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European Central Bank and Unconventional Monetary Policy: Spillover Effects

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Academic year 2021/2022

Abstract

The purpose of this study is to investigate the impact of unconventional monetary policy measures implemented by the European Central Bank (ECB) during the 2008 financial crisis and the sovereign debt crisis on four macroeconomic indicators. The study uses a factor model and a spillover model to analyze the impact of the ECB's announcements on the selected indicators. The analysis takes into account data from five different countries and reveals that the effects of unconventional monetary policy on the indicators vary depending on the country under consideration. The results suggest that there is a recursive relationship between the FRFA and inflation, and that the macroeconomic indicators not only have interconnections but also have self-influences.

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Chapter 1

Introduction

The global financial crisis of 2008 and the subsequent sovereign debt crisis had a profound impact on the world economy. In response to these challenges, central banks around the world implemented unconventional monetary policy measures to stabilize the financial markets and boost economic activity. The European Central Bank (ECB) was one of the central banks that took such measures to counter the effects of the crisis. The purpose of this thesis is to examine the impact of the unconventional monetary policy measures implemented by the ECB during the financial crisis of 2008 and the sovereign debt crisis on macroeconomic indicators. The study employs a factor model, following the paper of Swanson [2021] and a spillover model as described by Diebold and Yılmaz [2014] to analyze the effects of the ECB's announcements on four key macroeconomic indicators, namely Consumer Price Index (CPI), Retail Sales, Consumer Confidence, and Unemployment. The study takes into consideration data from five countries in the Eurozone: Italy, Spain, Austria, France, and Finland. These countries were carefully selected as they offer a diverse representation of the effects of unconventional monetary policy in the region. Italy and Spain, which experienced sovereign tensions, were the countries where the ECB implemented the Securities Market Programme (SMP), while Austria, France, and Finland are countries that are highly rated in the euro area. This division follows the work of Fratzscher et al. [2016]. To assess the impact of unconventional monetary policy on the selected macroeconomic indicators, the study collected data on the changes in the indicators one, three, and six months after the most significant announcements made by the European Central Bank. A factor model was then applied to these observations to determine the relationship between the changes in the indicators and the announcements. To further explore the interconnections between the indicators, the study also employs a spillover model and uncertainty indices to examine how changes in one indicator can affect the others.

This research offers valuable insights that can be useful for researchers and policymakers in challenging times. Despite the differences in the results for each country, the factor model and spillover model reveal some recurring patterns between the policies and the indicators. These findings can prove beneficial for decision-making during critical moments. The remainder of this work is organized as follows. In Chapter 1, we provide a brief overview of the measures taken by the ECB during the financial crisis; in Chapter 2 we will present the data and the two main methodological frameworks that we have used throughout the work; in Chapter 3 we will provide the results obtained; in the end, we provide the conclusions.

Chapter 2

ECB Unconventional Monetary Policy

In Europe, the economic and financial state created by the 2008 crisis in the US escalated in 2010 into a banking and sovereign crisis. Since 2007, the central banking authorities have faced a new and unexpected situation generated by the impossibility of lowering interest rates, requiring new policy responses, the so-called unconventional policies.

The general uncertainty concerning the health of banks' balance sheets led to an increase in the spread between the risk less rate and Euribor, a riskier interbank rate (see Fig. 2.1).

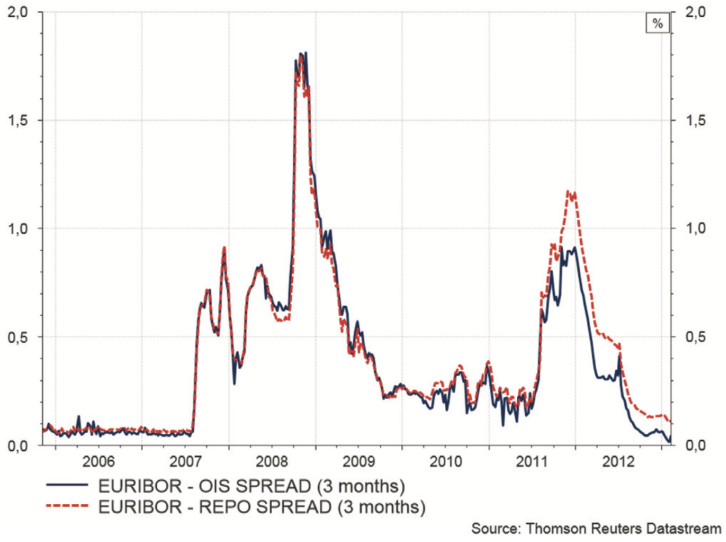


Figure 2.1: Money Market Spreads in the Eurozone

The ECB implemented various measures to address the increasing tension in the interbank market, including announcements of the fixed-rate full allotment procedure (FRFA), three-year refinancing operations, and

setting the deposit rate to zero, which was a first for the ECB. According to Szczerbowicz [2018], the most significant unconventional policy measures are depicted in Fig. 2.2.

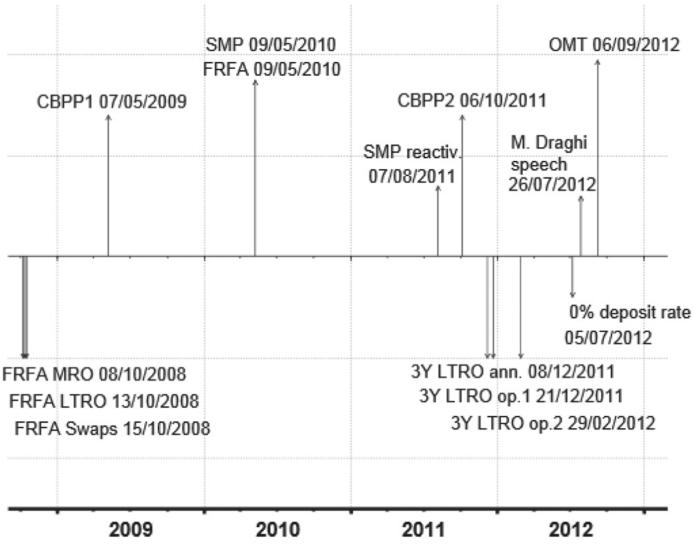


Figure 2.2: Timeline of Unconventional Policy Announcements

2.1 Unconventional Monetary Policy Actions

2.1.1 Fixed Rate Full Atonement Procedure (FRFA)

The FRFA can be considered part of the set of unconventional policies taken by the ECB during the crisis. Typically, refinancing operations were carried out through variable-rate offerings. With the fixed-rate procedure, banks were able to secure their liquidity needs with the specified interest rate known in advance. On October 8th, 2008, the ECB announced that all main refinancing operations would be conducted through a fixed-rate procedure. The variable-rate tender was reinstated in March 2010, but it was quickly discontinued due to the critical situation in Greece.

2.1.2 LTRO, SMP and OMT

In a more specific manner, we can highlight different types of policies adopted by the ECB between 2007 and 2012, which include supplementary long-term liquidity provisions (SLTROs), the Securities Market Program (SMP), and the Outright Monetary Transactions (OMT).

Supplementary Long Term Liquidity Provisions

The ECB altered the maturity structure of its liquidity-providing operations by offering collateralized loans over a longer period, with the aim of addressing illiquidity in the euro area money markets. In addition to the standard three-month long-term refinancing operations (LTROs/SLTROs), six-month SLTROs and 12-month SLTROs were introduced in March 2008 and May 2009, respectively. Six-month SLTROs reached around 160 billion euros in March 2009, while 12-month SLTROs peaked at around 660 billion euros between late 2009 and early 2010. During the 2011 sovereign debt crisis, the ECB announced two "very" long term refinancing operations (VLTROs) with a maturity of three years, allocating a total of 1,019 billion euros (Fratzscher et al. [2016]). The main goal of the liquidity provisions was to restore the smooth functioning of the interbank market and extend credit to firms and households.

These liquidity measures can stabilize the interbank market in several ways, such as avoiding credit crunches caused by illiquidity and ensuring that liquidity-constrained banks can accumulate liquidity through precautionary means, without having to resort to fire sales of assets and driving down their values (Szczerbowicz [2018]).

Securities Market Programme (SMP)

During a financial crisis, the central bank may choose to alter the composition of its balance sheet, particularly with regards to assets, by purchasing securities that are experiencing liquidity issues. This action is referred to as credit easing. The impact of credit easing can be measured through the portfolio rebalancing effect. If the securities are not perfect substitutes, reducing the quantity of an asset will increase its price and lower its yield, as explained by Bernanke [2010].

The sovereign debt crisis heightened the default risk of sovereign bond markets, causing participants to price not only default risk but also the probability of some member state exiting the eurozone. Fig. 2.3 illustrates the different spreads across Europe during the crisis, and it is evident that countries with higher spreads faced a more severe crisis and were covered by the SMP.

On May 2010, the ECB announced that it would make direct purchases of government bonds on secondary markets. These measures were implemented to address tensions that were impacting the monetary policy transmission mechanism.

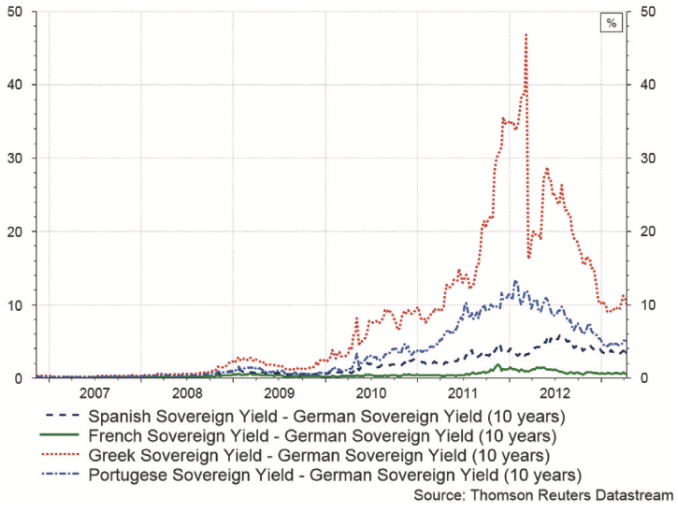


Figure 2.3: Sovereign Bond Spreads in the Euro-Zone Countries

Initially, in May 2010, the purchases were limited to Greek, Portuguese, and Irish government bonds. In August 2011, the SMP was expanded to include Italian and Spanish government bonds. By 2012, as a result of the program, the ECB held around 220 billion euros in sovereign bonds. The ECB intervened by purchasing government bonds on a potentially daily basis, without focusing on a specific price or quantity.

Outright Monetary Transactions (OMTs)

In September 2012, the ECB announced the introduction of a new policy instrument, the OMT, aimed at repairing the monetary policy transmission mechanism and containing redenomination risk. The OMT consisted of the possibility of purchasing government bonds issued by countries under a European Stability Mechanism (ESM) macroeconomic program or a precautionary program.

Compared to the SMP, the OMT had several differences. Firstly, the maturity of the bonds purchased was limited to three years, whereas the SMP purchased longer-term bonds. Secondly, the ECB would only purchase sovereign debt if the government accepted precautionary measures set by the European Financial Stability Facility (EFSF) or the ESM. Thirdly, the ECB chose to abandon its seniority status with respect to private lenders. Finally, once a country met all the requirements, the ECB would act without limits, unlike the SMP which was limited.

The announcement of the OMT was sufficient to calm markets, and the ECB did not have to purchase any sovereign bonds within it.

2.2 Channels of Transmission

It is possible to find different ways of classifying the potential transmission channels of unconventional monetary policy. Regarding the ECB policies, Fratzscher et al. [2016] identify four channels:

- Confidence Channel: it refers to the idea that by taking decisive actions, the European Central Bank (ECB) can restore confidence in the financial system, which in turn leads to a decrease in risk premiums and uncertainty, resulting in a positive impact on asset prices.
- Bank Credit Risk Channel: Addressing the liquidity concerns of banks could lower the credit risk in the banking sector, thereby increasing asset prices by reducing the overall risk premiums.
- Sovereign credit risk channel: The intermediate objective of the ECB's SMP and OMT policies was to restore the transmission mechanisms of monetary policy by reducing sovereign risk premiums.
- International Portfolio Balance Channel: This channel represents the possibility of transmitting the effects of asset purchases to asset prices across markets and countries.

Chapter 3

Methodology and Data

In this section are described the empirical strategy used to assess the impact of the policies from the central bank and the data used to implement them.
The section will begin with an overview of the data and later will briefly describe the methodology applied.

3.1 Data

Every indicator was taken for five different countries, a group of highly rated euro area countries (Austria, France and Finland) and a group of countires the experienced sovereign tensions (Italy and Spain), following the approach of Fratzscher et al. [2016].
The data come from Bloomberg and have a monthly frequency, which gives the possibility to compute their percentage changes after one, three and six months from the most important announcements of unconventional monetary policy of the ECB during the period 2008-2012, as described by Szczerbowicz [2018].

As macro indicators we considered:

- Consumer's Confidence: this index provides an insight on household's future consumption and savings, basing on answers regarding their financial situation. A value above 100 indicates that consumers are less prone to save and are more keen to spend in next 12 months, if the value is under 100, it indicates the opposite.
- Consumer Price Index: This indicator measures inflation measured from the changes in prices from a basket of goods, which are typically purchased from a selected group of consumers.

