times it was tested, which justifies the score of 2.

The asset purchase programmes had an impact on inflation over the two periods, but its effect was very slight, which explains the rate of 1. The instrument had an effect on unemployment over the two periods but in opposite way and very slightly, so it was awarded a rate of 1. The asset purchase programmes did not appear to have an impact on the GDP growt, which explains a rate of 0 on this criterion. Similarly, a score of 0 was given to this tool for its effect on the current account as it did not appear to have an impact on it.

The funding for lending programme did not appear to have an impact on inflation, which explains the rate of 0. The tool had a small effect on unemployment,which justifies the rate of 1. The funding for lending programme did not appear to have an impact on economic growth, which explains the rate of 0. Finally, the tool did not have an impact on the current account neither, so it was given the rate of 0.

Table 12. MCDA : rating of instruments according to their suitability for the implementation criteria

	Feasibility	**Quick to set up**	**No negative consequences**
Decrease key int rates	1	4	3
Asset purchases	4	2	0
Funding for lending programmes	4	1	3

4 = extreme (suitability) 3 = very high (suitability) 2 = moderate (suitability) 1 = slight(suitability) 0 = not (suitable) at all
Source : author, 2022

In the table 12 monetary policy instruments were rated according to their suitability for the implementation criteria. O is the lowest rate and 4 the highest. As explained in the literature review, the zero lower bound has been reached by a lot of central banks, what prevent them to low the key interest rate currently. This argument justifies the rate of 1 for the key interest rate tool on the feasibility criterion. Indeed, its suitability for this criterion is very low. Lowering key interest rates is very quick for central banks, as can be seen from the history of these rates, which sometimes change several times in the same month. So the rate of 4 was awarded on key interest rate on speed criterion. Decreasing key interest rates, if they remain positive, is not known to have negative consequences, apart from the risk of reaching the zero lower bound, which explains the rate of 3.

In the current situation, particularly with regard to the balance sheets of the central banks, a new asset purchase programme can be set up, which explains the rate of 4 on the feasibity criterion. Setting up an asset purchase programme as CBPP and PEPP takes time as you need to make the initiative known to the banks and give them time to apply, but it allows some flexibility. So the rate of 1 was awarded to asset purchase program on the speed criterion.

According to a working paper published in 2013 by the OECD Economics Department, asset purchase has a lot of negative consequences. In particular, it encourages risk-taking and increases the risk of instability in the bond markets. It explains the rate of 0 on this criterion.

In the current situation, a new funding for lending programme can be set up, which explains the rate of 4. Setting up a funding for lending programme takes time as you need to plan a timetable, make the initiative known to the banks, give them time to apply and and study the eligibility of banks, which explain the rate of 1. Finally, The European Banking Authority noted in a report in 2014 that banks did not use the funds obtained with these loans to lend to the real economy as a priority but only as a second step. This can be seen as a negative consequence and explains the score of 3 on this criterion.

4.5.2 Score of the monetary policy instruments

In order to determine which instrument has the highest score on macroeconomic criteria and the highest score on implementation criteria, the weight of the criterion was multiplied with the rate assigned to the instrument on that criterion. Adding the two scores together gives the total score. This process gives us the following table.

Table 13. MCDA : total score of monetary policy instruments

	Score macroeconomic impact	Score implementation	Total
Decrease of key int rates	200	230	430
Asset purchase programmes	90	260	350
Funding for lending programmes	50	290	340

Source : author, 2022

Table 13 gives us the final ranking of the three monetary policy tools studied. In first position is ranked the key interest rate, in second position the asset purchase programmes and in last position the funding for lending programmes.

It can be seen that the ranking is the same when looking at the score on the macroeconomic criteria. The difference is even more marked in this column.

However, the ranking changes completely when only the implementation criteria are considered. It is then the funding for lending instrument that comes out on top, followed by the asset purchase instrument. The decrease of the key interest rate comes in last place.

5. Results and Discussion

Thanks to the development of the VAR-X model and the application of the MCDA, it was found that the decrease in the policy interest rate is the best tool among the three studied. It is ranked ahead of the other thanks to its performance on macroeconomic indicators. Indeed, with regard to the implementation criteria, its results are lower and the two other studied tools outperform it.

5.1 Discussion about the best monetary policy instrument

The policy interest rate was mentioned several times in the literature review as the most appropriate and effective monetary policy tool.

