EFFECTS OF CENTRAL BANK'S ANNOUNCEMENTS ON FINANCIAL MARKETS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF APPLIED MATHEMATICS
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

BUĞRAHAN HANİKAZ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
FINANCIAL MATHEMATICS

DECEMBER 2022

Approval of the thesis:

EFFECTS OF CENTRAL BANK'S ANNOUNCEMENTS ON FINANCIAL MARKETS

submitted by **BUĞRAHAN HANİKAZ** in partial fulfillment of the requirements for the degree of **Master of Science in Financial Mathematics Department, Middle East Technical University** by,

Prof. Dr. A. Sevtap Selçuk Kestel
Dean, Graduate School of **Applied Mathematics** _______________

Prof. Dr. A. Sevtap Selçuk Kestel
Head of Department, **Financial Mathematics** _______________

Assoc. Prof. Dr. Esma Gaygısız
Supervisor, **Economics, METU** _______________

Examining Committee Members:

Prof. Dr. Fatih Özatay
Economics, TOBB ETÜ _______________

Assoc. Prof. Dr. Esma Gaygısız
Economics, METU _______________

Prof. Dr. Ceylan Yozgatlıgil
Statistics, METU _______________

Date: _______________

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: BUĞRAHAN HANİKAZ

Signature :

ABSTRACT

EFFECTS OF CENTRAL BANK'S ANNOUNCEMENTS ON FINANCIAL MARKETS

Hanikaz, Buğrahan
M.S., Department of Financial Mathematics
Supervisor : Assoc. Prof. Dr. Esma Gaygısız

December 2022, 69 pages

It has been stated in various studies that the Central Bank's announcements do not only affect the short-term interest rates, but also the long-term interest rates through different channels. In this study the effect of the decision of the Central Bank of Turkey on financial markets were examined via VAR with functional shocks method proposed by Inoue and Rossi[20]. High frequency identification method was adopted to reduce the identification problem in the VAR model, impulse response functions were obtained via local projections. Two more similar VAR models were created to compare the model results. As a result of the study, monetary policy statements rarely have significant effects on the stock market in first few days, similarly, the effects on the exchange rate and implied volatility are generally insignificant, but significant results can be obtained regarding the effects on CDS. It has been observed that mostly unexpected interest rate hikes have a downward effect on CDS, while interest rate decreases have an upward effect. The effects on other financial variables cannot be interpreted as clearly as in CDS. With the established model, the short-term effects of the Central Bank's decisions on the financial markets in Turkey could only be examined for a few days, apart from the effects on first few days, some delayed effects were also observed.

Keywords: Central Bank, Monetary Policy Shock,Vector Autoregression Models, Yield Curve

ÖZ

MERKEZ BANKASI AÇIKLAMALARININ FİNANSAL PİYASALAR ÜZERİNDEKİ ETKİLERİ

Hanikaz, Buğrahan
Yüksek Lisans, Finansal Matematik Bölümü
Tez Yöneticisi : Doç. Dr. Esma Gaygısız

Aralık 2022, 69 sayfa

Merkez Bankası açıklamalarının sadece kısa vadeli faiz oranlarını değil, uzun vadeli faiz oranlarını da farklı kanallardan etkilediği çeşitli çalışmalarda belirtilmiştir. Bu çalışmada, Inoue ve Rossi[20] tarafından önerilen "VAR with Functional Shocks" yöntemi ile Türkiye Cumhuriyet Merkez Bankası kararının finansal piyasalar üzerindeki etkisi incelenmiştir. VAR modelinde "identification" problemini azaltmak için "high frequency identification" yöntemi benimsenmiş, yerel yansımalar yoluyla "impulse response" fonksiyonları elde edilmiştir. Model sonuçlarını karşılaştırmak adına benzer iki VAR modeli daha oluşturulmuştur. Çalışma sonucunda, para politikası açıklamalarının ilk birkaç gün içinde hisse senedi piyasası üzerinde nadiren önemli etkileri olduğu, benzer şekilde döviz kuru üzerindeki etkileri ve ima edilen oynaklığın genellikle önemsiz olduğu, ancak CDS üzerindeki etkilerine ilişkin önemli sonuçlar elde edilebildiği görülmektedir. CDS üzerinde çoğunlukla beklenmeyen faiz artışlarının aşağı yönlü, faiz düşüşlerinin ise yukarı yönlü etki yaptığı gözlemlenmiştir. Diğer finansal değişkenler üzerindeki etkiler CDS'de olduğu kadar net yorumlanamamaktadır. Kurulan model ile Merkez Bankası kararlarının Türkiye'de finansal piyasalar üzerindeki kısa vadeli etkileri sadece birkaç gün için incelenebilmiş, bunlar dışında bazı gecikmeli etkiler de gözlemlenmiştir.

Anahtar Kelimeler: Merkez Bankası, Para Politikası Şoku, Vektör Otoregresyon Modelleri, Getiri Eğrisi

ACKNOWLEDGMENTS

I would like to express my very great appreciation to my thesis supervisor Assoc. Prof. Dr. Esma Gaygısız for his patient guidance, enthusiastic encouragement and valuable advices during the development and preparation of this thesis. Her willingness to give her time and to share her experiences has brightened my path.

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LIST OF ABBREVIATIONS

ABBRV	Abbreviation
MPC	Monetary Policy Committee
CBRT	Central Bank of the Republic of Turkey
VAR	Vector Autoregression
LP	Local Projection

CHAPTER 1

INTRODUCTION

Central banks use funding rates as the main policy tool. They expect their own interests to affect the market through various monetary transmission mechanisms, even if the name or method of implementation differences. In many countries, interest rate decisions of central banks are accepted as the main determinant of monetary policy and are followed closely by many segments. Similarly, interest rate decisions have been the most important indicator of monetary policy in Turkey in recent years. Many actors in the market closely follow interest rate decision announcements and these announcements can affect various financial decisions of individuals.

The Central Bank of the Republic of Turkey (CBRT) has implemented an interest rate corridor policy since the end of 2010 in order to respond to short-term financial volatility. The interest rate corridor application can be summarized as the fact that the Central Bank's funding rate is not fixed, that it funds the market with various instruments and thus changes the average interest daily. Throughout the implementation of this policy, the Monetary Policy Committee (MPC) meets regularly to review or, if necessary, change the policy rate and the interest rates of instruments above or below this rate, and these meetings are closely followed by the market. In this period, while the average funding cost may take different values on a daily basis within the corridor, it is observed that it is formed around the weekly repo rates, which is the policy rate in most periods. In some exceptional periods, the upper band of the interest rate corridor was used as the policy rate, or some of the funding was realized through traditional auctions and remained in the corridor, but not very close to the weekly repo rate.

Apart from the interest rate decisions, various statements of the Central Bank can also be perceived as an indicator for the monetary policy to be implemented in the future, and such statements may come at expected or unexpected moments. For this reason, market actors who are closely interested in monetary policy generally care about all statements from Central Bank officials. Central Banks regularly organize meetings or similar organizations in certain periods and make statements in order to influence the expectations of the markets. Inflation Report meetings for Turkey can be given as an example of such meetings.

In this context, Central Banks aim to be effective not only on direct short-term interest rates, but also on many indicators such as long-term interest rates with their interest policies and various explanations. The method of managing long-term policy expectations is accepted as a policy tool by European and US Central Banks and is called “Forward Guidance”. Even if the Central Bank of the Republic of Turkey does not use this concept directly, it gives clues that they want to use this tool effectively in various announcements.

To understand the effectiveness of the Central Bank’s instruments, it is necessary to examine the various effects of these announcements (both the interest rate decisions and the various statements mentioned). Examining the effects of the announcements on the financial markets can give an idea to understand the channels through which their activities take place. However, it will be difficult to examine the full implications of the announcements. Expectations regarding announcements are an important variable in terms of the effect of announcement on financial data. An expected explanation and an unexpected explanation can produce different effects even if they show the same characteristics. Accordingly, it will be necessary to assume that the expected parts of the announcements do not affect the financial indicators at all[2]. By understanding the surprise effects of the announcements, an idea can be obtained for the direction of the general effects.

Although there are similar studies in the literature, no study has been seen that examines the effects of Central Bank statements as multidimensional variables. In order to carry out this study, it will be an important question how to define the surprise effect or shock of the monetary policy statement. In this thesis, this shock will be defined as the changes in interest rates in different maturities in the bond market with the “High Frequency Identification” technique and its effects on other financial markets will be examined. In addition, some views on whether or not a few other market rates should be used as shock indicators will be given. In order not to examine the effects only instantaneously or for a single period, the analysis with the VAR system will be used to obtain more information. The method to be used will first be the “VAR with functional shocks” method developed by Inoue and Rossi [20], but then several different data techniques will be tried as shock data. In this thesis, while the overall effects of yield curve changes on financial assets will be examined, the effects on maturity basis will also be examined.

CHAPTER 2

MONETARY POLICY IN TURKEY SINCE 2000

2.1 Introduction

In this chapter, before moving on to the analysis to be used in the thesis, the place of interest rate policies in monetary policy practices in Turkey after 2000 will be emphasized. In the analyzes to be used in the rest of the study, the interest policy of the Central Bank and expectations regarding the interest rate policy were used. Data on other monetary policy instruments and indicators are considered not as effective as interest policy on the markets due to the nature of monetary policy practices. To explain this situation, especially after 2000, monetary policy applications analyzed without going into too much detail.

2.2 Monetary Policy in Turkey After 2000

The Turkish economy went through various crises and various monetary policy practices in the 1990s. In this period, very high interest levels were observed mostly due to high public debt and ineffectiveness of public banks. Due to the loss of confidence in the Turkish lira, dollarization was one of the most important problems of first years of 2000's. In this context, the Inflation Struggle Program entered into force in 2000. [38] After the monetary policy implementations implemented, the targeted goals in the economy could not be achieved sufficiently and the fixed exchange rate system was abandoned and "Transition to a Strong Economy" program was put into effect in 2001. The details of these programs will not be examined in this thesis.