- Retail Sales: represent a key macroeconomic metric that tracks consumer demand for finished goods.The retail sales report helps analysts and investors gauge the health of the economy and any inflationary pressures that may exist.
- Unemployment: the unemployed are people of working age who are without work, are available for work, and have taken specific steps to find work. The uniform application of this definition results in estimates of unemployment rates that are more internationally comparable than estimates based on national definitions of unemployment. This indicator is measured in numbers of unemployed people as a percentage of the labour force and it is seasonally adjusted.

3.2 Swanson's Model

Eric T. Swanson in his elaborate Swanson [2021], aims to compute the effects of the FED's unconventional monetary policy measures on a diversified set of financial indicators. His work starts from Gürkaynak et al. [2004] and extends it to separately identify three main policies adopted by the FED during the financial crisis.

In this elaborate, we started from the model he adopted and changed the data used to do the empirical work. The responses of the macroeconomic indicators are collected in three $T \times n$ matrices, X, where the rows correspond to every ECB announcements and the columns to the different indicator; each element x_{ij} of the matrices reports the variation after, respectively, 1, 3 and 6 months, of the jth indicator to the ith ECB announcement. These matrices can be thought as a factor model:

$$X = F\Lambda + \varepsilon \tag{3.1}$$

F is a $T \times k$ factor matrix containing $k \leq n$ unobserved factors, Λ is a $k \times n$ matrix of loadings of the indicator responses on the k factors, ε is a $T \times n$ matrix containing white noise residuals that is uncorrelated over time and across assets. This method has been applied to every country taken into consideration in this elaborate.

From this factor model is possible to compute the factor matrix F and the loadings matrix Λ through a singular value decomposition method, which states that every complex $m \times n$ matrix M can be decomposed in the following way:

$$M = U\Sigma V^* \tag{3.2}$$

Where the matrix U is a $m \times m$ unitary matrix, Σ is a $m \times n$ rectangular diagonal matrix and V is a $n \times n$

complex unitary matrix.

We identify the factor matrix F from equation 3.1 as the first k columns of matrix U from equation 3.2 and the matrix Λ from equation 3.1 as the first k rows of the matrix ΣV^* from equation 3.2.

The number k is computed as the rank of the factor model computed following Cragg and Donald [1997] and Gürkaynak et al. [2004]. The Cragg-Donald test, given a null hypothesis of rank k_0 and an alternative hypothesis $k > k_0$, searches over all possible models with k_0 factors to find the one whose residuals ε are as close as uncorrelated white noise as possible, after that, the test computes the distance between the residuals and the white noise with a Wald statistic.

In this study, we analyze a period where various policies were implemented and some discontinued. To effectively evaluate this period, we perform our analysis using two different models. The first model uses a matrix X that contains the variations of the indicators prior to the replacement of the Securities Market Programme (SMP) with the Outright Monetary Transactions (OMT) policy., as we can see from figure 2.2 in chapter 2.

In the continue of this chapter, we will show the results from our analysis of the five different countries we took into consideration.

3.3 Spillover Model

After the computation of the loadings and factors trough the factor model explained in section 3.2, we implement a methodology created by Balli et al. [2019] in order to compute a spillover network which considers our indicators for the five different countries.

The first step is to use a generalized dynamic factor model (GDFM), which can become a dynamic factor model (DFM) if the order of factor loadings is finite. According to Bai and Ng [2008], considering the number of cross sectional units to be N and considering T the number of observations taken for time series, the DFM for $i = 1,\ldots,N$ and $t = 1,\ldots,T$ is defined as follows:

$$z_{it} = \beta_i(L) f_t + \mu_{it} \tag{3.3}$$

Where f_t is a common factor vector and L is a lag operator. β_i is a loading vector linked with f_t, while $\beta_i(L) = (1 - \beta_{i1}L -, \ldots, -\beta_{is}L^s)$ indicates the dynamic factor loadings vector linked with the order s. μ_{it} indicates the idiosyncratic element of $z_i t$. Stock and Watson [2010] presented examples of DFM, which can

be written in the form:

$$\underset{(N\times T)}{Z} = \underset{(N\times r)}{B}\underset{(r\times T)}{F} + \underset{(N\times T)}{\mu} \tag{3.4}$$

In the first phase is possible to compute the idiosyncratic element of the model trough the following process:

$$\mu_{it}^{u} = Z_{it} - \hat{A}_{it} \tag{3.5}$$

Where $\hat{A}_{it} = \beta_i(L) f_t$.

From equation 3.5 a stochastic volatility model is identified on an individual level as:

$$\mu_t^u = \mu^{\frac{h_t}{2}} \varepsilon_t \tag{3.6}$$

$$h_t = \delta + \psi(h_{t-1} - \delta) + \sigma \nu_t \tag{3.7}$$

Following the methodology proposed by Kastner and Frühwirth-Schnatter [2014] the idiosyncratic stochastic volatilities h_{it} from equation 3.7 are computed and therefore is possible to calculate the individual uncertainty index V_t as the simple average of the volatilities:

$$V_t = \frac{\sum_{i=1}^{N} h_{it}}{N} \tag{3.8}$$

The uncertainty index is an economic indicator that measures the level of uncertainty faced by producers and consumers. It reflects the level of risk and unpredictability faced by producers and consumers, as well as their ability to make informed decisions about buying and selling goods. A high value indicates a high level of uncertainty and unpredictability, while a low value indicates a more stable and predictable market. This indicator is used by economists, policymakers, and investors to understand the overall health of the commodity market and the potential impact of commodity price changes on the wider economy.

Following the model of Diebold and Yılmaz [2014] and Koop et al. [1996], we employ a variance decomposition matrix to build different connectedness measures. In the connectedness table, the element $c_{ij}^{g(H)}$ measures the pairwise directional connectedness from j to i as:

$$C_{i\leftarrow j}^{H} = c_{ij}^{g(H)} \tag{3.9}$$

The off-diagonal sum of rows represents the toal directional connectedness from other i as:

$$C_{i\leftarrow\cdot}^{H} = \sum_{\substack{j=1 \\ j\neq i}}^{N} c_{ij}^{g(H)} \tag{3.10}$$

The off-diagonal sum of columns represents the total directional connectedness to others from j as:

$$C^{H}_{\cdot \leftarrow j} = \sum_{\substack{i=1 \\ i \neq j}}^{N} c^{g(H)}_{ij} \tag{3.11}$$

At last the total connectedness is the ratio of the sum of the to-others (from-others) elements of the variance decomposition matrix:

$$C^{H} = \frac{1}{N} \sum_{\substack{i,j=1 \\ i \neq j}}^{N} c^{g(H)}_{ij} \tag{3.12}$$

The graphical visualization of the connectedness table will be represented in the chapter below, where the individual indicators are represented as nodes and the arrows represent the pairwise connectedness among them.

Chapter 4

Empirical Analysis

In this chapter we report the results obtained from the methodology described in section 3. This chapter is organized into two main sections. The first section presents the results of the analysis for Spain and Italy, while the second section presents the results for Austria, France, and Finland.

4.1 Italy and Spain

In August 2011, the ECB announced the implementation of the Securities Market Programme (SMP) in Italy and Spain. As noted by Casiraghi et al. [2013], it is important to understand that the effects of these policies on a single country can only be partially explained due to the fact that they were aimed at the entire Eurozone. The situation in Spain and Italy provides a clear illustration of this point. As described by Royo and Royo [2020], the crisis in Spain was managed differently than in Italy, with Spain entering the crisis on a strong economic footing, while Italy was already facing political instability.

We performed a Cragg and Donald test [Cragg and Donald, 1997] on the two matrices of variation and determined that a rank of 3 would fit the data optimally. This result supports our analysis, suggesting that monetary policy has multiple dimensions that impact the macroeconomic environment. Interestingly, the effects of monetary policy on macroeconomic indicators can be effectively summarized by just three factors. We identified these three factors as FRFA, LTRO, and SMP before 2012. After 2012, the SMP was substituted with the OMT in our sample.

4.1.1 Italy

Table 4.11 shows the loadings matrix $\tilde{\Lambda}$ for the variations in the SMP and OMT periods across the three samples considered. The results suggest that the impact of the SMP and OMT programs was minimal on the indicators studied.

The SMP seemed to have a limited effect, with the only noticeable impact being on the Consumer Confidence (CC) indicator. This could be because the announcement itself had an effect on the individuals. Since both SMP and OMT were aimed at influencing financial markets, the effects on macroeconomic indicators might have diminished after a month from the policy announcement. Regarding the FRFA and LTRO, they had a minor impact on the indicators in the one-month window. FRFA contributed to reducing the inflation and unemployment rates and had a negative effect on retail sales. LTRO had a negative effect on retail sales in the first period and a positive effect in the second. It's worth noting that these indicators can be influenced by multiple factors, and thus, only a small fraction of their variation can be attributed to ECB policies.

The trend remained the same for all indicators after three months. Focusing on the SMP, a change in the effect on unemployment was observed after three months, with a negative effect on unemployment and a reduced negative effect on consumer confidence. In the case of the OMT, it had no significant effect on the indicators within the first month, as its primary focus was on financial markets and the mere announcement was sufficient to calm them. The effects of the FRFA remained unchanged for both samples, with a slight reduction in intensity. The LTRO had a positive impact on retail sales and a negative impact on unemployment in both samples, which was opposite to the one-month period.

After six months, the SMP and OMT showed similar patterns as in the previous periods. The FRFA had the same effects on the inflation rate for both samples and a positive impact on retail sales in both periods, except for the pre-OMT sample after three months. Its effects on unemployment and consumer confidence remained unchanged, with the exception of a positive impact on unemployment in the post-OMT sample. In the case of the LTRO, some of its effects changed between the two periods considered. The effects on retail sales and consumer confidence had the opposite sign in the pre-OMT sample compared to the three-month period. The same was true for consumer confidence in the post-OMT sample. However, it's important to note that the effects on consumer confidence were negative but very small in both samples.

Variance of the errors

In a factor model, the variance of the errors refers to the amount of unexplained variation in the dependent variable that remains after accounting for the influence of the factors or predictors. In other words, it represents the residual variation in the dependent variable that cannot be explained by the factors in the model. The variance of the errors is an important component of a factor model as it helps to determine the goodness-of-fit of the model and the reliability of the results. A low variance of the errors indicates that the model fits the data well and that the factors explain a significant portion of the variation in the dependent variable. Conversely, a high variance of the errors suggests that the model may not fit the data well and that the factors are not explaining a significant portion of the variation.

In order to validate our model, we estimated the variance of the errors, this estimation helps us assess the robustness of our results over different time periods and determine whether changes in our indicators are primarily driven by the unconventional monetary policy decisions made by the ECB.

As observed in Table 4.1, the variance of errors grows as the time window expands. This phenomenon can be attributed to the fact that a wider time window encompasses more fluctuations and complexities in the macroeconomic indicators, thus resulting in a higher variance of errors.

	CPI	**RETAIL**	**UNEMP**	**CC**
1 Month				
SMP Period	0,012	0,008	0,002	0,000
OMT Period	4,23E-31	1,32E-31	1,23E-32	8,63E-32
3 Months				
SMP Period	0,107	0,012	0,038	0,041
OMT Period	7,50E-32	1,24E-32	7,81E-32	1,34E-32
6 Months				
SMP Period	0,129	0,065	0,020	0,012
OMT Period	9,74E-31	2,93E-31	1,67E-31	1,48E-31

Table 4.1: Table containing the variance of the errors for Italy.

Furthermore, it is evident from Table 4.1 that the variance of errors in the first period is significantly lower

than that of the variances computed in the three-month and six-month windows. This disparity can be explained by the fact that as the horizon extends, the model can only capture a portion of the effects that the announcements have on the indicators, as their variations may be influenced by a multitude of external factors. Particularly, it is noticeable that the Consumer Price Index (CPI) has the highest variance of errors, implying that inflation is more susceptible to external shocks compared to the other indicators.

Focusing on the OMT period, it is possible to notice that all the variances are 0, this can come from two main reasons: when all the variances of the error from a factor model with a low number of inputs are 0, it means that the model is perfectly fitting the data. In other words the model is able to explain all the variations in the output variables with the given inputs. However, this is typically not a realistic scenario in real-world applications, as there is usually some degree of noise or unexplained variation in the data. In this case, it could indicate overfitting, where the model is too complex for the amount of data available and has learned to fit the noise in the data, rather than the underlying relationship. Therefore, since the amount of inputs in the model is low, another kind of model should be used to analyze the data. Alessi and Kerssenfischer [2019] explain the fact that factor models take into consideration large information sets, therefore they could be overfitting for a small number of data like the one used in this work.

Uncertainty Index

In our analysis, we also calculated the uncertainty index, as outlined in section 3.3. Our findings are presented in Table 4.2, where we show the uncertainty index for several important unconventional monetary policy announcements made by the ECB, and we examine the effects of these announcements on the macroeconomic indicators one, three, and six months after the announcement.