Indeed, Atkeson (2007) ranked it first among three instruments. Rosenberg (2020) also found that it had more to offer than a conventional monetary policy tool.

However, these studies are not completetly similar to the present one. Atkeson compared interest rates to exchange rates and money growth. The researches have in common the increase in money because the asset purchase programme increases the quantity of money by injecting money through the purchase of assets. However, he based his argument on how titled and transparent the instruments are, which was not determinant in the present research because the central banks studied, and especially the ECB, are very transparent both in setting key interest rates and in setting up asset purchase or funding for lending programmes.

Rosenberg studied the impact on house prices of a change in the policy interest rate and a change in the balance sheet of central banks, which means the use of unconventional monetary policy. He therefore focused on their effect on a price increase, which in the present case can be compared to inflation. And even if the final conclusions converge towards the fact that handling the interest rate is more impactful than using unconventional monetary policy, it should be noted that in the present study it was not established that the interest rate had an effect on inflation, unlike asset purchase programme. Nevertheless, he concluded his work by mentioning the possibility that the interest rate has a stronger and longer lasting impact on the main economic indicators than unconventional monetary policy in a monetary union. This thesis does not make a statement on the long lasting aspect of monetary policy instruments, but is perfectly in line with Rosenberg's suggestion that the interest rate has a stronger impact on a monetary union, in this case the eurozone.

The results of the present study complement those of the researches cited above as it highlights the superiority of the policy interest rate over two unconventional monetary policy instruments, by comparing their impact on four macroeconomic indicators. This reinforces their conclusion that the policy interest rate is the most effective monetary policy tool.

5.2 Discussion about the implementation difficulties and the need for a return to normal functioning

However, it is noticeable that the key interest rate is performing weaker regarding to the implementation criteria established. This is due to the low interest rates and the proximity to the zero lower bound which prevents most of central banks from reducing it further. As the key interest rate is the instrument with the greatest macroeconomic impact, it can appear as essential to increase this rate during periods of expansion so that it can be used in response to the next shock.

This result is at odds with the findings of Jézabel Couppey-Soubeyran (2019). Indeed, she considers that a return to a conventional monetary policy is impossible because of real and natural interest rates which should remain structurally low, notably because of the tertiarization of the economy, demographic ageing, and excess savings. Thus, she rather suggests that unconventional monetary policy will become conventional, i.e. that these instruments will be used permanently.

However, it can be seen, in the table 3 of the appendix that shows the data of Norway, that once the COVID-19 shock was dealt with, Norges Bank increased its key interest rate slightly. In the same vein, the European Central Bank is planning to raise its key interest rates in the near future. This shows the willingness of the two banks to preserve this tool for use when a new shock will make it necessary.

5.3 Limits of the study

The three monetary policy tools studied in this thesis were chosen according to the policies pursued by Norges Bank and the ECB in the two periods. The data allowed us to compare their macroeconomic effectiveness. However, as monetary policy evolves from one period to another and from one area to another, some instruments have been used more than others. This difference is reflected in the present research.

Indeed, for example the key interest rate impact was studied three times in the VAR-X model : for Norway in period 1 and 2 as well as for the eurozone in period 1, while the funding for lending programme was only analysed in period 2 for the eurozone.

An instrument that appears more frequently is more likely to be impacting than one that is studied only once. Thus, the results of the study may be impacted, specifically on the analysis of the macroeconomic impact.

It might be interesting to do this study on a larger number of central banks and to have the possibility to evaluate each instrument the same number of times. This would allow a fairer treatment of the tools.

6. Conclusion

The purpose of the study was to evaluate the efficiency of central banks monetary policy tools in response to external shocks and to determine which central banks' tool was the most important and effective on the periods studied. The sub-objective of the study was to find out if central banks are facing limits that prevent them from reacting effectively to shocks with the appropriate tool.

For this purpose, it was decided to study the case of the Eurozone and Norway, whose macroeconomic situations and monetary policies implemented by their central banks are very different. Indeed, the monetary policy of the Norges Bank is more conventional than that of the European Central Bank. Two periods over which to conduct this study were selected. The first one is the subprime mortgage crisis from 2007 to 2010 and the second one is the COVID-19 pandemic from 2019 to 2021. These periods correspond to the two biggest external shocks that the two central banks had to respond to in order to preserve the economy.