In 2001, important changes were made in the Central Bank law. With the abolition of the fixed exchange rate regime, it was stated that the main purpose of the Central Bank was to ensure price stability, and it was added to the law that the Central Bank would take the necessary measures. However, the Central Bank has been given the task of supporting the government's growth and employment policies, provided that it does not conflict with the aim of price stability. The Central Bank gained instrument independence during the monetary policy implementation process and the Monetary Policy Committee (MPC) was established to take monetary policy decisions. [37] In the annual reports of early 2000's, it is stated that the main policy instrument is short-term interest rates.[39]

When examining how the Central Bank has used funding tools since 2010 2.1 it is seen that, the Central Bank used an asymmetric and wide interest rate corridor system. The interest rate corridor is the application of different interest rates in various funding transactions of the Central Bank. Thus, the Central Bank, which does not have a single interest rate, will be able to react to instantaneous shocks by changing the composition of the funding instruments without changing the policy rate, and fine-tune the funding rates when necessary. In this period, the Central Bank declared that it would also monitor financial stability in addition to price stability. For this purpose, it has followed an actively managed liquidity policy on a daily basis within the wide interest rate corridor. In other words, the Central Bank used its instruments with different interest rates in daily funding operations in a controlled manner and ensured a different average funding cost each day. According to the effect of the instant shocks, the average funding rate was kept within the corridor, but at higher or lower levels than policy rate, in a controlled manner. Funding provided by different instruments was generally provided at different interest rates, in accordance with the daily liquidity needs of banks. [37]

Until the middle of 2016, the upper band of the interest rate corridor was kept quite high compared to the policy rate, and the funding composition was changed daily and the average funding rate was checked daily. However, it was later evaluated that this situation made it difficult to understand the monetary policy stance, and the upper band interest rate of the interest rate corridor was gradually reduced. In the graph 2.1, it is seen that the Average Funding Rate generally hovers above the Policy Rate in the years 2010-2016 and takes different values on a daily basis. However, when we look at the Overnight Money Market Rates, it is seen that the interest rates diverge from the Average Funding Rate and their volatility is high throughout the period. It is observed that especially from 2015 to 2017, Money Market Rates are consistently above the Average Funding Rate and remain at the upper band funding rate.

Since 2017, the interest rate corridor has narrowed considerably and has continued its course until today. However, with the narrowing of the band in 2017, the policy rate did not used as a funding rate at first. On the contrary, Late Liquidity Window funding, which has a higher interest rate than the upper band funding rate, was used regularly in this period and even became the only funding method. The Late Liquidity Window is considered as a non-standard part of the interest rate corridor, and its intended use can be considered as a last funding opportunity for banks that still need liquidity after the closure of many money markets. However, despite this, it was used as the main funding tool from mid-2017 to mid-2018.

After a sudden increase in the exchange rate overnight in August 2018 and subsequent volatility in the financial markets, the Central Bank increased the policy rate considerably and started to use the policy rate as the main funding tool. Especially since August 2018, MPC meetings have become the most important announcements in terms of monetary policy stance. In the second half of 2018, the Central Bank also used some funding transactions apart from the policy rate and weekly repo funding, but the Average Funding Rate generally moved around the Policy Rate and the overnight Money Market Rates remained at similar levels within the

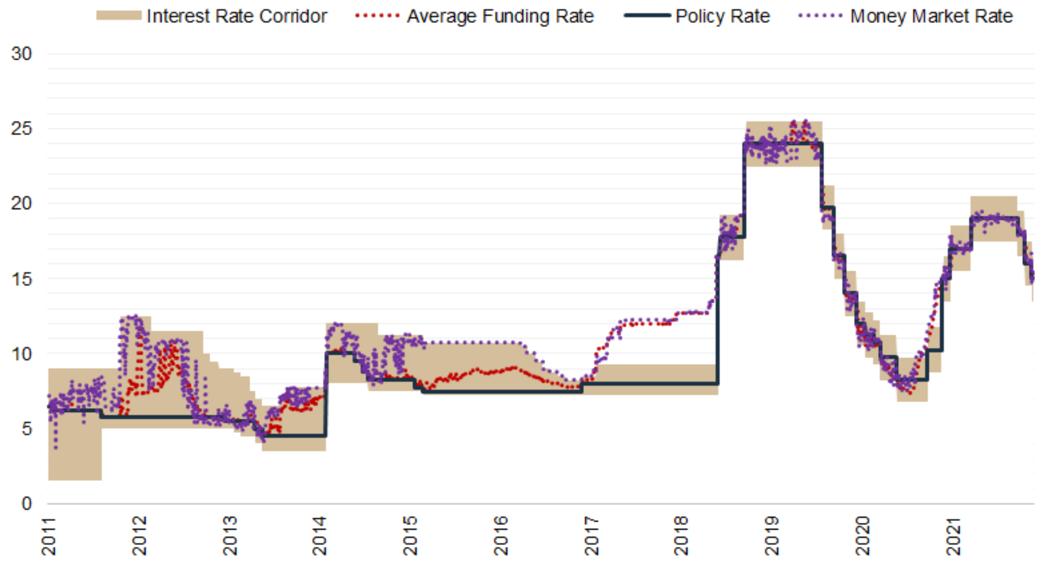


Figure 2.1: Interest Rate Corridor, Average Funding Rate and Money Market Rate

corridor. Starting from the second half of 2019, the policy rate has been gradually reduced. In this period, the funding was mostly realized through weekly repo transactions from the Policy rate and the Money Market Rates were formed accordingly. At the beginning of 2020, the interest rate reduction process to support the economy continued due to the Covid-19 pandemic, and at the end of 2020, the interest rate hikes were started again. In this period, funding at short intervals was realized with traditional auctions instead of fixed-rate amount auctions, and the Average Funding Rate was above the interest rate corridor with the expectation of an increase. From the beginning of 2021, interest rates started to be reduced again. In 2021, funding was generally realized through weekly repo auctions at the policy rate.

2.3 Providing Funding at the Level of Liquidity Needs of Banks

Central Banks does not directly determine the amount of funding, instead, the money is needed by the banks for their required or free reserves, the deficits caused by the inflows and outflows in payment systems accounts due to the fact that the Treasury accounts are with the Central Bank, and the deducted money from the payment systems accounts due to conversion into paper money due to the change in the emission volume. In addition, the Central Bank can create liquidity deficit or surplus in the market through foreign exchange or bond purchases and sales. For example, it will not be directly beneficial for the Central Bank to make extra funding to increase the volume of loans and deposits. Banks will try to lend more money than they need to each other and then to the Central Bank. If the central bank does not use its standing facility for borrowing, it is expected that the short-term market interest rates will fall to very low. On the contrary, if the required liquidity is not provided, the required reserves will not be kept adequately since there will not be enough money in the payment system accounts and the Central Bank will have to impose sanctions on some banks. If the banks are provided with even less liquidity, there will be a risk that there will not be enough money in the payment systems accounts for money transfer, so there will be a possibility of locking the payment systems. This example happens when the banking system is in liquidity deficit. On the contrary, if the Central Bank closed the entire liquidity gap of the banks through asset purchases and even led to the formation of excess liquidity, this time the banks would want to lend the excess liquidity to the Central Bank. After 2008, the US and European Central Banks started to purchase assets (usually private sector bonds) under the name of "Quantitative Easing" in order to reduce the long-term borrowing rates of the private sector, causing excess liquidity in the market.

This situation does not limit the amount of money that will occur in the market. The limiting assumption is that the monetary base and money multiplier are fixed, and banks cannot make loans without having deposits. On the contrary, banks can extend loans even if they do not have deposits[28]. Even if the deposit created in return for the loan opened when banks open a loan, is paid to other people, since those people also use the banking system, the deposit covering the newly opened loan will continue to exist in the banking system. However, as stated above, if this deposit is requested to be converted into paper money during the payment process or for any other reason, that is, if there is an increase in the emission volume, there is an outflow of money in the banking system and this outflow will be funded by the Central Bank in today's Central Banking system. If it is not funded, less liquidity will be provided to the banks than they need, and the above-mentioned situations will occur. Cases of providing over or under liquidity can be examined by looking at whether there is more or less money than required reserves in the payment system accounts data.

Since the amount of funding provided to the market by the Central Bank is not largely under the control of the Central Bank, interest rates come to the fore as the main monetary policy tool. For this reason, it is considered that the most important decisions taken on behalf of monetary policy in 2000's are the interest rate decisions.

In 2000's the Central Bank of Turkey provided the needed funding to the banks. Required reserve ratios of banks are shown in the graph 2.2.

Despite some daily or periodic volatility, the liquidity needed by the banks has been fully provided and not much excess liquidity has been given. Due to the daily uncertainties in the amount of money entering and leaving the banking system and the changes in the behavior of banks according to their daily expectations, the liquidity need cannot be calculated exactly. Therefore, although some volatility was observed, there were no major deviations from the need.

2.4 Conclusion

Despite the use of other policy tools from time to time, it is seen that the policy rate was the main policy tool of the Central Bank at the end of the 2000s. However, in some periods,