A higher value of the uncertainty index, i.e. greater than 100, suggests that the announcement had a greater impact on the variation of the macroeconomic indicators and therefore a higher degree of uncertainty. For example, for the one-month time window, the event "CBPP 05/2009" has an uncertainty index of 223.12, which is significantly higher than 100 and suggests a greater impact on macroeconomic indicators compared to the other events in the one-month time window. On the other hand, the event "FRFA 10/2008" has an uncertainty index of 59.85 after one month. This suggests that the macroeconomic indicators experienced greater variation and uncertainty in response to the "CBPP 05/2009" event compared to the "FRFA 10/2008" event. For some indicators, it is also possible to notice that, as time passes, the uncertainty related to them increases or decreases, implying a greater variation of the indicators. For example, the 0% announcement

	One Month	Three Months	Six Months
FRFA 10/2008	$59,85^{**}$	$32,47^{**}$	$166,08^{**}$
CBPP 05/2009	$223,12^{**}$	$148,90^{**}$	$47,67^{**}$
SMP,FRFA 05/2010	$165,82^{**}$	$185,63^{**}$	$123,47^{**}$
SMP Reactiv. 08/2011	$33,51^{**}$	$19,19^{**}$	$83,97^{**}$
CBPP2 10/2011	$100,67^{**}$	$118,64^{**}$	$128,86^{**}$
3Y LTRO 12/2011-02/2012	$17,02^{**}$	$95,18^{**}$	$49,96^{**}$
0% Deposit Rate 07/2012	$124,00^{**}$	$78,28^{**}$	$0,00^{**}$
M.Draghi Speech 07/2012	$154,80^{**}$	$107,40^{**}$	$160,77^{**}$
OMT 09/2012	$21,20^{**}$	$114,31^{**}$	$139,23^{**}$

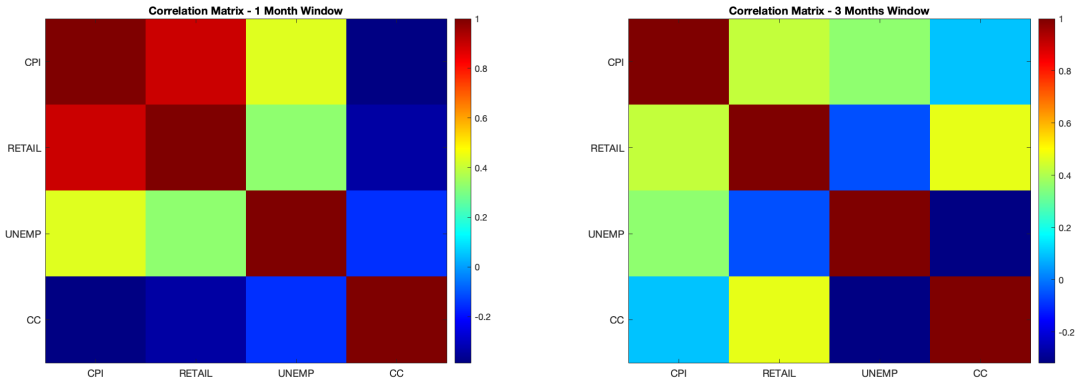
Table 4.2: Table containing the Uncertainty Index for the unconventional ECB measures in Italy. ** represents the significance level at 5%.

varies between 124 and 0 in six months, as well as the event "CBPP 05/2009", which varies between 223,12 to 47,67.

The findings of our analysis of the uncertainty index suggest that the impact of ECB unconventional monetary policy announcements was consistently characterized by high levels of uncertainty in Italy. This could reflect the difficult economic circumstances that the country faced during both the financial and sovereign debt crisis, leading to heightened uncertainty among consumers and a subsequent impact on the variation of macroeconomic indicators.

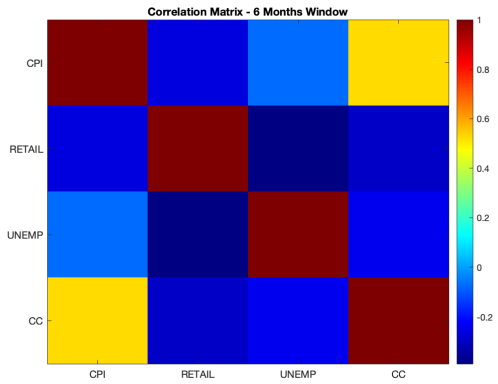
Correlation between indicators and spillover network

Furthermore, our analysis of the correlation and spillover network between the four indicators in Italy, across the three different time frames, highlights the interrelated nature of these indicators. These results demonstrate that the changes in one indicator can have a significant impact on the other indicators, implying a complex and interconnected system. The variations of the Retail Sales and Consumer Price Index (CPI) indicators are strongly positively correlated after one month, as seen in Fig. 4.1. However, as time passes, their correlation becomes weaker. Initially, an increase in the inflation index may boost sales, but after six months, the relationship appears to be inverse, with the two indicators showing a negative correlation. The



(a) Correlations after 1 Month

(b) Correlations after 3 Months



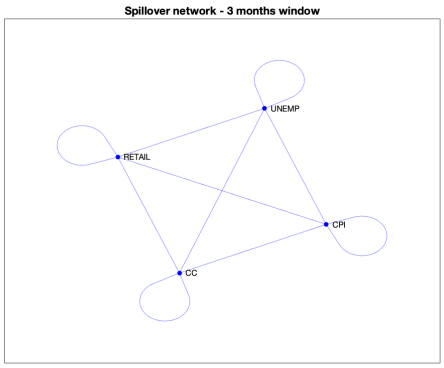
(c) Correlations after 6 Months

Figure 4.1: Heatmaps reporting the corretlations between the four macroeconomic indicators after 1, 3 and 6 months from the ECB announcements in Italy.

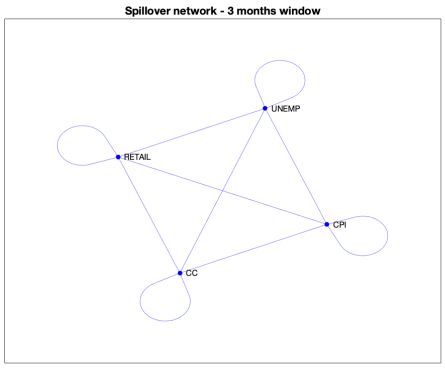
variation of inflation also has a strong negative impact on consumer confidence initially, but after 6 months, the effects are reduced.

The consumer confidence indicator is also negatively influenced by a positive variation of unemployment, which also has a negative effect on retail sales, with the latter effect becoming increasingly pronounced over time.

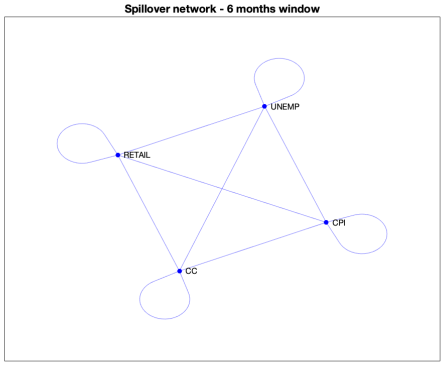
Furthermore, by examining the spillover network as outlined in Section 3.3, our findings indicate that not only are the changes in the indicators interdependent, but also that a change in one indicator can create a change in itself. For example, if there is an expectation of an increase in inflation, it can lead to actual high inflation, as described by Mishkin [2010]. This phenomenon is known as "expectations-augmented inflation". The results of the spillover network analysis are illustrated in Fig. 4.2.



(a) Spillover Network - 1 Month



(b) Spillover Network - 3 Months



(c) Spillover Network - 6 Months

Figure 4.2: Spillover Network reporting the relations between the variations of the indicators in Italy.

4.1.2 Spain

In this section, we analyze the same indicators for Spain using the same method as we did for Italy. The results are presented in Table 4.12. When comparing the results from Table 4.12 with those from Table 4.11, we can observe similar effects in the one-month sample with a few exceptions, such as the positive impact on unemployment in Spain due to FRFA. These variations can be attributed to the influence of multiple factors, not just the ECB's monetary policies. For the post-SMP sample, the results are similar to those in Italy, except for the negative effect on retail sales from the FRFA.

The three-month period shows that FRFA has the same effect on inflation in both countries (-0.91 in Spain and -0.86 in Italy), but opposite effects on retail sales and unemployment. Consumer confidence remains unchanged in both countries. The effects of LTRO are opposite in Spain and Italy, reflecting the fact that the policies were implemented at different times and had different impacts on the two countries. As stated by

Falagiarda and Reitz [2015], the cumulative effect of LTRO events was only significant in Ireland and Italy When considering the OMT sample, we see similar effects of FRFA for both Italy and Spain, but different effects of LTRO. In Spain, the policies had a negative impact on retail sales and unemployment, but positive impact on consumer confidence. However, these effects are not statistically significant.

Finally, focusing on the effects after six months from the announcement, we see that FRFA had a positive impact on inflation, retail sales, and consumer confidence in both Italy and Spain during the 2008-2012 period. LTRO had a positive impact on consumer confidence, but a negative impact on retail sales during the SMP period and a negative effect on retail sales and consumer confidence during the OMT period. Although the effects of OMT are zero in all periods, it may be due to the fact that OMT was never fully implemented and was mainly used to stabilize financial markets, with little impact on macroeconomic indicators.

Variance of the errors

To assess the efficiency of our model, we computed the variance of the errors as a measure of its goodness of fit. The results of this computation are presented in Table 4.3. The analysis of the variance of the errors helps us determine if the model is capable of accurately capturing and explaining the variations of the indicators over time.

	CPI	**RETAIL**	**UNEMP**	**CC**
1 Month				
SMP Period	0,060	0,046	0,000	0,012
OMT Period	2,01E-31	2,41E-31	1,48E-31	1,21E-31
3 Months				
SMP Period	0,006	0,043	0,004	0,033
OMT Period	3,08E-31	1,17E-31	3,00E-32	1,27E-31
6 Months				
SMP Period	0,004	0,015	0,000	0,022
OMT Period	1,23E-32	1,77E-31	1,13E-31	4,93E-32

Table 4.3: Table containing the variance of the errors for Spain.

The results suggest that the model is a good fit for the sample, especially during the SMP period, across all

the time windows considered. This is evident from the small variances observed and a general tendency for these variances to decrease over time.

In particular, the model appears to capture a significant portion of the variations in the Consumer Price Index (CPI), especially after three and six months. This result aligns with the close relationship between inflation and monetary policy decisions made by the ECB.

Additionally, the model demonstrates a good fit for the Retail Sales, Consumer Confidence, and Unemployment indicators, effectively explaining a substantial part of their variations.

Uncertainty Index

By conducting an analysis of the uncertainty index, as outlined in section 3.3, we aimed to gain a comprehensive understanding of the impact of ECB policies. The results of our analysis are presented in Table 4.4. According to the results reported in Table 4.4, the reactivation of the SMP program in August 2011

	One Month	**Three Months**	**Six Months**
FRFA 10/2008	$150,17^{**}$	$81,13^{**}$	$58,08^{**}$
CBPP 05/2009	$63,50^{**}$	$124,41^{**}$	$105,20^{**}$
SMP,FRFA 05/2010	$86,33^{**}$	$67,49^{**}$	$13,42^{**}$
SMP Reactiv. 08/2011	$190,42^{**}$	$88,73^{**}$	$226,67^{**}$
CBPP2 10/2011	$41,01^{**}$	$211,27^{**}$	$59,91^{**}$
3Y LTRO 12/2011-02/2012	$68,57^{**}$	$26,98^{**}$	$136,72^{**}$
0% Deposit Rate 07/2012	$114,04^{**}$	$34,37^{**}$	$116,83^{**}$
M.Draghi Speech 07/2012	$117,35^{**}$	$198,28^{**}$	$91,33^{**}$

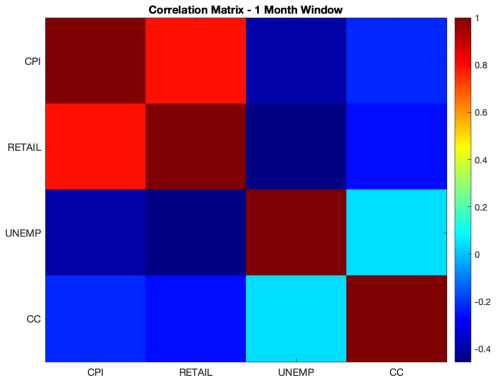
Table 4.4: Table containing the Uncertainty Index for the unconventional ECB measures in Spain. ** represents the significance level at 5%.

generated the highest level of uncertainty and subsequent fluctuations in the indicators. This is due to the fact that Spain, along with Italy and Greece, received support from the ECB through the SMP program, and the reactivation of the program could imply a concerning state of the economy. On the other hand, the 2010 SMP, which was not activated for Spain and Italy, did not result in high levels of uncertainty or fluctuations in the indicators.

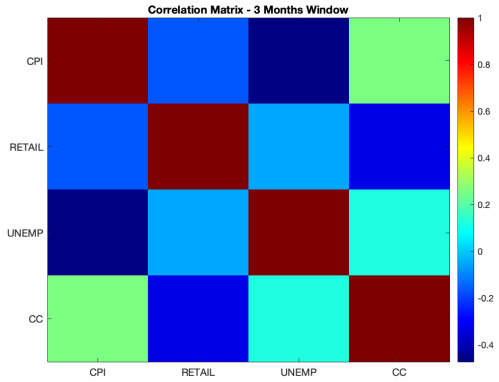
During the sovereign debt period, there was a general trend of high uncertainty, as evidenced by the analysis of the uncertainty index. The 0% deposit rate and the speech given by Mario Draghi were associated with high levels of uncertainty throughout all three time windows considered. Additionally, the two announcements of fixed rate full allotment were followed by initial high levels of uncertainty, which diminished noticeably after three and six months.