In response to these shocks, Norges Bank has mainly manipulated its key interest rate, lowering it. The European Central Bank was also able to lower its key interest rate in response to the subprime crisis in 2008. In addition, during this first period the ECB implemented an asset purchase programme, called Covered Bond Purchase Programme (CBPP). However, to respond to the second shock, it was confronted to the zero lower bound, which indicates that the key interest rate has reached a floor and can no longer be lowered. The ECB therefore made extensive use of unconventional monetary policy tools; the research was focused on a specific asset purchase programme, the Pandemic Emergency Purchase Programme (PEPP) and on a funding for lending programme, called Targeted Longer-Term Refinancing Operations III (TLTROIII). Thus, three different monetary policy instruments were to analyse : the reduction of the key interest rate, the asset purchase programmes and the funding for lending programmes. The monetary policy data for the first period was collected from 2007 quarter 4, when the shock started to be felt in Europe and the central banks set up their first policies. The selected end of it is 2010 quarter 2. The monetary policy data for the second period was collected between 2019 quarter 4, when the COVID-19 appeared, and 2021 quarter 4.

It was chosen to study the economic efficiency of these monetary policy tools through the four objectives defined in the Kaldor's magic square as they give a good idea of the economic

health of an area or a country. These indicators are growth, employment, price stability and external balance. They were respectively measured by the GDP growth rate, the unemployment rate, the inflation and the amount of current account.

In order to determine the impact of these three policy tools on these four indicators a vector autoregression model (VAR) was used. It was chosen to take into account monetary policy data only during the two "response to shock" periods studied, but macroeconomic data have been selected from the beginning of 2000 to the end of 2021 for the eurozone and from the beginning of 2003 to the end of 2021 for Norway. Inflation information for Norway was not available on a quarterly basis before 2003. The choice to analyse the macroeconomic data on a longer period compared to economic policies data is explained by the fact that a VAR model requires a large number of observations and by the fact that quarterly data were used. It was therefore not possible to find a reliable result with this system by analysing all data only during the "response to shock" periods. It implies that monetary policy is seen as exogenous in the VAR model, and the model is therefore referred to as a VAR-X model.

Thanks to this VAR-X model it was established that the reduction in the key interest rate had a significant positive impact on GDP growth in all cases. It had a moderate negative impact on the unemployment rate and a moderate positive impact on the current account. However, the policy interest rate had no effect on inflation in the three cases studied. The model also showed that the asset purchase programmes had an impact on inflation in both periods, but very slightly. Furthermore, it was found that in both periods they had an effect on unemployment, but this effect is slightly positive in one case and slightly negative in the other. Asset purchase programmes didn't impact the GDP growth and the current account. Finally, with regard to the funding for lending programme, the VAR-X model found that it had a small negative effect on unemployment. No other effects were found on the remaining macroeconomic indicators.

In order to obtain a ranking of the three policy instruments, a Multicriteria Decision Analysis (MCDA) was set up. This analysis included the results of the VAR-X model. Indeed, the first group of criteria of the MCDA was composed of the four macroeconomic indicators on which the effect of the monetary policy instruments was evaluated. The criteria were ranked in order of importance, from the most important to the least important. Unemployment was placed first, followed by inflation, then economic growth and finally the current account.

Following the results of the VAR-X model, the policy interest rate, asset purchase programmes and funding for lending programmes received rates from 0 to 4 according to each criterion. 0 is the lowest rate and 4 the highest. Moreover, other criteria have been established to judge the monetary policy tools. These criteria are related to the implementation process of the instruments by central banks. These criteria are listed from most important to least important : feasibility, i.e. whether or not it is currently possible to implement this tool, speed of implementation and absence of negative consequences. The fulfilment of these criteria by monetary policy instruments was rated from 0 to 4, based on general economic knowledge and official documents published by economic institutions. 0 is the lowest rate and 4 the highest. Next was the scoring step. It consisted of combining all the rates received by each tool on each criterion. These calculations took into account the importance of each criterion, with a higher weighting given to the rates for the criteria considered as more important. In this way, the score of each instrument on the macroeconomic criteria and the score of each instrument on the implementation criteria were obtained. According to the macroeconomic criteria, the policy interest rate is clearly the most effective instrument. Asset purchase programmes rank second, followed by funding for lending programmes. For implementation criteria, the ranking was different. Funding for lending programmes come first, followed by asset purchase programmes and then the key interest rate. The total of the scores of the two categories of criteria gave us the final ranking, which was the same as the ranking of the macroeconomic criteria. The policy interest rate thus appeared to be the most effective instrument to be used by central banks in response to a shock.