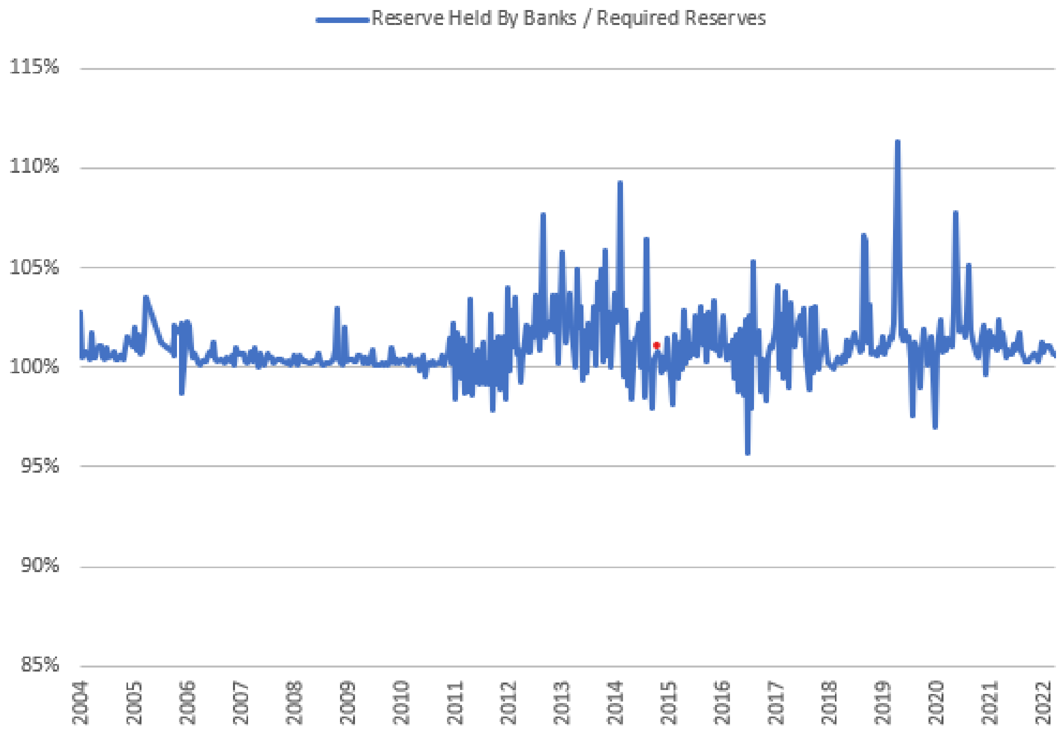


Figure 2.2: Required Reserves Holding Ratio of Banks since 2004

it is seen that the policy rate is not the weekly repo rate as explained in the policy texts, but by other overnight maturity funding instruments' rates. In addition to the fact that MPC interest rate decisions are the main policy text that affects policy expectations, it is considered that the explanations in the inflation report are also of great importance. Therefore, it is considered that it would be appropriate to examine the effects of these decision texts in terms of influencing monetary policy decisions. In addition to these policy texts, it is considered that the Central Bank's statements regarding the use of other funding instruments, not the weekly repo rate, are of the same importance as the interest rate decisions. Similarly, it is considered that the effects of some decisions taken within the scope of the Covid-19 pandemic measures and the recent statements about the unexpected arrival of the economic administration, which has a different stance on the monetary policy approach, will be important and should be examined.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

Nowadays, central banks do not try to directly control the amount of money and use the interest rate of this money as a policy tool in normal times, as it has the power to create money that is used as reserve money in the market. [28] For this reason, as the most important indicators of the monetary policy to be applied for the market, the interest rate statements of the central banks or various explanations about the interest policies to be implemented in the future, namely "forward guidance" are accepted. Apart from this, if the central bank interest rates reached the lowest possible level and the central bank nevertheless wanted to follow a more expansionary policy, it was necessary to follow methods other than interest rate changes. An example of this is the "Quantitative Easing" method followed by European and US central banks. In this example, which can be summarized as a kind of bond buying program, the aim is not for the central bank to put more reserve money on the market by buying assets. The main purpose is to buy private sector bonds from non-banks, to enable them to make new purchases in their portfolios and thus to enable the private sector to borrow more cheaply. [28] In summary, central banks' interest rate announcements and policies that indirectly affect interest rates are very important for the market. Market actors make various transactions in the financial markets according to their expectations in this regard and are determinant in asset prices.

3.2 Literature on the Effects of Central Bank Statements

The effects of central bank decisions on various assets have been examined in various studies in the literature. In previous studies, the effect of central bank rates on various market rates was examined and it was observed that the effect changed according to maturities. Cook and Hahn [10] stated that the changes in the Fed's interest rate target have an impact on short-term interest rates, but have little effect in the long and medium-term. However, it has been stated that the effects are similar and this is interpreted as being consistent with expectations theory, which claims that expected short-term rates determine long-term rates. Gürkaynak, Sack and Swanson [16] stated that the Fed's statements, attitudes and discourses that will change not only the interest rate target decisions but also the expectations for the interest rate decisions can be even more effective than the decisions themselves, especially since the decisions made in the period examined in the mentioned study are generally compatible with the expectations. found to be supported. In the study, the effects of various statements of Fed officials and interest rate decisions on long and short-term interest rates were examined, and it was assumed that the surprise effect of interest rate decisions would be effective on short and especially long-term interest rates, regardless of the direction of the decision. It has been understood that the decisions and explanations do not only have a one-dimensional effect on short-term interest rates, therefore the effects should be examined multidimensionally. In addition, in this study, it is mentioned that high frequency identification technique can be applied to indentify the effect of surprise. For this, Fed funds futures market rates, which are considered to be highly liquid, are used. For Turkey, the Overnight Interest Swap (OIS) market, which can be considered similar to this market, has very low transaction volumes and entered order amounts, and it is considered that it is not possible to use it in the same way. Instead, it would be appropriate to use the bond market interest rates or implied interest that obtained from USD/TRY exchange rate forward transactions.

In addition, in another study by the same authors [17], it was understood that the surprise effects of monetary policy decisions also significantly affected long-term interest rates, contrary to the view that central banks only had control over short-term interest rates and were not effective in long-term.

3.3 Literature on the Effects of Unconventional Monetary Policies

In the early 2000s, although the central bank interest rates in Europe and the USA were extremely low, it was evaluated that the economies could not create enough inflation, and many studies were conducted on the effectiveness of methods such as "Forward Guidance" and "Quantitative Easing" to be effective on long-term interest rates. A detailed review of the methods used to identify monetary policy shocks in similar studies made by Rossi [32].

The effects of the forward guidance policy implemented by Swanson [35] for the USA between 2009-2015 were low on long-term interest rates, but large-scale asset purchases were highly effective on long-term interest rates, and the effect of asset purchases on short-term interest rates was very limited, In the medium term, an empirical study has been carried out that both policies are highly effective and that the exchange rate and stock markets are also affected by these policies. In another study of the author [36], it is stated that the effects of the statements of these policies for the USA between 1991 and 2019 on bond rates, stocks and exchange rates are mostly permanent and evident. Studies by Breedon, Chadcha and Waters [6] on the effect of QE policies in the UK on bond rates significantly, and on the effect of QE policy on various market rates in the USA by Krishnamurthy and Vissing-Jorgensen [25] has been made. De Santis[12], on the other hand, stated that the high frequency identification technique would be insufficient to explain the surprise effect due to the more closed disclosures of asset purchases in the Eurozone, and developed an index based on the intensity of the Bloomberg news.

3.4 Literature on Analysis Methods

While examining the effects of monetary policies on various assets in empirical studies, many methods have been developed to separate these effects from other effects in the market. Gürkaynak, Sack and Swanson [16] adopted the "High Frequency Identification" technique. This is applied in the process of selecting the data to be used in technical analysis. In this technique, it is assumed that the change in the interest rates of the assets traded in the market in a short time after monetary policy statements are made, is caused by the monetary policy shock, and it is assumed that other variables are not effective in this short period of time. The change in market interest rates after the announcement is used in the analysis as the effect of the shock. The same approach is used by Inoue and Rossi [20], but the change in interest rates is included in the analysis as the change in the whole yield curve function, not just multidimensional. This method was used by Faust, Rogers, Swanson and Wright to determine the surprise effects of the [15] Fed statements, and it was stated that strong assumptions of the identification method based on recursive ordering in the VAR system would not be needed in this way.

An alternative method for creating impulse response functions of VAR systems has been suggested by Jorda [22]. This method is based on obtaining the impulse response function coefficients with a regression without the need to install the entire VAR system. In addition, Jorda states that the coefficients obtained by this method are more robust against missspecification. The idea that exogenous variables can be used to describe the causal effects of [33] macroeconomic shocks was proposed by Stock and Watson. For this, it is stated that regressions that define local projections can be used, as well as vector autoregressions. Vector autoregressions must be reversible in the identification procedure. However, in this study, it was stated that local projection regressions can be valid even if vector autoregression cannot be reversed. In the light of these studies, it is understood that high frequency data contain monetary policy shocks and the dynamic effects of these shocks can be obtained by local projection regressions.

Bailey [4] stated in his study in 1988 that surprise money supply changes affect various market volatility. Rigobon and Sack [31] used the short-term increases in market volatility caused by monetary policy surprises to define monetary policy shocks. They based this approach on the analysis that the correlation between the policy rate and the prices of the assets traded in the market changed on the days when the monetary policies were announced, and accordingly, they developed two different methods of finding the heteroskedasticity based estimator. The first of the methods is about using instrumental variables, while the second is a GMM method. As a result of the study, it was seen that the US monetary policy decisions were effective on the stock market, while the effect on bonds was intense in the short and medium terms, the effect on the long-term interest rates was relatively weak. The effects of monetary policy shocks on economic and financial variables were investigated by Gertler and Karaldi using instrumental high-frequency data as instrumental variables. The effects of shocks on output and inflation were examined, and also it was stated that relatively small changes in short-term interest rates had great effects on credit costs, and it was evaluated that this was due to the reactions in term premia and credit spreads, and that the "Forward Guidance" policy was quite effective. Tillmann stated that [40] stated that when monetary policy uncertainties are high, the response of the maturity structure of interest rates to monetary policy statements changes, and when uncertainty is high, long-term interest rates are relatively less affected by monetary policy statements. The reason for this is explained as the investors' increasing demand for long-term assets during periods of uncertainty and accepting a lower term premia. Pooter, Favara, Modugno and Wu [11] similarly stated that if the monetary policy seems uncertain, the effect of long-term interest rates from the announced monetary policy changes weakens, thus weakening the monetary transmission mechanism. As an indicator of monetary policy uncertainty, probability distributions of price expectations based on federal funds rate derivative transactions are used in the studies. This has created a shock definition that is valid in both cases, since the same shock definitions were not valid in the periods when Rogers and Wu [8] monetary policy was unconventional and conventional.

3.5 Literature on Yield Curves

When examining the effects of monetary policy shocks on interest rates, the maturity structure of interest rates comes to the fore. The maturity structures of interest rates are generally analyzed with yield curves. These are curves that show interest rates according to maturity, and it is of great importance that the markets they are obtained from have implied zero curves, that is, they are created with the assumption that each point of the curve gives the coupon-free bond interest at that point. Using the yield to maturity of assets with various cash flow structures directly in the calculation of yield curves can yield misleading results. Although yield curves can be created by various methods, it is generally seen that three-factor models come to the fore. Litterman and Josè [27] stated that the movements in the bond markets can generally be analyzed by three factors. The model created by Nelson and Siegel [29] and used in this study is a three-factor model. The use of a three-factor model compared to spline methods allows factors to be calculated separately and used in various analyzes. There are various studies in the literature to use the Nelson Siegel model to fit the curve more appropriately to market rates. Gürkaynak, Sack and Wright [18] studied the suitability of the four-factor Nelson Siegel Svensson model for the US bond market. Similarly, Akıncı, Gürcihan, Gürnaynak and Özel [1] stated that the same model can be used for Turkey yield curve estimation. They also provided that Diebold, Francis and Li's [13] three-factor Nelson Siegel model increased the estimation success and allowed the factors to be defined as level, slope and curvature. However, it is not possible to use the curve parameters as the specified factors for the Turkish bond market. Accordingly, Çepni, Güney, Küçüksaraç and Yılmaz [9] adopted a different approach that would allow the curve parameters to be defined as these three factors.