Correlation between indicators and spillover network

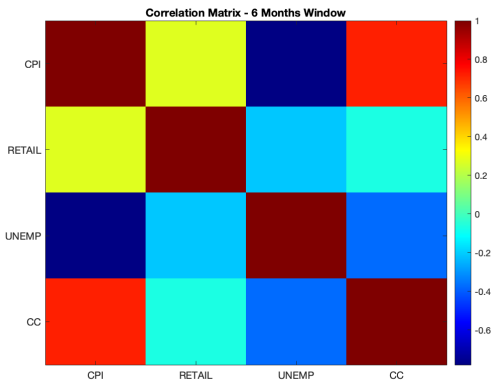
The correlation matrix computed between the variations of the indicators provides valuable insights into the interdependence of the indicators after the ECB announcements. Fig. 4.3 presents the heatmaps of these correlations over a period of one, three, and six months after the announcements.



(a) Correlations after 1 Month



(b) Correlations after 3 Months



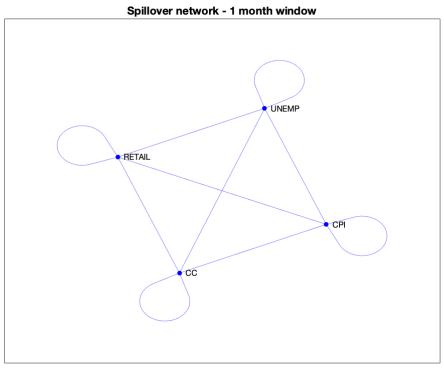
(c) Correlations after 6 Months

Figure 4.3: Heatmaps reporting the corretlations between the four macroeconomic indicators after 1, 3 and 6 months from the ECB announcements in Spain.

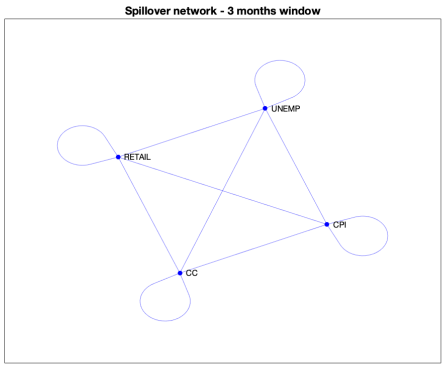
It is observed that after one month from the ECB announcements, there is a strong and positive correlation

between inflation and retail sales, which gradually decreases over time. After six months, the correlation between the two indicators remains positive but with a lower level of correlation compared to the one month window. The relationship between the CPI index and unemployment is negatively correlated, with a strong negative effect on unemployment for all periods, while it has an increasingly positive effect on consumer confidence. Furthermore, the relationship between unemployment and retail sales is also negatively correlated for all periods, but this correlation becomes weaker over time. Meanwhile, retail sales and consumer confidence are negatively correlated throughout the considered periods, but this correlation becomes increasingly weak.

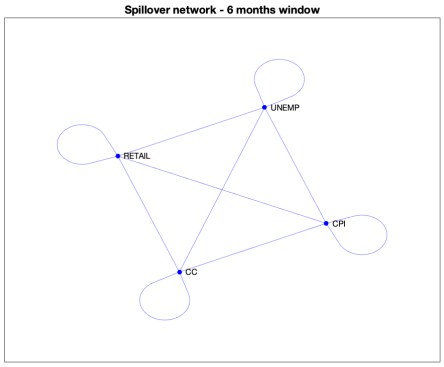
As depicted in Fig. 4.4, the results from the spillover network analysis show that, similarly to the case of Italy, not only are the variations of the indicators influenced by one another, but also that a variation in an indicator creates a variation in itself for all the periods considered.



(a) Spillover Network - 1 Month



(b) Spillover Network - 3 Months



(c) Spillover Network - 6 Months

Figure 4.4: Spillover Network reporting the relations between the variations of the indicators in Spain.

4.2 Austria, France and Finland

As outlined by Fratzscher et al. [2016], we will now consider the effects of the SMP and OMT programs on three countries where they were not implemented. Although we expect the impact of these policies to be minimal or absent, it is possible that they still may have some effect on the indicators of these countries due to their membership in the economic union. Additionally, these indicators may be influenced by various other factors, such as political decisions, fiscal policies, and other socio-economic drivers.

As described in section 4.1, we utilized the methodology of Cragg and Donald [1997] to analyze the effects of the ECB's monetary policies on these countries, and we obtained similar results as previously seen for Italy and Spain. We can surmise that the three key factors in the SMP sample may consist of FRFA, LTRO, and SMP, while the factors in the OMT sample may include the same, but with OMT replacing SMP.

4.2.1 Austria

As explained by Norris and Byrne [2018] the Austrian economy entered recession following the global financial crisis but this downturn was modest and short-lived. The Austrian economy grew in 2008, shrank in 2009 but recommenced growth the following year, moreover Austria has a long and stable housing market tradition, which helped to contrast the housing market bubble occurring during the period. Table 4.13 reports the results we obtained.

For both samples, it is apparent that the FRFA had a negative impact on inflation, following the trend set by Italy and Spain. It also had a negative impact on retail sales and consumer confidence. The SMP and OMT showed the same trend as the previous two countries: OMT had no effect on the indicators considered while SMP had a negative effect on unemployment and consumer confidence. The LTRO continued to have no effect on inflation, but had a positive impact on retail sales. Regarding unemployment, it had a positive effect in the first sample and a negative one in the OMT sample. This can be explained by the fact that Austria experienced the crisis mostly between 2008 and 2009, the period in which the SMP sample is set, as noted by Norris and Byrne [2018].

Over the three-month period, similarly to the one-month period, the FRFA had a negative impact on inflation and a positive impact on retail sales, with the latter being higher in the OMT period than in the SMP sample. Unemployment and consumer confidence had positive and negative effects, respectively, in both samples.

The LTRO, with the exception of inflation, had positive effects during the SMP sample and negative effects during the OMT period. SMP and OMT maintained their trend across all other samples.

After six months, it is clear that the effects of the FRFA, OMT, and SMP remained the same as the previous two periods. The LTRO had a positive impact on retail sales and negative impact on unemployment and consumer confidence during the SMP period, while it had negative effects on retail sales and unemployment and a positive effect on consumer confidence indicators during the OMT period.

Variance of the errors

Table 4.5 below we reports the error variances computed to test the fitness of our model towards the data.

	CPI	**RETAIL**	**UNEMP**	**CC**
1 Month				
SMP Period	0,01	0,00	0,00	0,00
OMT Period	1,03E-31	1,15E-31	1,24E-32	1,94E-31
3 Months				
SMP Period	0,02	0,00	0,04	0,05
OMT Period	2,00E-31	3,17E-31	5,85E-32	1,51E-31
6 Months				
SMP Period	0,01	0,00	0,04	0,03
OMT Period	4,75E-31	8,52E-31	1,77E-31	2,75E-31

Table 4.5: Table containing the variance of the errors for Austria.

As it is possible to see the variances are extremely small for the SMP period. This suggests that the model captures a great quantitative of the indicators' variation. Moreover, the variance is steady for all the periods considered, which implies that the model is a good fit despite the possible variations induced by exogenous shock to the indicators considered.

As for the previous models, for the OMT period the model faces the risk of overfitting.

Uncertainty Index

As in sections 4.1.1 and 4.1.2 we address effects of the unconventional policies of the ECB trough the uncertainty index. Table 4.6 reports the results obtained. Can you make a more refined text, maintaining

	One Month	**Three Months**	**Six Months**
FRFA 10/2008	$68,19^{**}$	$48,74^{**}$	$33,24^{**}$
CBPP 05/2009	$21,80^{**}$	$95,65^{**}$	$152,02^{**}$
SMP,FRFA 05/2010	$216,95^{**}$	$69,99^{**}$	$191,70^{**}$
SMP Reactiv. 08/2011	$14,85^{**}$	$24,13^{**}$	$38,14^{**}$
CBPP2 10/2011	$277,75^{**}$	$275,87^{**}$	$114,74^{**}$
3Y LTRO 12/2011-02/2012	$0,46^{**}$	$85,62^{**}$	$70,17^{**}$
0% Deposit Rate 07/2012	$175,78^{**}$	$133,08^{**}$	$140,54^{**}$
M.Draghi Speech 07/2012	$86,55^{**}$	$116,44^{**}$	$89,89^{**}$
OMT 09/2012	$37,67^{**}$	$50,47^{**}$	$69,57^{**}$

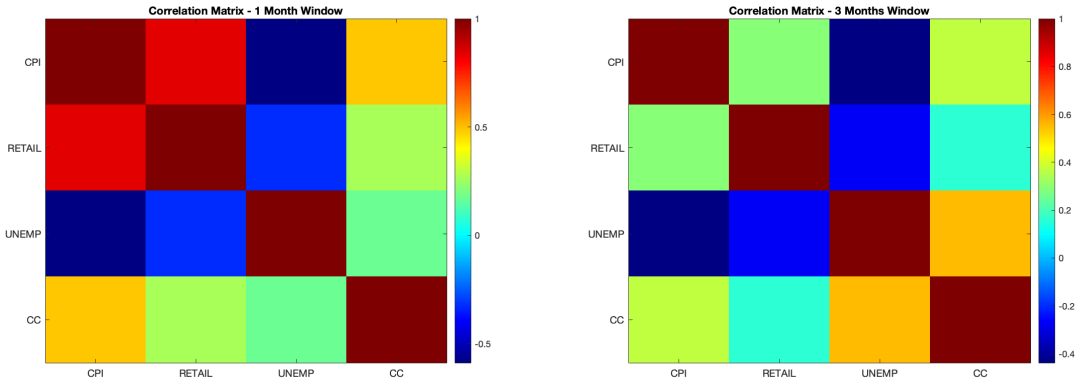
Table 4.6: Table containing the Uncertainty Index for the unconventional ECB measures in Austria. ** represents the signficance level at 5%.

the citations an references in latex? In analyzing the economy of Austria, it is evident that the level of uncertainty during the financial crisis and sovereign debt period was relatively low. This stability can be attributed to Austria's strong economic foundation, as noted in Norris and Byrne [2018]. Although there was an increase in uncertainty between 2010 and 2011 as the country was recovering from recession, the highest level of uncertainty was generated by the ECB's policies such as the FRFA of 2010 and CBPP of 2011.

It is worth noting that despite these events, the economy of Austria was not significantly impacted by the actions of the ECB. From 2012 onwards, uncertainty in the indicators began to decrease, with the exception of the 0% deposit rate, which continued to impact the economy. These results highlight the unique economic conditions and stability of Austria during this period.

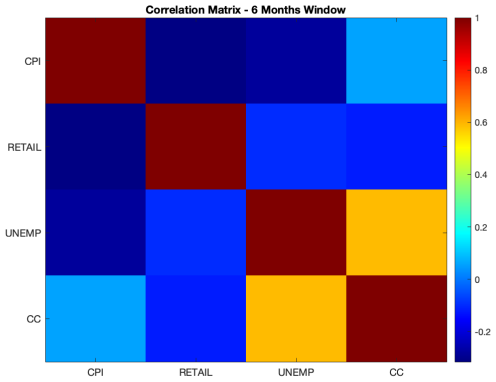
Correlation between indicators and spillover network

Fig. 4.5 shows the heatmaps reporting the correlations between the variations of the indicators.



(a) Correlations after 1 Month

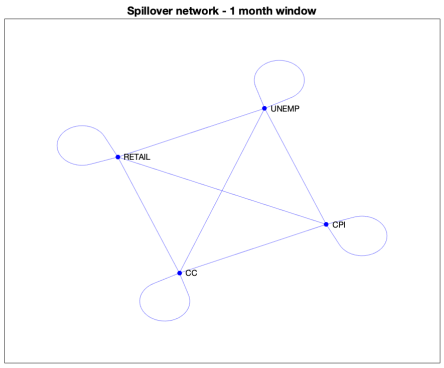
(b) Correlations after 3 Months



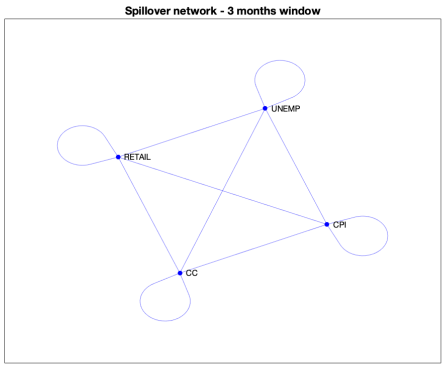
(c) Correlations after 6 Months

Figure 4.5: Heatmaps reporting the corretlations between the four macroeconomic indicators after 1, 3 and 6 months from the ECB announcements in Austria.

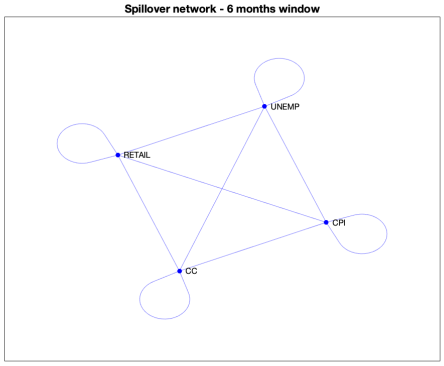
It is immediately noticeable the recursive pattern between retail sales and inflation: after one month from the announcements, there is a strong and positive relation between the two indicators, which decreases as time passes. In this case, after six months from the announcement CPI and Retail Sales are strongly and negatively correlated. Another recursive pattern regarding the CPI is the strong and negative correlation that is has with Unemployment during all the periods considered. CPI also has a positive correlation with consumer confidence which follows the pattern of its relation with the retail sales. The last observation can highlight a relation between Consumer Confidence and retail sales, which, indeed, follows the same behaviour for both the correlations with CPI and Retail Sales. The Unemployment is also negatively correlated with retails sales throughout all the periods.