This result complements the findings of several studies that have established that the key interest rate is the best monetary policy instrument. Indeed, compared to unconventional monetary policy instruments, it has been shown in the mentioned literature that interest rates have a stronger and longer-term impact.

However, the poor performance of the policy interest rate in meeting the implementation criteria should be taken seriously. Indeed, it suggests that even if it is the most effective monetary policy instrument it may not be usable by central banks. So, there is indeed an obstacle that prevent central from reacting the most effectively possible to shocks with the most appropriate tool. This is due to the fact that the zero lower bound has been reached by many of them. Thus, if they want to continue to use this conventional monetary policy tool

in response to an external shock, they need to raise policy interest rates during expansionary periods. This prospect has been taken into account by central banks, which have already begun to raise their key interest rates, like Norges Bank in the quarter 4 of 2021, or are considering doing so, like the ECB.

Finally, it might be interesting to conduct this study with a larger number of shock periods or more central banks. Indeed, this would enable the macroeconomic impact of each monetary policy tool to be tested the same number of times, which could be considered fairer.

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8. Appendix

Table 1. Macroeconomic data of eurozone from 2000Q1 to 2021Q4.

Time	Response to shock	GDP growth rate	Unemployment rate	Inflation rate	Current Account in million euro
2000Q1	No	0.042	0.09282733	0.019	-21922
2000Q2	No	0.045	0.09049225	0.019	-30294
2000Q3	No	0.039	0.08894356	0.022	-25024
2000Q4	No	0.034	0.08656144	0.025	-24721
2001Q1	No	0.032	0.08437289	0.021	-17624
2001Q2	No	0.023	0.08381362	0.029	-22181
2001Q3	No	0.019	0.08386902	0.023	1360
2001Q4	No	0.013	0.08465594	0.021	12063
2002Q1	No	0.004	0.08493191	0.025	12040
2002Q2	No	0.009	0.085839	0.021	-5363
2002Q3	No	0.012	0.08736312	0.021	23065
2002Q4	No	0.012	0.08881577	0.023	16239
2003Q1	No	0.008	0.09077264	0.023	-1304
2003Q2	No	0.004	0.09139244	0.02	-10400
2003Q3	No	0.005	0.09135045	0.02	12103
2003Q4	No	0.011	0.09172063	0.021	18750
2004Q1	No	0.019	0.09351544	0.017	14344
2004Q2	No	0.024	0.09344455	0.023	5619
2004Q3	No	0.021	0.09328925	0.023	14030
2004Q4	No	0.017	0.09346122	0.023	23635
2005Q1	No	0.015	0.09247552	0.021	161
2005Q2	No	0.014	0.09285419	0.02	-4002
2005Q3	No	0.019	0.09141718	0.023	4411
2005Q4	No	0.022	0.09055973	0.024	8391
2006Q1	No	0.029	0.08846763	0.023	-11394
2006Q2	No	0.034	0.08561088	0.025	-18131
2006Q3	No	0.032	0.08331601	0.022	-1568
2006Q4	No	0.038	0.08116116	0.018	16406
2007Q1	No	0.035	0.07889115	0.018	2876
2007Q2	No	0.031	0.07616346	0.019	-7673
2007Q3	Yes	0.03	0.07538531	0.019	5984
2007Q4	Yes	0.023	0.0744441	0.029	2598
2008Q1	Yes	0.022	0.07387662	0.034	-61138
2008Q2	Yes	0.011	0.07491099	0.036	-45762
2008Q3	Yes	0.001	0.07649991	0.038	-37378
2008Q4	Yes	-0.022	0.08160411	0.023	-32684
2009Q1	Yes	-0.057	0.09129471	0.01	-35517
2009Q2	Yes	-0.054	0.09691607	0.002	-19388