3.6 Literature on the Effects of Monetary Policy Implementations in Turkey

There are similar studies examining the effects of the Central Bank's monetary policy practices on financial markets and macroeconomic indicators for Turkey. Binici, Kara and Özlü [5] showed that, during the period the overnight Central Bank average funding rate change every day in interest rate corridor, the overnight interest rates formed in the interbank market is effective on higher maturity market interest rates rather than the Central Bank's average funding rate. After the period examined in this study, the Central Bank switched to the method of funding interbank market rates in a way that converges to the policy rate. Therefore, within the scope of this thesis, it will be assumed that the Central Bank interest rates will be effective interest rates for the markets. Similarly, Kılınç and Tunç [24], who used the Central Bank's interest rates in the analysis of monetary policy shock, reached the conclusion that the increase in interest rates negatively affects output and monetary aggregates with the Structural VAR method.

The heteroskedasticity-based generalized method of moments (GMM) developed by Rigobon and Sack [31] has been used for Turkey by Duran, Özcan, Özlü and Ünalmış [14] to define the monetary policy shock. In this study, it was seen that the effect of monetary policy on market rates was significant, but it was understood that the effect decreased as the maturity lengthened. In addition, it was concluded that the monetary policy effect did not have a significant effect on the USDTRY exchange rate, but it was effective on the EURTRY exchange rate for the period examined. In addition, it has been observed that the stock index also reacts to monetary policy shocks.

Aktaş, Alp, Gürkaynak, Kesriyeli and Orak [2] examined the effects of monetary policy on various financial assets in order to examine the various channels of the monetary transmission mechanism. In this study, it is assumed that the expected part of monetary policy will not have an effect on asset prices. It is assumed that the surprise part of the interest rate decision will be the change in 1-month treasury bill returns between the day before and the day after the decision. At the end of the study, it was seen that the surprise changes in the policy rate did not have a significant effect on the stock prices, but on the bond rates.

While examining the effects of monetary policy on financial markets in the studies conducted for Turkey, no study was found in which the surprise effect of monetary policy was defined as multidimensional. While the surprise effect by Aktaş, Alp, Gürkaynak, Kesriyeli and Orak [2] is only considered as the daily change in short-term bond rates, in this thesis it will be evaluated that the change in all maturities is taken as a collective effect. Apart from the bond market, it is possible to use different market rates as a surprise effect indicator. Alp, Kara, Keleş, Gürkaynak and Orak [3] stated that Turkish Lira Interbank Bid Rate (TRLIBID) interest rates are the best showing the monetary policy expectations, and especially short-term TRLIBID rates show the forecasts best as they get closer to the interest rate decision.

However, these rates are only calculated for maturities up to one year and cannot be used as an indicator of the longer-term effects of the monetary policy surprise. In this context, it is considered that the markets that can be used as an indicator of the surprise effect are the bond market and USD/TRY forward markets due to their high transaction volumes.

CHAPTER 4

METHODOLOGY OF THE ANALYSIS

4.1 Introduction

In this chapter, analysis methods to be used in examining the effects of Central Bank announcements on financial markets will be discussed. The analysis was basically carried out by establishing a VAR system and examining the impulse response graphs of shock variables. However, the established VAR system is not a standard VAR system, but allows the collective effects of multidimensional shock variables to be examined. Since the "VAR with functional shocks" method is used in this thesis, information about this method, then basic information about the yield curve function that will define the shock variable, and information about identifying the VAR system will be explained in this chapter. Since in this VAR system, aggregate impulse response graphics of multiple shock variable data should be obtained, the VAR system was not directly created as a single model, instead the "Local Projection" of impulse responses were calculated with a regression for each time interval. Information about this method will also be given in this section.

Although the basic information about the yield curve function used will be given in this chapter, the process of creating the yield curve and the analysis of the obtained parameters will be examined in another chapter, since this subject needs to be dealt with in more detail.

4.2 VAR with Functional Shocks

In this thesis, a trial of the "VAR with functional shocks" method introduced by Inoue and Rossi [20] was conducted to investigate the effect of monetary policy decisions on financial assets in Turkey. They did not take only the change in short-term interest rates as the measure of monetary policy shocks, but instead emphasized that the effect is multidimensional. A similar view was expressed by Gürkaynak, Swanson and Sack[16], the effects of unexpected monetary policy statements on both short-term and long-term securities were examined, and it was revealed by principal component analysis that interest rate changes in a very short period of time have a multidimensional structure. However, according to the results of the analysis, it can be said that the number of effective dimensions is not high, so it is expected that examining the effects of the yield curve function as a whole is not an effective method.

As one of the most basic assumptions of the method, Ionue and Rossi [20] considers the instantaneous interest rate changes immediately after monetary policy decisions or explanations as the movement of the entire yield curve, not only in certain maturities. In other words, if monetary policy decisions are predicted by the actors in the market depending on the market developments and the yield curve is formed accordingly, it is expected that the announcement will not have an effect on the curve, and in other words, the decision is considered to have no surprise effect. If the decision has a surprise effect, it is expected to have an effect at every point of the yield curve. Inoue and Rossi [20] stated that this surprise effect is a situation that concerns not only short-term interest rates but also the entire yield curve. In the method to be used in this study, the change of the yield curve function is directly inserted into the VAR model instead of interest changes. Inoue and Rossi [20] used Nelson Siegel [29] model as the yield curve function in his study.

$$y_t(\tau) = \beta_{1,t} + \beta_{2,t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right) + \beta_{3,t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right) \tag{4.1}$$

In this function y_t represents the yield, τ represents the year to maturity, and λ and β's represent the parameters to be obtained by optimization. In the literature, it is stated that β_1 shows the return as maturity goes to infinity, $\beta_1 + \beta_2$ shows the return in the shortest term, λ shows the place where the curve humps, and β_3 shows the size of the hump. In the study of Rossi [20] and in the first part of this study, the λ parameter was fixed as 0.0609, which was stated by Diebold and Li [13] as the figure that maximizes the medium-term factor. In another approach developed by Çepni, Güney, Küçüksaraç and Yılmaz[9], it is stated that the lambda parameter, which minimizes the correlation between beta parameters in the model, can be used to fix the lambda parameter. Thus, the model can be constructed by estimating only three parameters. The loadings of these three parameters β have become fixed functions. The fixation of the λ parameter is important in terms of making the weight function of the beta coefficients a constant number in the VAR system, as well as providing the estimation of the three β parameters with the OLS method.

In order to embed the yield curve function in the VAR model, we can write it as follows.

$$f_t(\tau;\lambda) = \sum_{j=1}^{q} \beta_{j,t} g_j(\tau;\lambda) \tag{4.2}$$

A VAR model with this function can be represented as:

$$X_t = c_1 + \phi_{1,1}X_{t-1} + \phi_{1,1}\int w(\tau) f_{t-1}(\tau;\lambda)d\tau + u_{X,t}, \tag{4.3}$$

$$f_t(.;\lambda) = c_2(.;\lambda) + \phi_{2,1}(.;\lambda)X_{t-1} + \phi_{2,2}f_{t-1}(.;\lambda) + u_{f,t}(.;\lambda) \tag{4.4}$$

$c_2(.)$, $\phi_{2,1}(.)$ and $u_{f,t}(.)$ are same class linear functions with (4.2).

$$c_2(\tau;\lambda) = \sum_{j=1}^{q} \tilde{c}_j g_j(\tau;\lambda), \tag{4.5}$$

$$\phi_{2,1}(\tau;\lambda) = \sum_{j=1}^{q} \tilde{\phi}_j g_j(\tau;\lambda), \tag{4.6}$$

$$u_{2,1}(\tau;\lambda) = \sum_{j=1}^{q} \tilde{u}_{j,t} g_j(\tau;\lambda), \tag{4.7}$$

If we consider while $w(.)$ is a given weight function $\int w(\tau)g_j(\tau;\lambda)d\tau$ as I_j and write VAR model in matrix form:

$$\begin{bmatrix} X_t \\ \beta_{1,t} \\ ... \\ \beta_{q,t} \end{bmatrix} = \begin{bmatrix} \phi_{1,1} & \phi_{1,2}I_1 & ... & \phi_{1,2}I_q \\ \tilde{\phi}_1 & \phi_{2,2} & 0 & 0 \\ ... & ... & ... & ... \\ \tilde{\phi}_q & 0 & 0 & \phi_{2,2} \end{bmatrix} \begin{bmatrix} X_{t-1} \\ \beta_{1,t-1} \\ ... \\ \beta_{q,t-1} \end{bmatrix} + \begin{bmatrix} u_{X,t} \\ \tilde{u_1}_{,t} \\ ... \\ \tilde{u_q}_{,t} \end{bmatrix} \tag{4.8}$$

The model is written in reduced form above. As with the standard VAR method, the identification problem also arises when the model is used in this way. The methods used in standard structural VAR can be used to solve the identification problem. Rossi [20] used the "high frequency identification" technique to alleviate this problem. According to this method, the data of the variable (daily interest return changes) whose effect is desired to be examined in a very short time are used in the model. The very short time may differ depending on the frequency of the data or the event to be examined. Inoue and Rossi [20] used monthly macroeconomic data in his study and took interest changes on a daily basis. Gürkaynak, Swanson and Sack [16], on the other hand, took the interval between 10 minutes before the announcement of the decision and 20 minutes after the decision as a basis. However, in this study this kind of high frequency data could not be obtained and another assumption is based in order to solve data problem.