(a) Spillover Network - 1 Month



(b) Spillover Network - 3 Months



(c) Spillover Network - 6 Months

Figure 4.6: Spillover Network reporting the relations between the variations of the indicators in Austria.

Fig. 4.6 contains the results obtained from the spillover network computed for Austria. The effects are the same for the other countries taken into consideration.

4.2.2 France

France also experienced some tough times during the 2008-2012 period despite not being one of the hardest-hit countries. Its GDP declined in 2009 and 2013, marking its worst post-war recession.

Our analysis of France's data and indicators, presented in table 4.14, starts from analysing the effects after one month and shows that the FRFA had a negative impact on inflation, while the SMP and OMT had no impact on CPI and retail sales. However, the SMP had a negative impact on unemployment and consumer confidence. In terms of LTRO, France showed different results from Austria for the unemployment indicator. During the SMP period, LTRO had a positive effect on retail sales and a negative effect on consumer confidence in both countries. In France, LTRO had a small negative effect on unemployment during the SMP. These minor differences between countries can be attributed to different crisis situations faced by each country and the limited ability to analyze the impact of eurozone-wide policies on a single country, as noted by Casiraghi et al. [2013].

For the three-month period, the FRFA, OMT, and SMP had the same effects as in other countries analyzed: the FRFA lowered inflation, the OMT had no impact on macro indicators, and the SMP had impacts only on unemployment and consumer confidence. In terms of LTRO, it had positive impacts on retail sales, unemployment, and consumer confidence in the pre-OMT period, and only a positive impact on retail sales in the OMT period.

Finally, after six months, the FRFA had a negative impact on inflation and a positive impact on the remaining indicators, as seen in Italy, Spain, and Austria. The LTRO had a negative impact on retail sales, unemployment, and consumer confidence during the SMP period and only a positive impact on consumer confidence during the OMT period. The SMP had a positive impact on unemployment and a negative impact on consumer confidence, while the OMT had no impact on the chosen indicators.

Variance of the errors

To check for the fitness of the model, we compute the error variances from the model. Table 4.7 shows the results obtained.

As we can notice from the table, the model is able to capture most of the variation for the SMP period, while it seems to be overspecified for the OMT period, as for the previous countries.

	CPI	RETAIL	UNEMP	CC
1 Month				
SMP Period	0,08	0,00	0,01	0,05
OMT Period	4,60E-31	2,04E-31	2,87E-31	1,48E-31
3 Months				
SMP Period	0,03	0,03	0,08	0,07
OMT Period	9,55E-32	6,04E-31	1,52E-31	1,77E-31
6 Months				
SMP Period	0,01	0,02	0,03	0,01
OMT Period	1,11E-31	2,88E-32	2,01E-32	1,37E-31

Table 4.7: Table containing the variance of the errors for France.

Regarding the SMP period, the capability of the model to capture most of the variation does not change as the period of time increases, differently from the two countries in which the SMP was activated. This may signal a more stable economy, with less exogenous shocks that may interfere with the computation.

Uncertainty Index

To asses the impact of the unconventional policies, we computed the uncertainty index related to them for France. Table 4.8 below provides the results obtained. It is possible to notice that the uncertainty in France was initially exceptionally slow, but it changes in 2009, reaching extremely high values for both 1, 3 and 6 months after the announcement of the CBPP. This may be explained by the fact that in 2009 France its greater post-war recession. After 2009 it is possible to notice a decrease in uncertainty, with only one very high peak in 2011, after six months from the SMP reactivation.

Overall, it would seem that individuals in France did not suffer a lot of uncertainty coming from the ECB announcements, with the exception of 2009, year of recession in the country.

Correlation between indicators and Spillover Model

Fig. 4.7 reports the correlations between the variations of the indicators after one, three and six months from the announcements. The correlation between the variations of CPI and Retail Sales is still present, even if the intensity is lower with respect to the other countries we took into consideration until now. As for

	One Month	Three Months	Six Months
FRFA 10/2008	$10,20^{**}$	$8,46^{**}$	$14,81^{**}$
CBPP 05/2009	$205,63^{**}$	$291,54^{**}$	$210,20^{**}$
SMP,FRFA 05/2010	$254,69^{**}$	$79,75^{**}$	$26,46^{**}$
SMP Reactiv. 08/2011	$3,09^{**}$	$48,01^{**}$	$258,73^{**}$
CBPP2 10/2011	$84,17^{**}$	$65,48^{**}$	$88,31^{**}$
3Y LTRO 12/2011-02/2012	$42,22^{**}$	$106,76^{**}$	$1,48^{**}$
0% Deposit Rate 07/2012	$146,77^{**}$	$95,22^{**}$	$102,33^{**}$
M.Draghi Speech 07/2012	$85,4^{**}0$	$106,63^{**}$	$146,51^{**}$
OMT 09/2012	$67,83^{**}$	$98,15^{**}$	$51,16^{**}$

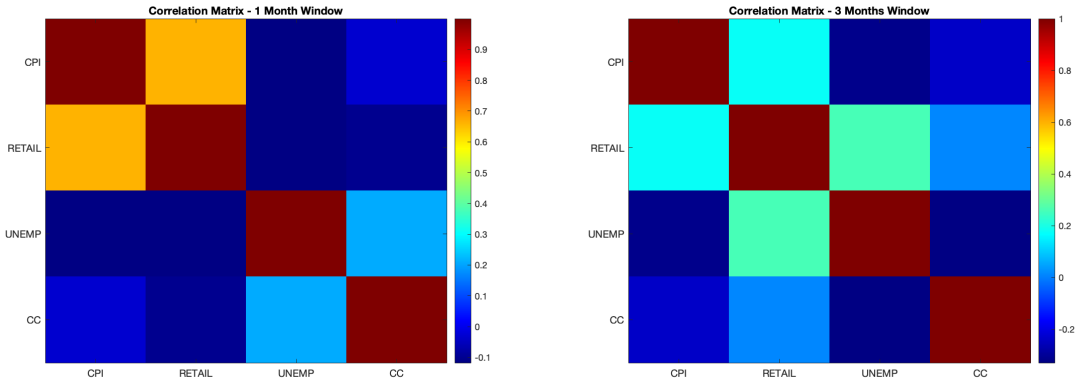
Table 4.8: Table containing the Uncertainty Index for the unconventional ECB measures in France. ** represents the significance level at 5%.

Austria, inflation has a strongly negative correlation with the variations in unemployment. The Consumer Confidence has a negative correlation with the variations of CPI, but they increase as time passes, the same pattern is followed by the correlation with Retail Sales, even if in this case the increase is more noticeable. At last, Unemployment has negative correlations with all of the other indicators. It is worth noticing that after six months from the announcements, there is a positive correlation with retail sales. Although not straightforward, this relationship is possible, if unemployment benefits are generous, people may have more money to spend on retail goods, leading to a boost in sales. Additionally, if people feel uncertain about the future and their job prospects, they may decide to spend money now, while they still have it, leading to increased retail sales.

With regard to the Spillover Network (fig. 4.8), also in this case it is possible to notice that indicators not only influence each other but also influence themselves.

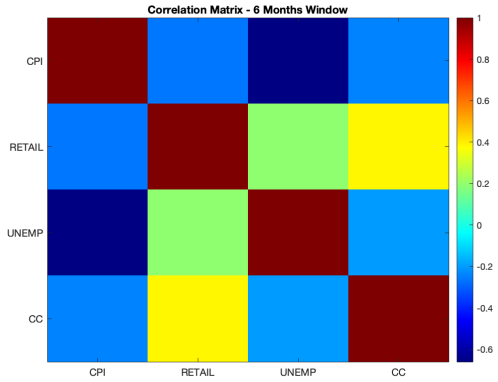
4.2.3 Finland

As described by Kaitila [2015], the financial crisis resulted in a global recession, causing Finnish exports of investment goods to be negatively impacted. The global slowdown severely impacted exports and domestic demand in 2009, leading to one of the largest contractions in the euro zone. Despite this, the recovery of exports, domestic trade, and household consumption boosted economic growth between 2010 and 2011.



(a) Correlations after 1 Month

(b) Correlations after 3 Months

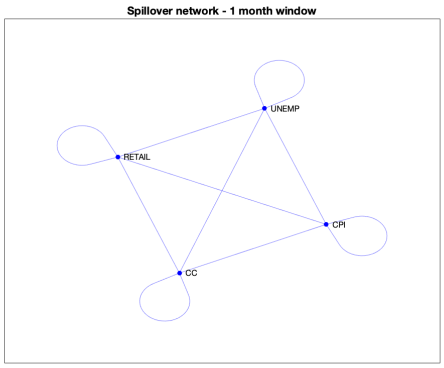


(c) Correlations after 6 Months

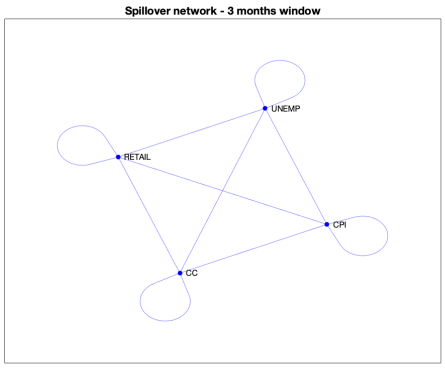
Figure 4.7: Heatmaps reporting the corretlations between the four macroeconomic indicators after 1, 3 and 6 months from the ECB announcements in France.

However, the economy suffered due to the continued recession in 2012-2013, negatively impacting general government finances and the debt ratio, causing previously strong budget surpluses to become deficits. Finland took measures to meet EU deficit targets in 2013 and maintain its triple-A credit rating. Despite these efforts, the country still faced weak export demand in the EU and government austerity measures, making it difficult to stimulate growth.

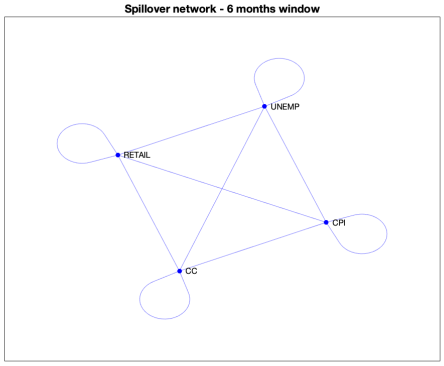
The results of the study on the effects of the financial crisis on the Finnish economy are summarized in Table 4.15. For the one-month period, the FRFA had negative effects on the Consumer Price Index (CPI) and near 1. During the SMP period, FRFA had a positive effect on retail and unemployment, while having no effect on consumer confidence. In the OMT period, the trend changed, with negative effects on retail sales and consumer confidence and a positive effect on unemployment.



(a) Spillover Network - 1 Month



(b) Spillover Network - 3 Months



(c) Spillover Network - 6 Months

Figure 4.8: Spillover Network reporting the relations between the variations of the indicators in France.

Considering the three months period, the SMP and OMT indicators showed similar results as previous samples, with no significant effects on CPI and retail sales and slight effects on unemployment and consumer confidence for the SMP. The LTRO had a positive effect on retail sales during the OMT period and on unemployment and consumer confidence during the SMP period. The FRFA continued to have negative effects on the inflation index, with positive effects on retail and unemployment and negative effects on consumer confidence during the SMP period and positive effects on consumer confidence during the OMT period. The LTRO followed a similar pattern in both samples, with negative effects on retail sales and positive effects on unemployment and consumer confidence.

After six months, the effects of the financial crisis and actions taken on financial markets remained largely unchanged, with little impact on macroeconomic indicators.

	CPI	RETAIL	UNEMP	CC
1 Month				
SMP Period	0,02	0,05	0,02	0,01
OMT Period	5,24E-32	1,03E-33	1,61E-31	1,95E-32
3 Months				
SMP Period	0,00	0,01	0,00	0,02
OMT Period	3,42E-31	1,23E-32	8,63E-32	6,57E-32
6 Months				
SMP Period	0,07	0,01	0,06	0,02
OMT Period	2,04E-31	1,23E-32	7,86E-32	4,93E-32

Table 4.9: Table containing the variance of the errors for Finland.

Variance of the errors

As for Austria and France, from the error variances of the model we can infer that it is able to capture most of the variation of the indicators during the SMP period, while it faces the risk of overfitting during the OMT period.

In particular it is possible to notice that the error variances are very small for all of the time windows considered, meaning that the variations of the indicators were not influenced significantly by other exogenous variables during the periods considered.

Uncertainty Index

From table 4.10 it is possible to infer that during the first phases of the crisis the uncertainty of the individuals was moderate, despite facing during 2009 one of the biggest economic contractions in euro zone, this could signal that other factors other than the economic situation influenced the general opinion in Finland, such as the actions of policymakers and the presence of stabilizing mechanisms, that may have mitigated the impact of the economic contraction and helped reducing uncertainty.