2009Q3	Yes	-0.045	0.09986522	-0.004	11151
2009Q4	Yes	-0.023	0.1020448	0.004	15110
2010Q1	Yes	0.012	0.10339383	0.011	-23740
2010Q2	Yes	0.022	0.10402924	0.016	-20466
2010Q3	No	0.023	0.10279446	0.017	488
2010Q4	No	0.025	0.102723	0.02	12496
2011Q1	No	0.029	0.10173874	0.025	-39841
2011Q2	No	0.019	0.10096343	0.027	-18155
2011Q3	No	0.016	0.10358376	0.027	-2119
2011Q4	No	0.006	0.10728851	0.029	25218
2012Q1	No	-0.005	0.1105476	0.027	-18099
2012Q2	No	-0.008	0.11396598	0.025	18201
2012Q3	No	-0.01	0.1161564	0.025	39841
2012Q4	No	-0.01	0.11939317	0.023	56341
2013Q1	No	-0.012	0.12193907	0.019	24052
2013Q2	No	-0.004	0.12176085	0.014	47245
2013Q3	No	0.001	0.12108619	0.013	56362
2013Q4	No	0.007	0.12028895	0.008	80255
2014Q1	No	0.015	0.1197482	0.007	30617
2014Q2	No	0.012	0.1170465	0.006	35287
2014Q3	No	0.014	0.11587022	0.004	73605
2014Q4	No	0.015	0.11557741	0.002	98946
2015Q1	No	0.018	0.1132733	-0.003	55479
2015Q2	No	0.02	0.11116749	0.004	36034
2015Q3	No	0.02	0.10758815	0.004	92439
2015Q4	No	0.02	0.10615848	0.003	98548
2016Q1	No	0.019	0.10416614	0.001	55324
2016Q2	No	0.017	0.10238136	-0.001	79297
2016Q3	No	0.017	0.09960605	0.003	93353
2016Q4	No	0.02	0.09815567	0.007	100950
2017Q1	No	0.022	0.09572702	0.017	70454
2017Q2	No	0.027	0.09222069	0.015	31177
2017Q3	No	0.03	0.09000385	0.015	123078
2017Q4	No	0.031	0.08789169	0.014	131318
2018Q1	No	0.024	0.08636382	0.013	81214
2018Q2	No	0.021	0.08335541	0.017	73194
2018Q3	No	0.015	0.08044838	0.021	98929
2018Q4	No	0.012	0.0797758	0.019	87642
2019Q1	No	0.019	0.07837183	0.014	77707
2019Q2	No	0.016	0.0766281	0.014	30293
2019Q3	No	0.018	0.07480184	0.009	109991
2019Q4	Yes	0.011	0.07476775	0.01	59287
2020Q1	Yes	-0.032	0.07379881	0.011	3203
2020Q2	Yes	-0.146	0.07680128	0.002	26948

2020Q3	Yes	-0.04	0.08575213	0	90739
2020Q4	Yes	-0.043	0.08265835	-0.003	100702
2021Q1	Yes	-0.009	0.08190898	0.01	74776
2021Q2	Yes	0.146	0.08026892	0.018	68534
2021Q3	Yes	0.04	0.07509776	0.029	89465
2021Q4	Yes	0.046	0.07103263	0.047	83964

Source : European Central Bank database.

Table 2. Monetary policy instruments during period 1 and period 2.

Time	**Response to shock**	**ECB key interest rate period 1**	**ECB asset purchase period 1** in million euro	**ECB asset purchase period 2** in million euro	**ECB funding for lending period 2** in million euro
2000Q1	No	0	0	0	0
2000Q2	No	0	0	0	0
2000Q3	No	0	0	0	0
2000Q4	No	0	0	0	0
2001Q1	No	0	0	0	0
2001Q2	No	0	0	0	0
2001Q3	No	0	0	0	0
2001Q4	No	0	0	0	0
2002Q1	No	0	0	0	0
2002Q2	No	0	0	0	0
2002Q3	No	0	0	0	0
2002Q4	No	0	0	0	0
2003Q1	No	0	0	0	0
2003Q2	No	0	0	0	0
2003Q3	No	0	0	0	0
2003Q4	No	0	0	0	0
2004Q1	No	0	0	0	0
2004Q2	No	0	0	0	0
2004Q3	No	0	0	0	0
2004Q4	No	0	0	0	0
2005Q1	No	0	0	0	0
2005Q2	No	0	0	0	0
2005Q3	No	0	0	0	0
2005Q4	No	0	0	0	0
2006Q1	No	0	0	0	0
2006Q2	No	0	0	0	0
2006Q3	No	0	0	0	0
2006Q4	No	0	0	0	0
2007Q1	No	0	0	0	0