4.3 Obtaining Impulse Response Functions by Local Projections

It is possible to use the local projection method to obtain the impulse responses of the installed VAR system. In this method discussed by Jorda [22], impulse responses are expressed as the following function.

$$IR(t,s,d_i) = E(y_{t+s} \mid v_t = d_i; X_t) - E(y_{t+s} \mid v_t = 0; X_t) \qquad s = 0,1,2,...,h \tag{4.9}$$

where d_i is structural shock on variable i, y_{t-s} is value of variable y at $t+s$ and X_t is $[y_{t-1}, y_{t-2}, ...]$.

When the impulse response function is expressed as above, the impulse responses of a standard VAR system can be calculated approximately with the following function. Jorda [22] stated that the impulse responses obtained in this way are significant, more robust against model miss specification, and can be easily calculated with standard regression methods.

$$y_{t+s} = \alpha^s + B_1^{s+1} y_{t-1} + B_2^{s+1} y_{t-2} + ... + B_p^{s+1} y_{t-p} + u_{t+s}^s \qquad s = 0, 1, 2, ..., h \quad (4.10)$$

where α^s is constant vector and B_i^{s+1} is coefficient matrix for i'th lag and time $s+1$. Therefore, every impulse response can be represented as follows.

$$\widehat{IR}(t, s, d_i) = \widehat{B}_1^s d_i \qquad s = 0, 1, 2, ..., h \quad (4.11)$$

Obtaining impulse responses with this method is simply reduced to solving a series of equations with OLS. Impulse response functions that will be of interest in adapting this to the VAR model above will be functions that will examine the relationship of X_t's and β's. However, the aim of this study is not to explain the long-term relationship between the yield curve and other financial variables, but only to examine the effects of monetary policy announcements. The yield curve parameters will be used only as a tool. Accordingly, the basic assumption to be considered is to accept that the numerical effect of monetary policy statements is the change in yield curve parameters and other variables that affect yield curve parameters on the days of monetary policy announcement will be ignored. With this assumption, the impulse responses of the VAR system can be easily obtained by solving the following regressions.

$$X_{t+s} = \Gamma_{0,s} + \Gamma_{1,s}(L)\Delta\bar{\beta}_{1,t} + \Gamma_{2,s}(L)\Delta\bar{\beta}_{2,t} + \Gamma_{3,s}(L)\Delta\bar{\beta}_{3,t} + A(L)X_{t-1} + V_{t+s} + u_{t+s} \qquad s = 1, 2, ..., h \quad (4.12)$$

In the function,$\Gamma_{j,h}$ represents the coefficients of the responses at time $t+h$. Delta $\beta_{j,t}$ represents the changes in the parameters of the Nelson Siegel function on the day of monetary policy announcements, and X_t represents the vector of other financial variables whose responses to monetary policy statements will be measured at time t in the study and $A(L)$ is the lag operator for these variables.V_t represents exogenous control data. Daily changes in VIX Index used as exogenous control data in this thesis. Thanks to the constant taking of the lambda parameter in the function, the regression to be solved can be reduced to its simple form above. In this study, models created with two different approaches used to keep the Lambda parameter constant will be included.

VAR models and impulse responses obtained by the local projection method by Brugnolini [7] were compared when the data generating process is a well-specified VAR. In this study, it was stated that determining the lag order as a constant value from the beginning and not changing it in other local projection regressions increases the probability of choosing the right specification, especially for the later period impulse responses, thus improving the results. It has also been shown that the wide confidence bands in the local projection method enable the method to give better results in case of model misspecification than VAR impulse responses.

Li, Plagborg-Møller and Wolf [26] compared impulse responses derived from VAR systems and those derived by Local Projection method in their studies. In their studies, it was stated that there was a bias and standard deviation trade-off between local projection and VAR, and local projections showed low bias at high standard deviation. In this context, it has been stated that shrinkage methods can be reduced for some bias and for the loss function used in the related article, the application of LP systems in short horizons and VAR systems in long horizons using shrinkage method gives the most successful results. Due to the uncertainties observed in the process of determining the lag number of the VAR system created with the data in this thesis, the model is open to misspecification, therefore it is thought that it would be appropriate to use the Local Projection method in order to minimize the bias. The specification process of the VAR system will be examined in detail in Chapter 6.

Also, it was stated that by Li, Plagborg-Møller and Wolf [26] least squares LP estimation method, if the shock was observed, it was directly added to the impulse response equation and lagged variables were used as control variables. It is stated that in case of using recursive identification, the values of the variables at time t can be added to the equation in order. However, since the "High Frequency Identification" method was adopted as the identification method in this thesis, the control variables are only included as lagged in the equation.

In these studies comparing VAR and LP impulse responses, data generating process is a well-specified VAR or a process that approximates to a well-specified VAR. The studies were carried out on the estimation of the general system by taking samples from the data generated by the data generating process. Based on the studies carried out in this context, no method has been found that will directly benefit the model specification in the LP method. In this context, in this thesis, the VAR model specification will be made without the shock variable, which is assumed to be the yield curve changes at central bank announcement dates, and when obtaining impulse responses with LP's selected VAR model will be assumed as the VAR specification. However, since the possibility of misspecification is considered to be high, the least squares LP method will be used and high standard deviations will be accepted. In addition, Li, Plagborg-Møller and Wolf stated that the [26] conventional model selection methods could not detect misspecification in realistic sample sizes.

Olea and Plagborg-Møller [30] stated that, with highly persistent data the estimation of impulse responses at long horizons by LP's asymptotically valid uniformly over both stationary and non-stationary data. Thus, they stated that the LP method is robust and easy to apply, even more than it is generally accepted in the literature. They stated that the impulse responses obtained with LP have higher standard deviation but less bias compared to the standard VAR method. In the study, it was also stated that VAR lag length selection could be made with traditional methods for LPs, but even if the selected lag number is higher than the actual structure of the data, there is no asymptotic efficiency cost and logically the coefficients in high lag orders will be low in real data and their effect will be low. Therefore, they stated that it would be sufficient to have control variables containing enough lag to provide the conditional mean independence condition in the LP application. In addition, in this study, when calculating the confidence intervals of LP impulse responses, instead of heteroskedasticity- and autocorrelation-consistent standard errors, Eicker–Huber–White heteroskedasticity-robust standard errors are used in lag augmented LP's (containing more lagged control variables than real processes) stated to be sufficient.

Herbst and Johannsen [19]indicated that impulse responses obtained with LP in low sample data number may result in high bias, and bias can be reduced with lagged control variables, but still cannot be completely eliminated. In this study, an estimation technique is proposed that reduces the bias slightly, albeit slightly.

4.4 Identification of VAR Model

Interest rate changes, which are used as shock variables in this study, are defined as a simultaneous change in the yield curve parameter. Accordingly, since the interest rate changes in the return VAR system are defined as the changes in the whole curve function, they are included in the model as the changes in the coefficients in the light of the explanations above. However, it is possible to use interest rates with different maturities directly in the model. In both ways, not only the short-term but also the long-term effects of monetary policy will be considered by the model. In this case, the effect of unexpected monetary policy developments on other variables through interest rates can be represented by the chain rule.

$$\frac{\partial X_{t+h}}{\partial \epsilon_t^f(.)} = \frac{\partial X_{t+h}}{\partial \Delta \tilde{\beta}_t'} \frac{\partial \Delta \tilde{\beta}_t}{\partial \epsilon_t^f(.)} = \Lambda_h \delta_t \tag{4.13}$$

With chain rule, it is explained that the shock ϵ in the variable f, whose effect is examined at time t, primarily affects the yield curve parameters, namely β's, and how much it is affected by the change in β, affects the variable vector X at time $t+h$, which is examined. It is assumed that the shock applied to $epsilon$ is a function of the same type as the yield curve function. Thus, this shock will only cause changes in the β parameters, assuming that the weight function is 1. Adding the changed β parameters directly to the model also causes us to assume that the variable δ_t is equal to 1.

In this study "High frequency identification" method, which is a data technique based on using data with different frequency, is used. In data used for model time cycle of β's are different than other variables. Due to the use of high frequency identification, the following assumptions were made in the model. Yield curve shocks do not affect other variables simultaneously. The change in the yield curve on the day of the policy announcement only reflects the unexpected effects of the monetary policy announcement. Any developments other than these dates are not included in the model as they do not cause a change in monetary policy expectations. As can be seen, the assumptions allow very restrictive explanations to be made.

4.5 Yield Curve Models

The yield curve model to be used is the Nelson-Siegel function as stated above. However, if necessary, it is possible to use the version of the function developed by Svensson [34]. Because of this situation, the number of time parameters in the function will increase to four and it will not be possible to accept the λ parameter as a constant number.

$$\begin{aligned} y_t(\tau) = \beta_{1,t} + \beta_{2,t}\left(\frac{1-e^{-\lambda_{1,t}\tau}}{\lambda_{1,t}\tau}\right) + \beta_{3,t}\left(\frac{1-e^{-\lambda_{1,t}\tau}}{\lambda_{1,t}\tau} - e^{-\lambda_{1,t}\tau}\right) \\ +\beta_{4,t}\left(\frac{1-e^{-\lambda_{2,t}\tau}}{\lambda_{2,t}\tau} - e^{-\lambda_{2,t}\tau}\right) \end{aligned} \tag{4.14}$$

In this thesis, first of all, the three-parameter Nelson Siegel function is used. While obtaining the function parameters, bond interests were not used directly, instead, the method of estimating the yield curve parameters by using the prices discussed by Gürkaynak, Sack and Wright [17] was adopted. Because there are both coupon and non-coupon bonds in the bond market and the bond coupons are different, it would be misleading to directly take the yield to maturity of these bonds as zero rate. Instead, parameters that minimize the difference between estimated bond prices and market prices should be used. However, as it is known, the price of long-term securities is more affected by interest rate movements than short-term securities. The parameters to be obtained in this way will be more sensitive to long-term interest rates than short-term ones. In order to eliminate this problem, it was suggested by Akıncı, Gürcihan, Gürkaynak and Özel[1] that the difference between the estimated prices and market prices should be weighted by $1/duration$ of the security.

The entire yield curve should be a function that shows the interest rate of the current discounted bonds, in other words, the zero rates. For this, all cash flows of all bonds traded in the market must be discounted with the interest obtained from the function, and the cash flows obtained in this way must be summed to obtain the estimated prices. By using these estimated prices, the differences with respect to market prices are minimized with the least squares technique. For this, a function that defines the sum of the squares of the difference between the market prices and the predicted prices in a Matlab script is prepared and the parameters that give the minimum value of this function is estimated with ready-made optimization functions within Matlab.