However, towards the end of 2011 we can see an important increase in uncertainty related to the announcements of the ECB, which continued, although with lower values, during 2012. As explained at the beginning of the section, between 2012 and 2013 Finland's economy suffered due to continued recession and the gov-

	One Month	Three Months	Six Months
FRFA 10/2008	$94,80^{**}$	$47,19^{**}$	$71,51^{**}$
CBPP 05/2009	$74,38^{**}$	$55,56^{**}$	$63,46^{**}$
SMP,FRFA 05/2010	$41,46^{**}$	$44,11^{**}$	$88,21^{**}$
SMP Reactiv. 08/2011	$170,93^{**}$	$116,10^{**}$	$123,71^{**}$
CBPP2 10/2011	$129,07^{**}$	$255,89^{**}$	$88,08^{**}$
3Y LTRO 12/2011-02/2012	$89,36^{**}$	$81,15^{**}$	$165,03^{**}$
0% Deposit Rate 07/2012	$135,16^{**}$	$98,58^{**}$	$97,67^{**}$
M.Draghi Speech 07/2012	$47,79^{**}$	$146,73^{**}$	$84,59^{**}$
OMT 09/2012	$117,05^{**}$	$54,68^{**}$	$117,74^{**}$

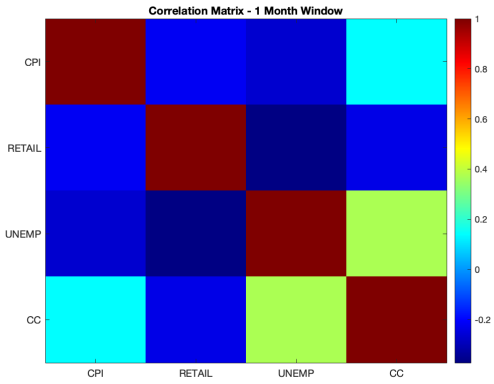
Table 4.10: Table containing the Uncertainty Index for the unconventional ECB measures in Finland. ** represents the signficance level at 5%.

ernment took some austerity actions in order to meet EU's austerity targets in 2013. This situation could have influenced negatively the uncertainty of the individuals, causing consequently the indicators to vary more.

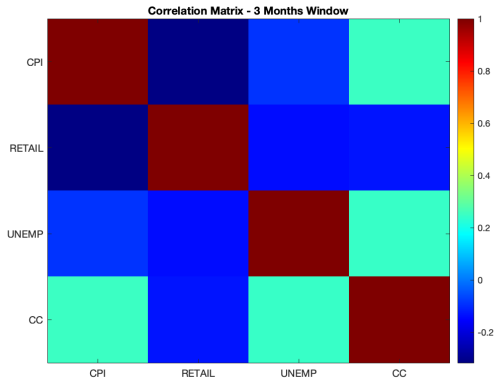
Correlation between indicators and Spillover Model

To fully understand the variations of the indicators related to ECB's announcements we focused also on the correlation between the indicators' variations and computed a Spillover mode to address the relations which develop between them. Figures 4.9 and 4.10 reports the results obtained.
Differently from the other countries taken into consideration, the correlation between the variations of CPI and Retail sales is weakly negative after one month from the announcements, and becomes strongly negative after three and six months. This can be explained by the strong economic recession which took place in Finland, indeed, looking at the correlation between consumer confidence and the two previous indicators, it is possible to infer a negative attitude of the individuals towards the economic state in the country.

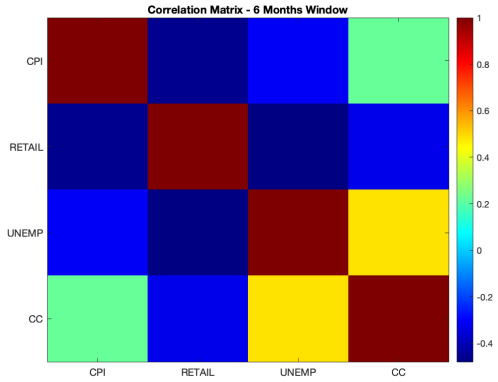
The variations in Unemployment are strongly negatively correlated with Retail Sales and CPI during all the periods considered, while it has a weak positive correlation with Consumer Confidence, which may come from low levels of unemployment during the period.



(a) Correlations after 1 Month



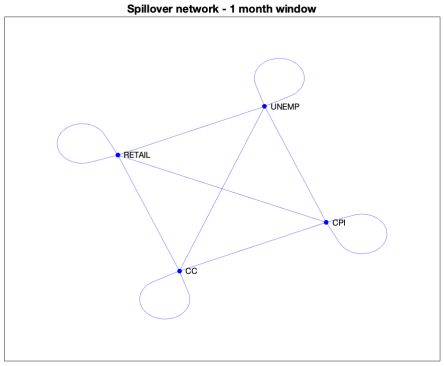
(b) Correlations after 3 Months



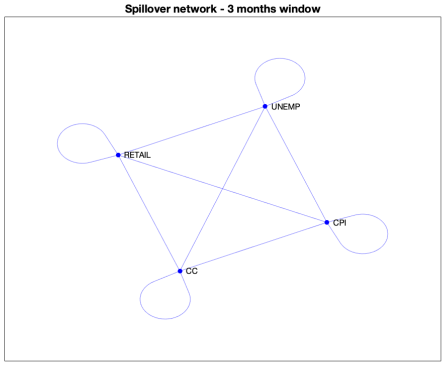
(c) Correlations after 6 Months

Figure 4.9: Heatmaps reporting the corretlations between the four macroeconomic indicators after 1, 3 and 6 months from the ECB announcements in Finland.

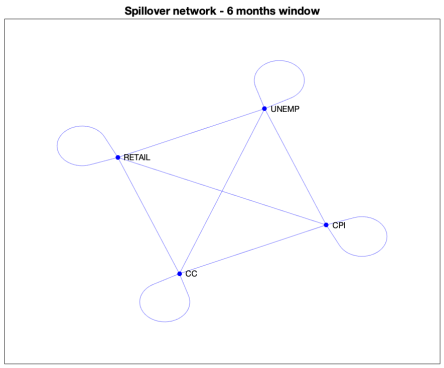
As for all the countries taken into consideration, the spillover network highlights that the variations of the indicators influence themselves.



(a) Spillover Network - 1 Month



(b) Spillover Network - 3 Months



(c) Spillover Network - 6 Months

Figure 4.10: Spillover Network reporting the relations between the variations of the indicators in Finland.

Tables

		CPI	RETAIL	UNEMP	CC		CPI	RETAIL	UNEMP	CC
Effects after one month			**SMP Period**					**OMT Period**		
	FRFA	$-0,91^{**}$	$-0,85^{***}$	$-0,62^{***}$	$0,24^{***}$	**FRFA**	-0,82	-0,66	-0,22	0,47
	LTRO	0,00	$-0,31^{**}$	$0,66^{***}$	$-0,14^{***}$	**LTRO**	0,00	0,47	0,79	0,67
	SMP	0,00	0,00	$0,09^{**}$	$-0,87^{***}$	**OMT**	0,00	0,00	0,00	0,00
Effects after three months										
	FRFA	$-0,86^{**}$	$-0,32^{**}$	$-0,69^{**}$	$0,56^{**}$	**FRFA**	-0,82	0,48	0,20	-0,43
	LTRO	0,00	$0,85^{***}$	$-0,01^{*}$	$0,44^{**}$	**LTRO**	0,00	0,66	-0,79	0,69
	SMP	0,00	0,00	$-0,57^{**}$	$-0,54^{**}$	**OMT**	0,00	0,00	0,00	0,00
Effects after six months										
	FRFA	$-0,85^{**}$	$0,79^{**}$	$-0,31^{**}$	$-0,56^{**}$	**FRFA**	-0,82	-0,77	0,78	-0,82
	LTRO	0,00	$-0,39^{*}$	$-0,66^{**}$	$-0,05^{*}$	**LTRO**	0,00	0,29	-0,79	-0,02
	SMP	0,00	0,00	$0,53^{**}$	$-0,71^{**}$	**OMT**	0,00	0,00	0,00	0,00

Table 4.11: Table of the loadings for the ECB unconventional policies before and after the implementation of the OMT in Italy, for 1,3 and 6 months after the announcement. *, **,*** represents the significance at 10%, 5% and 1%, respectively.

		CPI	RETAIL	UNEMP	CC		CPI	RETAIL	UNEMP	CC
Effects after one month			**SMP Period**					OMT Period		
	FRFA	$-0,89^{**}$	$-0,79^{**}$	$0,42^{***}$	$0,50^{**}$	**FRFA**	-0,82	-0,61	0,81	-0,04
	LTRO	0,00	$0,40^{**}$	$-0,33^{***}$	$0,75^{**}$	**LTRO**	0,00	0,54	-0,12	-0,82
	SMP	0,00	0,00	$0,74^{***}$	$0,13^{*}$	**OMT**	0,00	0,00	0,00	0,00
Effects after three months										
	FRFA	$-0,91^{***}$	$0,47^{**}$	$0,45^{**}$	$0,00^{**}$	**FRFA**	-0,82	0,63	-0,07	-0,63
	LTRO	0,00	$-0,76^{**}$	$-0,01^{*}$	$0,86^{*}$	**LTRO**	0,00	-0,52	0,81	-0,52
	SMP	0,00	0,00	$0,79^{***}$	$0,27^{**}$	**OMT**	0,00	0,00	0,00	0,00
Effects after six months										
	FRFA	$-0,91^{***}$	$0,20^{**}$	$0,77^{***}$	$-0,54^{**}$	**FRFA**	-0,82	-0,53	0,71	-0,82
	LTRO	0,00	$-0,88^{**}$	$0,10^{***}$	$0,73^{**}$	**LTRO**	0,00	0,62	-0,41	-0,03
	SMP	0,00	0,00	$0,47^{***}$	$0,00^{*}$	**OMT**	0,00	0,00	0,00	0,00

Table 4.12: Table of the loadings for the ECB unconventional policies before and after the implementation of the OMT in Spain, for 1,3 and 6 months after the announcement. *, **,*** represents the significance at 10%, 5% and 1%, respectively.

		CPI	RETAIL	UNEMP	CC		CPI	RETAIL	UNEMP	CC
Effects after one month			**SMP Period**					**OMT Period**		
	FRFA	$-0,91^{***}$	$-0,73^{***}$	$-0,04^{*}$	$-0,70^{***}$	**FRFA**	-0,82	-0,60	0,70	-0,13
	LTRO	0,00	$0,55^{***}$	$0,65^{***}$	$-0,19^{**}$	**LTRO**	0,00	0,55	-0,41	-0,81
	SMP	0,00	0,00	$-0,64^{***}$	$-0,55^{***}$	**OMT**	0,00	0,00	0,00	0,00
Effects after three months										
	FRFA	$-0,91^{**}$	$0,10^{**}$	$0,11^{*}$	$-0,41^{**}$	**FRFA**	-0,82	0,80	0,24	-0,34
	LTRO	0,00	$0,91^{***}$	$0,20^{*}$	$0,29^{*}$	**LTRO**	0,00	-0,15	-0,78	-0,74
	SMP	0,00	0,00	$-0,87^{**}$	$-0,73^{**}$	**OMT**	0,00	0,00	0,00	0,00
Effects after six months										
	FRFA	$-0,91^{***}$	$0,54^{***}$	$0,37^{**}$	$-0,01^{*}$	**FRFA**	-0,82	0,76	-0,64	-0,14
	LTRO	0,00	$0,73^{*}$	$-0,18^{*}$	$-0,16^{*}$	**LTRO**	0,00	-0,29	-0,51	0,80
	SMP	0,00	0,00	$0,80^{***}$	$0,88^{***}$	**OMT**	0,00	0,00	0,00	0,00

Table 4.13: Table of the loadings for the ECB unconventional policies before and after the implementation of the OMT in Austria, for 1,3 and 6 months after the announcement. *, **,*** represents the significance at 10%, 5% and 1%, respectively.

		CPI	RETAIL	UNEMP	CC		CPI	RETAIL	UNEMP	CC
Effects after one month			**SMP Period**					**OMT Period**		
	FRFA	$-0,87^{**}$	$-0,54^{***}$	$0,48^{***}$	$-0,77^{**}$	**FRFA**	-0,82	-0,08	0,73	0,59
	LTRO	0,00	$0,73^{***}$	$-0,08^{*}$	$-0,17^{*}$	**LTRO**	0,00	0,81	-0,36	-0,57
	SMP	0,00	0,00	$-0,77^{**}$	$-0,41^{**}$	**OMT**	0,00	0,00	0,00	0,00
Effects after three months										
	FRFA	$-0,90^{***}$	$0,11^{**}$	$0,48^{**}$	$0,19^{**}$	**FRFA**	-0,82	0,55	0,66	0,62
	LTRO	0,00	$0,89^{***}$	$0,12^{*}$	$0,41^{*}$	**LTRO**	0,00	0,61	-0,49	-0,53
	SMP	0,00	0,00	$0,72^{**}$	$-0,75^{**}$	**OMT**	0,00	0,00	0,00	0,00
Effects after six months										
	FRFA	$-0,91^{***}$	$0,53^{**}$	$0,64^{**}$	$0,30^{***}$	**FRFA**	-0,82	-0,79	0,79	-0,57
	LTRO	0,00	$-0,73^{***}$	$-0,36^{*}$	$-0,38^{*}$	**LTRO**	0,00	-0,21	-0,21	0,59
	SMP	0,00	0,00	$0,52^{***}$	$-0,77^{***}$	**OMT**	0,00	0,00	0,00	0,00

Table 4.14: Table of the loadings for the ECB unconventional policies before and after the implementation of the OMT in France, for 1,3 and 6 months after the announcement. *, **,*** represents the significance at 10%, 5% and 1%, respectively.