2007Q2	No	0	0	0	0
2007Q3	Yes	0.05	0	0	0
2007Q4	Yes	0.05	0	0	0
2008Q1	Yes	0.05	0	0	0
2008Q2	Yes	0.05	0	0	0
2008Q3	Yes	0.0525	0	0	0
2008Q4	Yes	0.04	0	0	0
2009Q1	Yes	0.03	0	0	0
2009Q2	Yes	0.0225	0	0	0
2009Q3	Yes	0.0175	16856	0	0
2009Q4	Yes	0.0175	14252	0	0
2010Q1	Yes	0.0175	13790	0	0
2010Q2	Yes	0.0175	15102	0	0
2010Q3	No	0	0	0	0
2010Q4	No	0	0	0	0
2011Q1	No	0	0	0	0
2011Q2	No	0	0	0	0
2011Q3	No	0	0	0	0
2011Q4	No	0	0	0	0
2012Q1	No	0	0	0	0
2012Q2	No	0	0	0	0
2012Q3	No	0	0	0	0
2012Q4	No	0	0	0	0
2013Q1	No	0	0	0	0
2013Q2	No	0	0	0	0
2013Q3	No	0	0	0	0
2013Q4	No	0	0	0	0
2014Q1	No	0	0	0	0
2014Q2	No	0	0	0	0
2014Q3	No	0	0	0	0
2014Q4	No	0	0	0	0
2015Q1	No	0	0	0	0
2015Q2	No	0	0	0	0
2015Q3	No	0	0	0	0
2015Q4	No	0	0	0	0
2016Q1	No	0	0	0	0
2016Q2	No	0	0	0	0
2016Q3	No	0	0	0	0
2016Q4	No	0	0	0	0
2017Q1	No	0	0	0	0
2017Q2	No	0	0	0	0
2017Q3	No	0	0	0	0
2017Q4	No	0	0	0	0
2018Q1	No	0	0	0	0

2018Q2	No	0	0	0	0
2018Q3	No	0	0	0	0
2018Q4	No	0	0	0	0
2019Q1	No	0	0	0	0
2019Q2	No	0	0	0	0
2019Q3	No	0	0	0	0
2019Q4	Yes	0	0	0	3.4
2020Q1	Yes	0	0	15444	97.72
2020Q2	Yes	0	0	339542	114.92
2020Q3	Yes	0	0	212197	1308.43
2020Q4	Yes	0	0	189983	174.46
2021Q1	Yes	0	0	186481	50.41
2021Q2	Yes	0	0	240986	330.92
2021Q3	Yes	0	0	227658	110.35
2021Q4	Yes	0	0	185275	98.81

Source : European Central Bank website and database

Table 3. Macroeconomic and monetary policy data for Norway, from 2003Q1 to 2021 Q4.

Time	**Response to shock**	**GDP growth rate**	**Inflation rate** Adjusted Tax	**Unemployment rate**	**Current Account** in million NOK	**NB key interest rate**
2003Q1	No	0	0.0053333	0.04	56973	0
2003Q2	No	-0.005	-0.005333	0.042	48034	0
2003Q3	No	0.014	0.0016667	0.044	42407	0
2003Q4	No	0	0.0003333	0.043	58494	0
2004Q1	No	0.035	0	0.042	61935	0
2004Q2	No	0.002	0.0006667	0.042	56149	0
2004Q3	No	-0.012	0.001	0.044	53689	0
2004Q4	No	0.01	0.0003333	0.044	63106	0
2005Q1	No	0.016	-0.000333	0.044	77533	0
2005Q2	No	0.005	0.0036667	0.046	72895	0
2005Q3	No	0.008	0.0016667	0.046	76106	0
2005Q4	No	0.002	0	0.044	91695	0
2006Q1	No	0.006	0.0016667	0.039	112345	0
2006Q2	No	0.001	0.0026667	0.037	91343	0
2006Q3	No	0.01	0.0033333	0.033	85435	0
2006Q4	No	0.018	-0.001667	0.028	86173	0
2007Q1	No	0.001	-0.001333	0.027	81823	0
2007Q2	No	0	0.0003333	0.025	72066	0
2007Q3	Yes	0.013	0.0006667	0.025	69223	0.045
2007Q4	Yes	0.011	0.0096667	0.025	92110	0.05
2008Q1	Yes	-0.013	0	0.025	115188	0.0525