Nelson-Siegel and Svensson parameters were estimated by this method for the daily yield curves for the entire data set period. Since Nelson-Siegel parameters will be used in the VAR model, the λ value has been accepted as constant, while in the Svensson function, since only the interest on the yield curve will be used with this version of the function, the lambda values have also been estimated.

CHAPTER 5

YIELD CURVE ESTIMATION AND ANALYSIS OF PARAMETERS

5.1 Introduction

In this chapter, the process of creating the yield curve will be examined. The Nelson Siegel yield curve is derived on the assumption that the instantaneous forward rates derives from the solution of second-order differential equation with two equal roots[29]. In order to create the curve, the Nelson Siegel function must be fit for the yields of the bonds in the market and the function parameters must be calculated. However, the Nelson Siegel function is not suitable for methods of fitting linear functions. The λ parameter is included in the loadings to be multiplied by the β parameters. For this, either non-linear fitting methods should be used or λ should be taken as a constant number. In this thesis λ parameters are used as a constant number.

Although making the λ parameters a constant number will make linear methods available in the fitting process of the function, the interest rates of these bonds cannot be used as data to fit. Because the bonds in the market have coupon payments. In order to solve this problem, it is necessary to know the interest rates corresponding to the coupon payment dates of the bonds. However, these interests have to be calculated inside the yield curve anyway. For this reason, OLS, which is a linear fit method, cannot be used. The non-linear fitting method to be used instead will be explained in this chapter.

In addition, when yield curve parameters are obtained, it is important for the VAR system that the correlation between them is not high. Analysis of the obtained parameters in this direction will also be discussed in this section.

5.2 Fitting Yield Curve to Bond Yields Data

In order to fit the yield curve to coupon-paying bond returns, the outputs of a suitable function should be minimized by non-linear optimization techniques. This function should discount all coupon payments with the Nelson Siegel function, should aggregate discounted cash flows of bonds as their estimated prices and give the difference of these values with the market prices of the bonds. In this thesis, since the optimization will be based on the logic of least squares, the function to be used in the optimization is established as the square of the difference between the estimated values of the bonds and the market prices.

While fitting the Nelson Siegel curve, the method of minimizing the differences between the estimated and actual prices of the bonds is adopted. However, this method brings with it a problem. As the duration of bonds increases, their sensitivity to interest movements increases, therefore, when the fit process is applied to bonds with different maturities, the importance given to the interests of long-term securities increases compared to short-term ones. In this case, when the yield curve is fit in this way, it is expected that the errors in the short-term values will increase. In order to solve this problem, it is necessary to weight the estimation errors of the assets in the opposite direction. The inverse of the durations of the securities is suitable for use in this weighting. The fitting process used in this thesis is about minimizing the difference between the estimated and real prices by first multiplying the inverses of the durations of the assets and then squaring them by function optimization.

If m represents the vector of all non-repeating cash flow dates of s bonds, l_{sxm} represents the matrix where these bonds have their respective cash flows relative to the vectors m and s, and 0 if the sth bond has no cash flow at the relevant cash flow date, $y(.)$ represents the Nelson Siegel function, the vector f represents the column vector containing the real market prices of the bonds, w represents the column vector representing the weights of the bonds relative to the inverse of their duration, objective function takes the form below.

$$obj = ((l \times (e^{-(y(m) \odot m)})^T - f) \times w)^2 \tag{5.1}$$

Where $\odot$ represents point-wise multiplication.

In order to fit the function with this method, ready-made optimization functions in the "Matlab" application are used. The optimization function also needs some initial values. Initial values are all possible triple choices of values -20, -10, 0, 10, 20 for β_1, -10, -5, 0, 5, 10 for β_2 and -20, -10, 0, 10, 20 for β_3. The lowest error terms were selected from the curves calculated with the initial values. λ values values are chosen as constant numbers as specified in the next section.

5.3 Yield Curve Parameters

The λ parameter recommended by Diebold [13] is the value that maximizes the loadings of β_2 and β_3. In this way, it is argued that the medium term of the curve is best formed by only fitting the βs. On the other hand, the lambda parameter proposed by Çepni, Güney, Küçüksaraç and Yılmaz [9] is a value obtained by empirical methods that reduce the correlation between the β parameters. It is considered that the latter of the two values reduces the correlation between

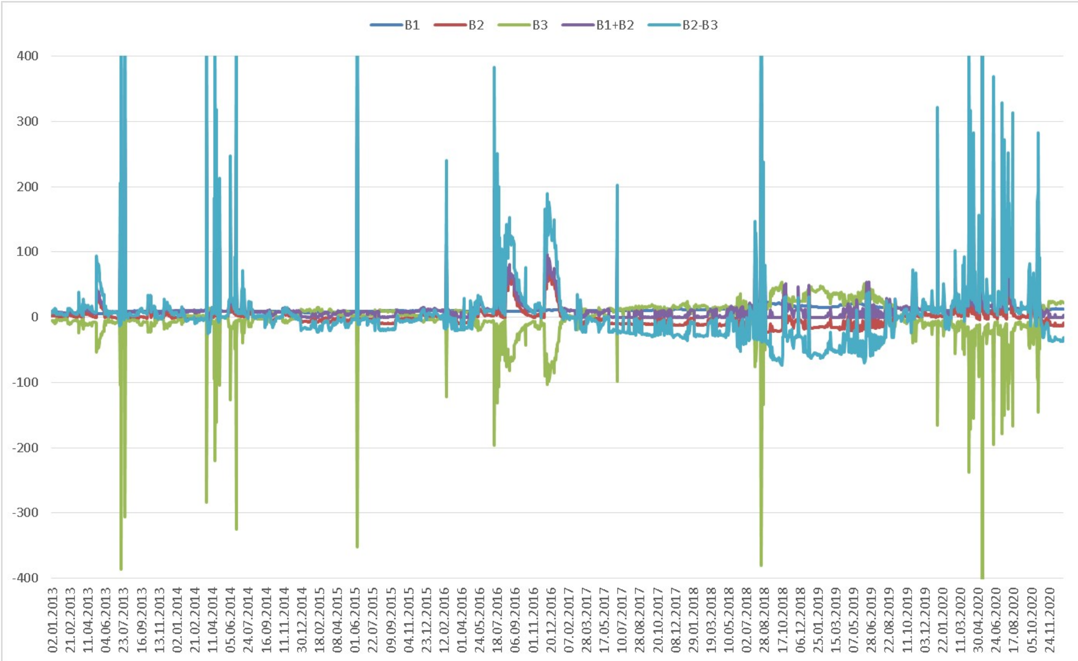


Figure 5.1: Nelson Siegel Parameters with $\lambda = 0.0609$

β parameters in accordance with the mentioned study and is more suitable for this thesis. Using less corralated yield curve parameters will allow model to observe multidimensional effects better. However, the curve fitting process is a separate regression estimation. For this reason, as in any regression, an existing correlation between the data can affect the confidence interval of the coefficients, and in the fit method, which is based on minimizing the errors by algorithmic optimization (the best curve is based on the smallest point found between various local minimum points, not the global minimum point) may cause the parameters to function with each other. For this reason, the parameters of the yield curve formed by the value of λ proposed by both authors are examined below.

Nelson Siegel model was run with the value of λ 0.0609 and 0.95 for the daily bond market transactions since the beginning of 2013 and the following model parameters were obtained.

When the model parameters are examined in 5.1, it is seen that β_1 follows a stable movement, while β_2 and β_3 can take very high or low values on some dates. It is thought that the loadings of these parameters are quite similar and the only difference between them is the $-e^{(-\lambda\tau)}$ term. However, it is seen that the difference between these two parameters can reach very high values.

The high correlation between the loads causes this situation in calibrating the model parameters. When β_2 parameter gets a positive high value, β_3 parameter gets a negative high value. Therefore, using the parameters as shock variables in the VAR model will not be effective.

The graph of the coefficients calculated for $\lambda = 0.95$ suggested by Çepni, Güney, Küçüksaraç and Yılmaz can be seen in 5.2. Compared to Diebold's coefficients, the tendency to take high or low values in these coefficients is much less. This is clearly seen when figure 5.4 and 5.3