		CPI	RETAIL	UNEMP	CC		CPI	RETAIL	UNEMP	CC
Effects after one month			**SMP Period**					**OMT Period**		
	FRFA	$-0,90^{**}$	$0,39^{**}$	$0,30^{**}$	$0,00^{*}$	**FRFA**	-0,82	-0,60	0,81	-0,80
	LTRO	0,00	$-0,80^{**}$	$0,81^{***}$	$0,82^{***}$	**LTRO**	0,00	0,55	-0,11	-0,17
	SMP	0,00	0,00	$0,26^{**}$	$-0,39^{**}$	**OMT**	0,00	0,00	0,00	0,00
Effects after three months										
	FRFA	$-0,91^{***}$	$0,50^{***}$	$0,23^{***}$	$-0,25^{**}$	**FRFA**	-0,82	0,80	-0,29	0,13
	LTRO	0,00	$-0,76^{***}$	$0,53^{***}$	$0,83^{***}$	**LTRO**	0,00	-0,16	0,76	-0,81
	SMP	0,00	0,00	$0,71^{***}$	$0,25^{**}$	**OMT**	0,00	0,00	0,00	0,00
Effects after six months										
	FRFA	$-0,88^{***}$	$0,60^{***}$	$0,63^{*}$	$-0,25^{*}$	**FRFA**	-0,82	0,69	-0,62	-0,77
	LTRO	0,00	$-0,68^{***}$	$0,38^{**}$	$0,17^{***}$	**LTRO**	0,00	-0,44	0,53	0,26
	SMP	0,00	0,00	$0,50^{*}$	$0,85^{**}$	**OMT**	0,00	0,00	0,00	0,00

Table 4.15: Table of the loadings for the ECB unconventional policies before and after the implementation of the OMT in Finland, for 1,3 and 6 months after the announcement. *, **,*** represents the significance at 10%, 5% and 1%, respectively.

Chapter 5

Conclusions

In this thesis, we proposed a novel approach to evaluate the impact of unconventional monetary policy measures taken by the European Central Bank (ECB) during the financial crisis of 2008 and the sovereign debt crisis. To achieve this goal, we employed a factor model, following the works of Swanson [2021] and Gürkaynak et al. [2004], and a spillover network approach, following Balli et al. [2019] and Diebold and Yılmaz [2014], to analyze the effects of the ECB's announcements on four key macroeconomic indicators, namely Consumer Price Index (CPI), Retail Sales, Consumer Confidence, and Unemployment, the uncertainty related to the announcements and the interconnections between the indicators. The analysis was conducted using data from five countries in the Eurozone: Italy, Spain, Austria, France, and Finland.

Our findings reveal that the Fixed Rate Full Allotment Procedure (FRFA) had a negative impact on inflation in the early stages of the crisis. During the financial crisis, the FRFA provided banks with low-cost funding, which helped ease tensions in the credit markets and restore stability to the banking sector. This, in turn, could have had a positive impact on economic activity, leading to an increase in demand for goods and services, which could help bring down prices and reduce inflation. Additionally, the increased liquidity provided by the FRFA could have helped to lower interest rates, which can also lead to a decrease in inflation.

Moreover, we noticed that the Secured Market Purchase Program (SMP) and Outright Monetary Transactions (OMT) announcements had minimal effects on the indicators we studied. This may be due to the financial nature of the SMP and OMT. Additionally, our results suggest that the mere announcement of OMT helped calm the financial markets. It's also worth noting that the relationship between the announcements of the SMP and OMT and economic indicators is complex and can change over time, so a lack of effect in

the short term does not necessarily mean there was no effect in the long term.

Focusing on the uncertainty index, it showed that the countries most affected by the crisis, such as Italy and Spain, experienced greater uncertainty after the ECB announcements, leading to higher variations in the indicators compared to less affected countries such as France, Austria, and Finland. In Spain and Italy, the financial crisis had a particularly severe impact on the banking sector, which could have contributed to a higher level of uncertainty about the future of the eurozone and the ability of the ECB's policy measures to restore stability. In contrast, France, Austria, and Finland may have had more stable banking sectors, which could have helped to reduce uncertainty and promote confidence. It's worth noting that the relationship between the ECB's policy announcements and uncertainty is complex and can be influenced by many other factors, such as changes in global oil prices, government spending, and exchange rate movements.

The correlation and spillover network analysis showed a strong positive correlation between Consumer Price Index (CPI) and Retail Sales in all countries, excluding Finland. This correlation weakened over time. The variations of the indicators had both mutual and self-influence. For example, a change in the cost of living (as reflected by the CPI) can alter consumer behavior and cause prices to fluctuate, creating a feedback loop. Retail Sales can also self-influence, for instance, a decrease in consumer spending may lead businesses to reduce prices, which can result in an increase in consumer spending and sales.

Unemployment can also self-influence, with an increase in joblessness causing a decrease in consumer spending and economic activity, which can further lead to job losses. Conversely, an increase in job creation can result in increased consumer spending and economic activity.

Consumer confidence can also impact the economy through its influence on consumer spending. A decrease in confidence can lead to decreased spending and economic activity, while an increase in confidence can boost spending and economic activity, creating a positive feedback loop.

In conclusion, our study provides valuable insights into the behavior of macroeconomic indicators in response to unconventional monetary policy announcements during crisis periods. The findings of this study can be useful for policymakers, researchers, practitioners, and central authorities in better understanding the impact of their monetary policy decisions during challenging times.

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Long Abstract

The global financial crisis of 2008 and the subsequent sovereign debt crisis had a profound impact on the world economy. In response to these challenges, central banks around the world implemented unconventional monetary policy measures to stabilize the financial markets and boost economic activity. The European Central Bank (ECB) was one of the central banks that took such measures to counter the effects of the crisis. The purpose of this thesis is to examine the impact of the unconventional monetary policy measures implemented by the ECB during the financial crisis of 2008 and the sovereign debt crisis on macroeconomic indicators. The study employs a factor model, following the paper of Swanson [2021] and a spillover model as described by Diebold and Yılmaz [2014] to analyze the effects of the ECB's announcements on four key macroeconomic indicators, namely Consumer Price Index (CPI), Retail Sales, Consumer Confidence, and Unemployment. The study takes into consideration data from five countries in the Eurozone: Italy, Spain, Austria, France, and Finland. These countries were carefully selected as they offer a diverse representation of the effects of unconventional monetary policy in the region. Italy and Spain, which experienced sovereign tensions, were the countries where the ECB implemented the Securities Market Programme (SMP), while Austria, France, and Finland are countries that are highly rated in the euro area. This division follows the work of Fratzscher et al. [2016]. To assess the impact of unconventional monetary policy on the selected macroeconomic indicators, the study collected data on the changes in the indicators one, three, and six months after the most significant announcements made by the European Central Bank. A factor model was then applied to these observations to determine the relationship between the changes in the indicators and the announcements. To further explore the interconnections between the indicators, the study also employs a spillover model and uncertainty indices to examine how changes in one indicator can affect the others. This research offers valuable insights that can be useful for researchers and policymakers in challenging times. Despite the differences in the results for each country, the factor model and spillover model reveal some recurring patterns between the policies and the indicators. These findings can prove beneficial for decision-making during critical moments.

The general uncertainty about the health of banks' balance sheets led to an increase in the spread between the riskless rate and Euribor, a riskier interbank rate. To address the increasing tension in the interbank market, the ECB implemented various measures, including announcements of the fixed-rate full allotment procedure (FRFA), three-year refinancing operations, and setting the deposit rate to zero. The thesis describes the

FRFA, Supplementary Long Term Liquidity Provisions (SLTROs), Securities Market Program (SMP), and Outright Monetary Transactions (OMTs) as the most significant unconventional policies taken by the ECB during the crisis. The measures aimed to stabilize the interbank market, ensure that liquidity-constrained banks could accumulate liquidity without having to resort to fire sales of assets, and extend credit to firms and households.

The European Central Bank (ECB) introduced longer-term collateralized loans to address illiquidity in euro area money markets, including three-month, six-month, and 12-month long-term refinancing operations. During the 2011 sovereign debt crisis, the ECB announced two "very" long-term refinancing operations (VLTROs) with a maturity of three years, allocating a total of 1,019 billion euros. The goal of these liquidity provisions was to restore the smooth functioning of the interbank market and extend credit to firms and households, helping to avoid credit crunches caused by illiquidity and prevent fire sales of assets.

During a financial crisis, central banks can use credit easing to address liquidity issues by purchasing securities. This action can be measured through the portfolio rebalancing effect. During the sovereign debt crisis, the ECB made direct purchases of government bonds on secondary markets to address tensions impacting the monetary policy transmission mechanism. Initially limited to Greek, Portuguese, and Irish bonds, the program expanded to include Italian and Spanish bonds. The ECB held around 220 billion euros in sovereign bonds by 2012 as a result of the program, purchasing bonds without focusing on a specific price or quantity.

In 2012, the ECB introduced a new policy instrument called the OMT, which aimed to repair the monetary policy transmission mechanism and contain redenomination risk. The OMT allowed the ECB to purchase government bonds issued by countries under an ESM or precautionary program, with some differences from the previous SMP policy. The announcement of the OMT was enough to stabilize the markets, and the ECB did not need to use it.

It is possible to find different ways of classifying the potential transmission channels of unconventional monetary policy. Regarding the ECB policies, Fratzscher et al. [2016] identify four channels:

- Confidence Channel: it refers to the idea that by taking decisive actions, the European Central Bank (ECB) can restore confidence in the financial system, which in turn leads to a decrease in risk premiums and uncertainty, resulting in a positive impact on asset prices.

- Bank Credit Risk Channel: Addressing the liquidity concerns of banks could lower the credit risk in the banking sector, thereby increasing asset prices by reducing the overall risk premiums.
- Sovereign credit risk channel: The intermediate objective of the ECB's SMP and OMT policies was to restore the transmission mechanisms of monetary policy by reducing sovereign risk premiums.
- International Portfolio Balance Channel: This channel represents the possibility of transmitting the effects of asset purchases to asset prices across markets and countries.

Every indicator was taken for five different countries, a group of highly rated euro area countries (Austria, France and Finland) and a group of countries the experienced sovereign tensions (Italy and Spain). The data come from Bloomberg and have a monthly frequency, which gives the possibility to compute their percentage changes after one, three and six months from the most important announcements of unconventional monetary policy of the ECB during the period 2008-2012, as described by Szczerbowicz [2018]. As macro indicators we considered:

- Consumer's Confidence: this index provides an insight on household's future consumption and savings, basing on answers regarding their financial situation. A value above 100 indicates that consumers are less prone to save and are more keen to spend in next 12 months, if the value is under 100, it indicates the opposite.
- Consumer Price Index: This indicator measures inflation measured from the changes in prices from a basket of goods, which are typically purchased from a selected group of consumers.
- Retail Sales: represent a key macroeconomic metric that tracks consumer demand for finished goods.The retail sales report helps analysts and investors gauge the health of the economy and any inflationary pressures that may exist.
- Unemployment: the unemployed are people of working age who are without work, are available for work, and have taken specific steps to find work. The uniform application of this definition results in estimates of unemployment rates that are more internationally comparable than estimates based on national definitions of unemployment. This indicator is measured in numbers of unemployed people as a percentage of the labour force and it is seasonally adjusted.

Eric T. Swanson in his elaborate Swanson [2021], aims to compute the effects of the FED's unconventional monetary policy measures on a diversified set of financial indicators. His work starts from Gürkaynak et al.

[2004] and extends it to separately identify three main policies adopted by the FED during the financial crisis.

In this elaborate, we started from the model he adopted and changed the data used to do the empirical work. The responses of the macroeconomic indicators are collected in three $T \times n$ matrices, X, where the rows correspond to every ECB announcements and the columns to the different indicator; each element x_{ij} of the matrices reports the variation after, respectively, 1, 3 and 6 months, of the jth indicator to the ith ECB announcement. These matrices can be thought as a factor model:

$$X = F\Lambda + \varepsilon \tag{5.1}$$

F is a $T \times k$ factor matrix containing $k \leq n$ unobserved factors, Λ is a $k \times n$ matrix of loadings of the indicator responses on the k factors, ε is a $T \times n$ matrix containing white noise residuals that is uncorrelated over time and across assets. This method has been applied to every country taken into consideration in this elaborate.

From this factor model is possible to compute the factor matrix F and the loadings matrix Λ through a singular value decomposition method, which states that every complex $m \times n$ matrix M can be decomposed in the following way:

$$M = U\Sigma V^* \tag{5.2}$$

Where the matrix U is a $m \times m$ unitary matrix, Σ is a $m \times n$ rectangular diagonal matrix and V is a $n \times n$ complex unitary matrix.

We identify the factor matrix F from equation 5.1 as the first k columns of matrix U from equation 5.2 and the matrix Λ from equation 5.1 as the first k rows of the matrix ΣV^* from equation 5.2.