2008Q2	Yes	0	0.0006667	0.026	122020	0.055
2008Q3	Yes	-0.002	0.0076667	0.029	102522	0.0575
2008Q4	Yes	0.003	-0.001667	0.031	102016	0.0475
2009Q1	Yes	-0.008	0.0013333	0.03	76137	0.0225
2009Q2	Yes	-0.009	0.0036667	0.033	60736	0.02
2009Q3	Yes	0.001	0	0.033	58525	0.0125
2009Q4	Yes	0.001	0.0013333	0.035	81851	0.015
2010Q1	Yes	0.02	0.006	0.039	89503	0.0175
2010Q2	Yes	-0.011	-0.001	0.039	61197	0.0175
2010Q3	No	-0.025	-0.000333	0.036	52364	0
2010Q4	No	0.028	0.0046667	0.037	88999	0
2011Q1	No	0.001	-0.000667	0.032	89712	0
2011Q2	No	-0.004	0	0.034	88625	0
2011Q3	No	0.016	0.0006667	0.034	83220	0
2011Q4	No	0.001	0	0.035	97988	0
2012Q1	No	0.022	0.0023333	0.032	131948	0
2012Q2	No	0.002	-0.001667	0.032	93753	0
2012Q3	No	-0.014	0.001	0.032	70031	0
2012Q4	No	0.008	0.003	0.036	93966	0
2013Q1	No	0.002	0.002	0.037	97006	0
2013Q2	No	0.007	0.001	0.037	74173	0
2013Q3	No	0.01	0.0026667	0.038	65944	0
2013Q4	No	-0.002	0.0006667	0.038	96034	0
2014Q1	No	0.005	0.002	0.035	103687	0
2014Q2	No	0.007	0.0006667	0.033	65155	0
2014Q3	No	0.004	0.0036667	0.038	42978	0
2014Q4	No	0.012	0	0.038	81202	0
2015Q1	No	-0.003	0.002	0.043	57958	0
2015Q2	No	0.005	0.0033333	0.044	40310	0
2015Q3	No	0.012	0.0013333	0.046	39013	0
2015Q4	No	-0.009	0.0013333	0.048	41438	0
2016Q1	No	0.001	0.0046667	0.05	24090	0
2016Q2	No	0	0.0043333	0.048	4257	0
2016Q3	No	-0.003	0.0013333	0.048	2968	0
2016Q4	No	0.013	0.0006667	0.045	30015	0
2017Q1	No	0.01	0.0016667	0.043	45616	0
2017Q2	No	0.01	0.0026667	0.045	19386	0
2017Q3	No	0.007	0.0006667	0.041	19430	0
2017Q4	No	-0.006	0.0006667	0.04	30958	0
2018Q1	No	0.008	0.0023333	0.039	58937	0
2018Q2	No	0.003	0.004	0.039	35740	0
2018Q3	No	0.006	0.003	0.04	53756	0
2018Q4	No	0	0.001	0.037	55340	0
2019Q1	No	-0.003	0.002	0.038	45648	0

2019Q2	No	0.002	0.0006667	0.034	1930	0
2019Q3	No	0.002	0.0016667	0.037	-15794	0
2019Q4	Yes	0.014	0.0003333	0.04	21020	0.015
2020Q1	Yes	-0.013	-0.000333	0.035	9663	0.015
2020Q2	Yes	-0.047	0.0036667	0.046	-26250	0.0025
2020Q3	Yes	0.045	0.003	0.053	-18556	0
2020Q4	Yes	0.006	0	0.05	6497	0
2021Q1	Yes	0	0.0056667	0.047	63570	0
2021Q2	Yes	0.008	0.0016667	0.05	63574	0
2021Q3	Yes	0.039	0.007	0.04	131596	0
2021Q4	Yes	0.001	0.008	0.035	257468	0.0025

Sources : Norges bank for key interest rate and SSB for macroeconomic data
* 1 NOK = 0.10 euro