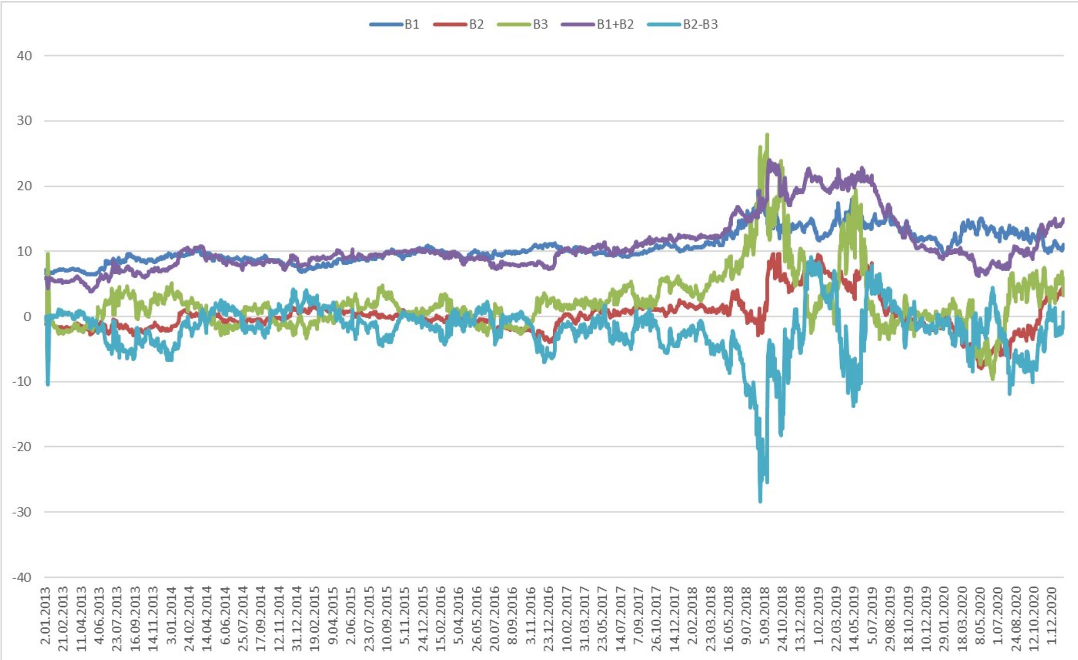


Figure 5.2: Nelson Siegel Parameters with $\lambda = 0.95$

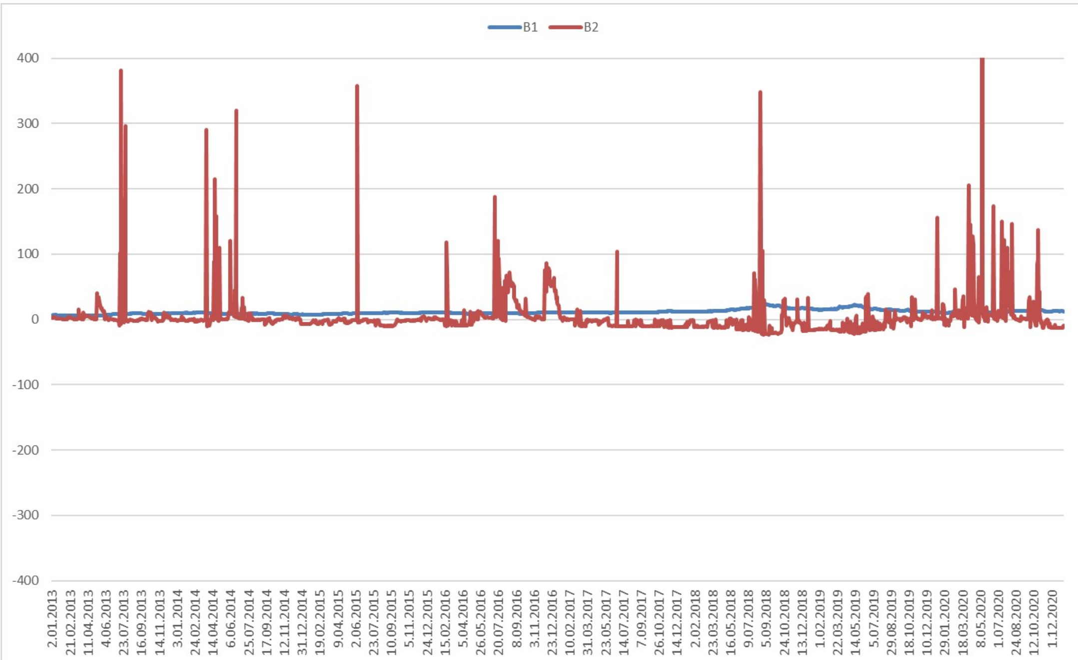


Figure 5.3: Nelson Siegel β_1 and β_2 Parameters with $\lambda = 0.0609$

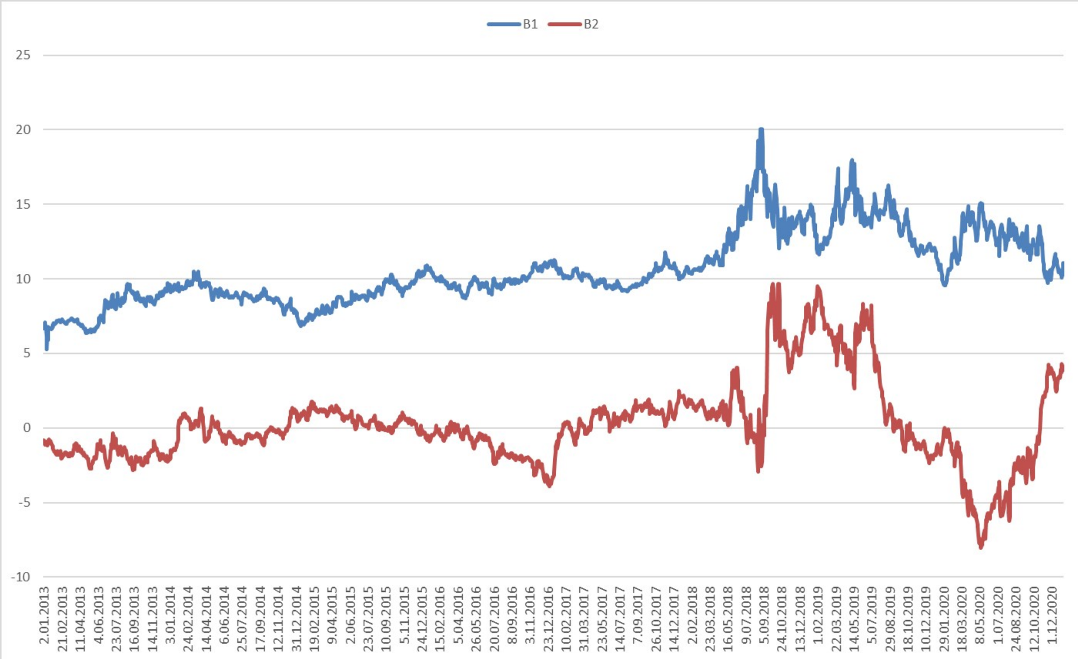


Figure 5.4: Nelson Siegel β_1 and β_2 Parameters with $\lambda = 0.95$

are examined. The β_2 coefficients calculated for $\lambda = 0.0609$ can reach very high values, and this parameter which should represent the slope feature of the curve and does not take appropriate values for this situation. While the correlation coefficient between β_2 and β_3 coefficients for $\lambda = 0.0609$ was calculated as -0.99, this coefficient decreased to 0.49 for $\lambda = 0.95$. When these coefficients and graphs are evaluated together, it can be seen that in the $\lambda = 0.0609$ method, the β_2 and β_3 coefficients can be substituted for each other due to the similarities in their loadings, and this problem is solved by equating λ to 0.95. Therefore, it would be correct to take λ as 0.95 in the model to be built with Nelson Siegel coefficients.

As an alternative to the bond market yield curve, it is possible to use the yield curve formed from the interest implied by these market transactions, since the transaction volumes of the USD/TRY forward transactions market are relatively more intense. In this market, quotations are entered in basis points and each quotation represents an additional exchange rate change. In this case, the implied annual interest can be obtained as follows.

$$r_{implied} = ln(USDTRY_{forward}/USDTRY_{spot})/maturity \tag{5.2}$$

When the interest rates obtained in this way are analyzed, it is understood that quotations with a maturity of approximately 4-6 months do not reflect the short-term interest movements in the domestic market. For this reason, large 6-month futures transactions are taken into account in the yield curve to be created for this market. Again, the yield curve was created with the Nelson Siegel formula. Yield curve parameters are obtained with OLS since all interest rates to be used in the creation of the curve are discounted. The graph of the parameters obtained in this way is given below.

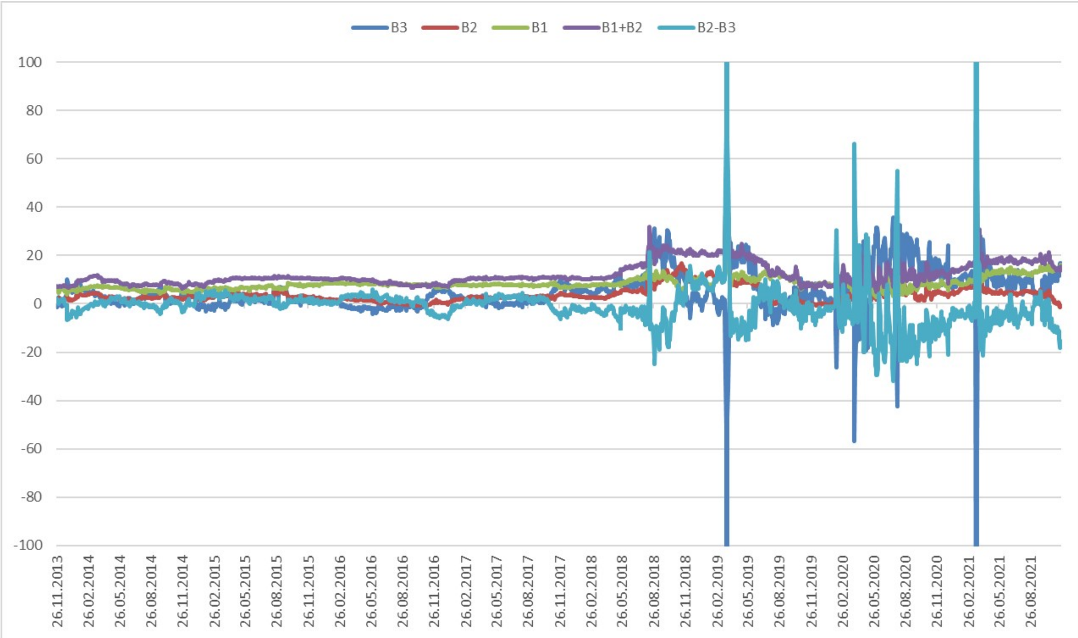


Figure 5.5: Nelson Siegel Parameters based on forward currency market with $\lambda = 0.95$

It is observed that the model parameters remained calm until the post-2018 period when the volatility in the financial markets increased relatively, and the volatility of the model parameters over time increased with the increase in the volatility in the financial markets. This happens because the volatility in the forward market affects the implied interest rates. Therefore, it would not be appropriate to directly use the yield curve parameters obtained by using these interests in the model. In fact, the β_1 parameter can be used because it has a less volatile course than other parameters. However, it will not be sufficient to include only one feature of the yield curve in the study.

5.4 Conclusion

When Yield curve parameters are examined, it is considered that it would be appropriate to use 0.95 as the λ value. However, although this selected parameter considerably reduces the correlation between the β parameters, it is thought that it is necessary to establish VAR models with different shock variables in order to support the estimations of the VAR model with yield curve parameters.

In this context, it is thought that it would be appropriate to create a VAR model in which the yields for some maturities selected from the yields which obtained with the Nelson Siegel function are used directly as shock data. However, since the terms to be chosen in this case will be subjective, another VAR model should be established with a small number of principal components of all maturities obtained from the yield curve.

CHAPTER 6

VARIABLES OF THE ANALYSIS

6.1 Introduction

In this chapter, information about all dependent and independent variables to be used in VAR models will be given.In addition, examinations on the lag order selection to be used in the VAR model are also included in this chapter.