The number k is computed as the rank of the factor model computed following Cragg and Donald [1997] and Gürkaynak et al. [2004]. The Cragg-Donald test, given a null hypothesis of rank k_0 and an alternative hypothesis $k > k_0$, searches over all possible models with k_0 factors to find the one whose residuals ε are as close as uncorrelated white noise as possible, after that, the test computes the distance between the residuals and the white noise with a Wald statistic.

In this study, we analyze a period where various policies were implemented and some discontinued. To effectively evaluate this period, we perform our analysis using two different models. The first model uses a matrix X that contains the variations of the indicators prior to the replacement of the Securities Market Programme (SMP) with the Outright Monetary Transactions (OMT) policy., as we can see from figure 2.2

in chapter 2. After the computation of the loadings and factors trough the factor model, we implement a methodology created by Balli et al. [2019] in order to compute a spillover network which considers our indicators for the five different countries.

The first step is to use a generalized dynamic factor model (GDFM), which can become a dynamic factor model (DFM) if the order of factor loadings is finite. According to Bai and Ng [2008], considering the number of cross sectional units to be N and considering T the number of observations taken for time series, the DFM for $i = 1,\ldots,N$ and $t = 1,\ldots,T$ is defined as follows:

$$z_{it} = \beta_i(L) f_t + \mu_{it} \tag{5.3}$$

Where f_t is a common factor vector and L is a lag operator. β_i is a loading vector linked with f_t, while $\beta_i(L) = (1 - \beta_{i1}L -, \ldots, -\beta_{is}L^s)$ indicates the dynamic factor loadings vector linked with the order s. μ_{it} indicates the idiosyncratic element of $z_i t$. Stock and Watson [2010] presented examples of DFM, which can be written in the form:

$$\underset{(N\times T)}{Z} = \underset{(N\times r)}{B}\underset{(r\times T)}{F} + \underset{(N\times T)}{\mu} \tag{5.4}$$

In the first phase is possible to compute the idiosyncratic element of the model trough the following process:

$$\mu_{it}^{u} = Z_{it} - \hat{A}_{it} \tag{5.5}$$

Where $\hat{A}_{it} = \beta_i(L) f_t$.

From equation 5.5 a stochastic volatility model is identified on an individual level as:

$$\mu_t^u = \mu^{\frac{h_t}{2}} \varepsilon_t \tag{5.6}$$

$$h_t = \delta + \psi(h_{t-1} - \delta) + \sigma \nu_t \tag{5.7}$$

Following the methodology proposed by Kastner and Frühwirth-Schnatter [2014] the idiosyncratic stochastic volatilities h_{it} from equation 5.7 are computed and therefore is possible to calculate the individual uncertainty index V_t as the simple average of the volatilities:

$$V_t = \frac{\sum_{i=1}^{N} h_{it}}{N} \tag{5.8}$$

The uncertainty index is an economic indicator that measures the level of uncertainty faced by producers and consumers. It reflects the level of risk and unpredictability faced by producers and consumers, as well as their ability to make informed decisions about buying and selling goods. A high value indicates a high

level of uncertainty and unpredictability, while a low value indicates a more stable and predictable market. This indicator is used by economists, policymakers, and investors to understand the overall health of the commodity market and the potential impact of commodity price changes on the wider economy.

Following the model of Diebold and Yılmaz [2014] and Koop et al. [1996], we employ a variance decomposition matrix to build different connectedness measures. In the connectedness table, the element $c_{ij}^{g(H)}$ measures the pairwise directional connectedness from j to i as:

$$C_{i\leftarrow j}^{H} = c_{ij}^{g(H)} \tag{5.9}$$

The off-diagonal sum of rows represents the toal directional connectedness from other i as:

$$C_{i\leftarrow \cdot}^{H} = \sum_{\substack{j=1 \\ j\neq i}}^{N} c_{ij}^{g(H)} \tag{5.10}$$

The off-diagonal sum of columns represents the total directional connectedness to others from j as:

$$C_{\cdot\leftarrow j}^{H} = \sum_{\substack{i=1 \\ i\neq j}}^{N} c_{ij}^{g(H)} \tag{5.11}$$

At last the total connectedness is the ratio of the sum of the to-others (from-others) elements of the variance decomposition matrix:

$$C^{H} = \frac{1}{N} \sum_{\substack{i,j=1 \\ i\neq j}}^{N} c_{ij}^{g(H)} \tag{5.12}$$

The graphical visualization of the connectedness table will be represented in the chapter containing the empirical results, where the individual indicators are represented as nodes and the arrows represent the pairwise connectedness among them.

The impact of various ECB programs on the Italian economy was analyzed using a loadings matrix. The results showed that the SMP and OMT programs had a minimal impact on the indicators studied. The SMP had a limited effect, with only a noticeable impact on consumer confidence, possibly due to the announcement itself having an effect on individuals. The FRFA and LTRO had a minor impact on the indicators within the one-month window. The trend remained largely unchanged for all indicators after three months, with some changes observed for the SMP and OMT after 6 months. However, the variance of the errors increased as the time window expanded, indicating that the model may not fit the data well and the factors may not explain a significant portion of the variation. The correlation and spillover network analysis revealed some interesting findings. The correlation between Retail Sales and CPI became weaker over time,

while the variation of inflation negatively impacted consumer confidence initially, but the effects reduced over time. The consumer confidence indicator was negatively influenced by the positive variation of unemployment, which also had a negative effect on retail sales, becoming increasingly pronounced over time. In summary, the results suggest that the ECB programs had a limited impact on the Italian economy, with only some short-term effects observed. The findings also highlight the complex interrelationships between various economic indicators and the need for a deeper understanding of the factors that influence them.

The study also analyzed the impact of ECB's monetary policies on Spain and found that the effects were similar to those observed in Italy, but with a few exceptions. The results suggested that the model was a good fit for the sample, as evidenced by the small variances observed, especially during the SMP period. The uncertainty index analysis gave a comprehensive understanding of the impact of ECB policies on inflation, retail sales, consumer confidence, and unemployment. The results showed that the policies generally had positive effects on these indicators. The study observed a strong and positive correlation between inflation and retail sales one month after the announcements, which decreased over time. The relationship between the Consumer Price Index (CPI) and unemployment was negatively correlated, and it had a strong effect on unemployment for all periods but an increasingly positive effect on consumer confidence. The relationship between unemployment and retail sales was also negatively correlated, but it weakened over time. Retail sales and consumer confidence were negatively correlated throughout the periods, but the correlation became increasingly weak. The spillover network analysis revealed that the variations of the indicators were influenced by each other, and a variation in one indicator created a variation in itself for all periods considered. In summary, the study found that the impact of the ECB's monetary policies on Spain was similar to that observed in Italy, but with some exceptions. The results suggested that the policies had generally positive effects on inflation, retail sales, consumer confidence, and unemployment. The correlation and spillover network analysis revealed that a variation in one indicator created a variation in itself for all periods considered.

In Austria, the study indicates that the ECB's monetary policies had varying effects on the indicators studied. The policies had negative impacts on inflation and consumer confidence, while it had positive impacts on retail sales and unemployment. The study shows that the model is a good fit for the Austrian economy, as evidenced by the small error variances observed. However, the study also found that the ECB's unconventional policies increased the uncertainty in the Austrian economy. One month after the announcement, there

was a strong and positive correlation between inflation and retail sales. However, this correlation decreases over time and becomes negative after six months, suggesting that the policies had a short-term impact. The study also found a strong and negative correlation between the Consumer Price Index (CPI) and unemployment, which persisted throughout all periods considered. This suggests that variations in unemployment had a significant impact on inflation, which can also have a spillover effect on consumer confidence and retail sales. Moreover, there is a positive correlation between CPI and consumer confidence, which mirrors the pattern between consumer confidence and retail sales. The study also found that unemployment has a negative correlation with retail sales, indicating that variations in unemployment can affect the performance of the retail sector. These results are also reflected in the spillover network for Austria and are similar for the other countries studied, suggesting that the ECB's policies have similar impacts across different countries in the Eurozone. Overall, the study highlights the complex and interconnected nature of the Eurozone economy, with various indicators influencing each other. The results suggest that the ECB's monetary policies have significant short-term impacts on the economy, but their long-term effects may be limited.

In France, the results of the study indicate that the ECB's unconventional policies had different effects on various indicators. The FRFA had a negative impact on inflation after one month, while the SMP and OMT had no effect on CPI and retail sales. However, the SMP did have negative impacts on unemployment and consumer confidence. After three months, the FRFA and SMP had similar effects to those observed in other countries studied, while the OMT had no impact. After six months, the FRFA had negative impacts on inflation but positive impacts on other indicators, while the SMP had positive impacts on unemployment but negative impacts on consumer confidence. The model was able to capture most of the variation during the SMP period, but it appeared overspecified for the OMT period. The uncertainty index, which was calculated to assess the impact of the unconventional policies, revealed significant results for the FRFA and CBPP. The correlation analysis revealed that the variations of the Consumer Price Index (CPI) and Retail Sales had a lower intensity than in other countries analyzed. In Austria, inflation had a strongly negative correlation with unemployment, while consumer confidence had a negative correlation with both CPI and Retail Sales. However, the correlation with retail sales increased over time. Unemployment had negative correlations with all other indicators, but after six months from the announcements, there was a positive correlation with retail sales. The Spillover Network analysis showed that the indicators not only influenced each other but also influenced themselves, meaning that a variation in one indicator would create a variation in itself for all periods considered. Overall, the study shows that the ECB's unconventional policies had varying impacts

on the different indicators and that these effects evolved over time.

In Finland, the study found that the FRFA policy had negative impacts on the Consumer Price Index (CPI), while having positive effects on retail sales and unemployment during the SMP period. Additionally, the LTRO policy had a positive effect on retail sales during the OMT period, and on unemployment and consumer confidence during the SMP period. The model was found to be a good fit for the Finnish economy, with most of the variation in indicators during the SMP period being captured, although there was a risk of overfitting during the OMT period. The study's uncertainty index showed that the variations of the indicators were not influenced significantly by other exogenous variables during the periods considered. Furthermore, the study found that the relationship between changes in CPI and Retail Sales was weakly negative after one month from announcements, but became strongly negative after three and six months. This was likely due to the severe economic recession in the country, which is also reflected in the negative correlation between consumer confidence and the two indicators. The study found that unemployment had a strong negative correlation with Retail Sales and CPI, while having a weak positive correlation with Consumer Confidence. It also found that the changes in the indicators affected each other. In particular, the changes in retail sales and consumer confidence were positively correlated, while the correlation between consumer confidence and CPI was negative. Unemployment had a negative correlation with all other indicators, but it had a positive correlation with retail sales after six months from the announcement. Overall, the study provides important insights into the effects of the ECB's policies on the Finnish economy and highlights the interconnectedness of various economic indicators.

To conclude, our findings reveal that the Fixed Rate Full Allotment Procedure (FRFA) had a negative impact on inflation in the early stages of the crisis. During the financial crisis, the FRFA provided banks with low-cost funding, which helped ease tensions in the credit markets and restore stability to the banking sector. This, in turn, could have had a positive impact on economic activity, leading to an increase in demand for goods and services, which could help bring down prices and reduce inflation. Additionally, the increased liquidity provided by the FRFA could have helped to lower interest rates, which can also lead to a decrease in inflation.

Moreover, we noticed that the Secured Market Purchase Program (SMP) and Outright Monetary Transactions (OMT) announcements had minimal effects on the indicators we studied. This may be due to the financial nature of the SMP and OMT. Additionally, our results suggest that the mere announcement of OMT

helped calm the financial markets. It's also worth noting that the relationship between the announcements of the SMP and OMT and economic indicators is complex and can change over time, so a lack of effect in the short term does not necessarily mean there was no effect in the long term.

Focusing on the uncertainty index, it showed that the countries most affected by the crisis, such as Italy and Spain, experienced greater uncertainty after the ECB announcements, leading to higher variations in the indicators compared to less affected countries such as France, Austria, and Finland. In Spain and Italy, the financial crisis had a particularly severe impact on the banking sector, which could have contributed to a higher level of uncertainty about the future of the eurozone and the ability of the ECB's policy measures to restore stability. In contrast, France, Austria, and Finland may have had more stable banking sectors, which could have helped to reduce uncertainty and promote confidence. It's worth noting that the relationship between the ECB's policy announcements and uncertainty is complex and can be influenced by many other factors, such as changes in global oil prices, government spending, and exchange rate movements.

The correlation and spillover network analysis showed a strong positive correlation between Consumer Price Index (CPI) and Retail Sales in all countries, excluding Finland. This correlation weakened over time. The variations of the indicators had both mutual and self-influence. For example, a change in the cost of living (as reflected by the CPI) can alter consumer behavior and cause prices to fluctuate, creating a feedback loop. Retail Sales can also self-influence, for instance, a decrease in consumer spending may lead businesses to reduce prices, which can result in an increase in consumer spending and sales.

Unemployment can also self-influence, with an increase in joblessness causing a decrease in consumer spending and economic activity, which can further lead to job losses. Conversely, an increase in job creation can result in increased consumer spending and economic activity.

Consumer confidence can also impact the economy through its influence on consumer spending. A decrease in confidence can lead to decreased spending and economic activity, while an increase in confidence can boost spending and economic activity, creating a positive feedback loop.

In conclusion, our study provides valuable insights into the behavior of macroeconomic indicators in response to unconventional monetary policy announcements during crisis periods. The findings of this study can be useful for policymakers, researchers, practitioners, and central authorities in better understanding the impact of their monetary policy decisions during challenging times.