Since information about yield curve parameters has been reviewed in the previous section, it will not be discussed again in this section. However, information about the shock variables of the other two VAR models, except the one to be created using yield curve parameters, is also available in this section.

This yield data is the points on the curve obtained with the yield curve calculations described in the previous section. It would be more appropriate to use the estimations on the yield curve as yield data since there are no transactions in the market every day at every maturity. Information on choosing zero rates of various maturities for a VAR model and the principal components for another VAR model will also be discussed in this chapter.

6.2 General Information About Data

Daily closings of transactions in the spot market are used for financial asset data. In order to use BIST 100 index, USD/TRY exchange rate, 5-year maturity CDS data and for an indicator of financial asset volatilities, 1-month volatility data obtained from USD/TRY options are used daily. To make the data stationary, the daily change of CDS and volatility data, the daily return of BIST 100 index and USD/TRY parity was calculated as continuously compounded yields.

These data show many expectations that are not dependent on the interest rates in the Turkish financial markets. The reason why only spot markets are taken as a basis is that the return expectations according to the transaction maturity in forward and all other derivative markets directly affect the transaction prices of these assets. CDS data is added to the model as an indicator of default risk, and volatility data obtained from options is added to the model as an indicator of future volatility expectations. The USD/TRY exchange rate is one of the important indicators when the foreign trade volume and structure of Turkey are considered. The BIST 100 index is included in the model because that explains the expectations for the state of real economy.

$$\begin{aligned} \Delta CDS &= CDS_t - CDS_{t-1} \\ \Delta Impliedvol &= Impliedvol_t - Impliedvol_{t-1} \\ r_{usdtry} &= ln(usdtry_t / usdtry_{t-1}) * n \\ r_{bist100} &= ln(bist100_t / bist100_{t-1}) * n \end{aligned} \tag{6.1}$$

Data cover the period from January 2013 to January 2021. All data is used in all models.

The yield curve is obtained by using the transactions in the BIST Debt Securities Market Outright Purchases and Sales Market of fixed coupon and discount bonds issued by the Treasury. According to the high-frequency identification technique, the changes in the yield curve should cover the period immediately before and after the monetary policy statements. However, in this market, the number of daily transactions does not make it possible to use such frequent data. Instead, it seems appropriate to use same-day trading transactions in the creation of the curve. Same-day transactions can be made at the BIST Debt Securities Market Outright Purchases and Sales Market until 14:00. The interest rate decisions announced by the Central Bank's Monetary Policy Committee (MPC) are also announced at exactly at 14:00. When the data is used on a daily basis, since the market closes just before the decision, interest rate changes between the two days will largely reflect the effect of the decision. However, the effect of market developments other than decisions and explanations during the day on yield curve interests is neglected in this study.

It seems possible to use the implied interest to be obtained from the USD/TRY forward market instead of this market. However, minute or more frequent data of this market could not be reached. In addition, it has been observed that the interest rates obtained from short-term transactions, especially in this market, differ greatly from short-term repo rates, and it can be misleading to use them.

As monetary policy statements, all MPC decisions from the beginning of 2013 until the end of 2020 and the interest rate changes in the Inflation Report statements were evaluated as shock data, and it was assumed that other market developments in these days did not affect the interest rates. In addition, interest rate changes in some irregular announcements are also included in the shock data.

In this thesis, apart from the model based on the assumption that shock variables are changes in the parameters of the Nelson Siegel [29] function, as in Inoue and Rossi [20], separate models were created using the principal components of interest rate changes and raw interest rate changes in different maturities, and the results were examined. This is because in order to examine individual effects of yield changes in different maturities.

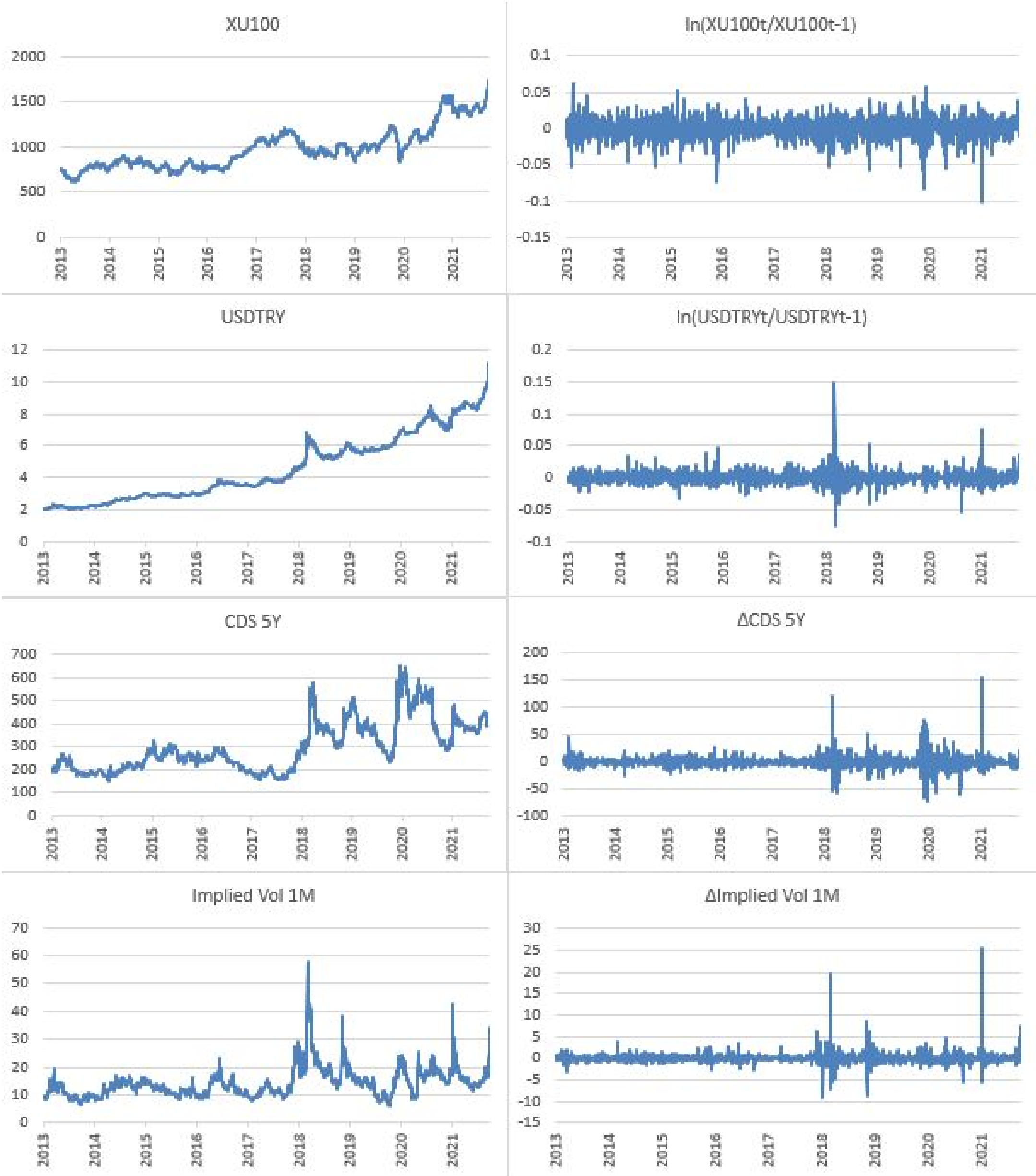


Figure 6.1: Financial Data used in Models

Table 6.1: Unit Root Tests (Augmented Dickey-Fuller Test With 12 Lags) of Financial Data used in Models

	XU100	USD/TRY	CDS 5Y	Implied Vol 1M
Dickey-Fuller	-12.282	-12.219	-11.775	-14.452
p-value	>0.01	>0.01	>0.01	>0.01

In order to differentiate shocks from foreign events, the VIX index was added to the model as an exogenous variable. The VIX Index is calculated using the implied volatility of call and put options written on the SP 500 stock market index with a maturity date of more than 23 days and less than 37 days. The aim is to estimate the projected volatility for the average 30-day stock market.

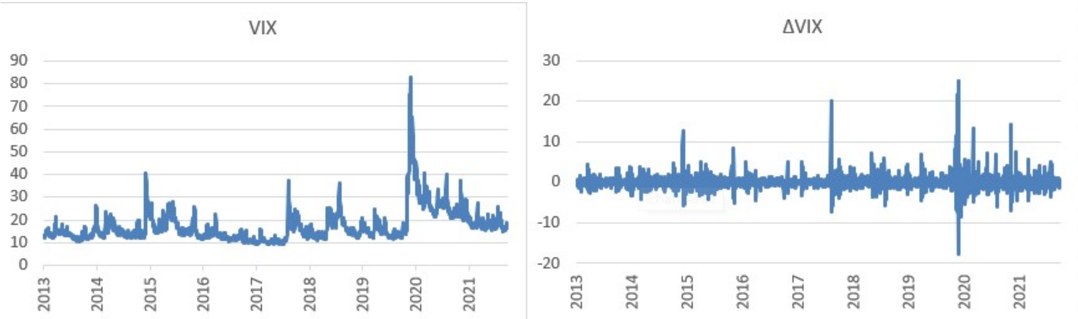


Figure 6.2: VIX Index Data

Events and developments affecting international markets are expected to have an impact on the VIX index. The variables used in this thesis can also be affected by international markets. Since the aim is only to analyze the effects of Central Bank announcements, it is necessary to separate the effects from international developments that can rapidly affect the markets. In fact, the basic assumption of the model is that the shock effect can be observed in a short time with high-frequency variables and shock variables are not affected by different events during this period. However, due to the low frequency of data in the bond market, the frequency of high-frequency shock variables had to be one day. However, it has been stated that this day can be used in this thesis since there is a time difference compared to other variables and the shock variable disclosure hours are in line with the Central Bank announcement hours. However, there may be international events that may affect the markets, especially during the hours when the markets are closed in Turkey. It was thought that it would be appropriate to add the VIX index to the model as exogenous in order to distinguish the shocks investigated in the thesis from the effects of these events.

6.3 VAR Model Selection

In this section, the VAR model diagnostics to be established will be examined. In accordance with the method discussed in this thesis, the shock effect of Central Bank announcements is obtained by external observations to the VAR model with financial variables. The changes caused by the Announcement in the yield curve were accepted as an indication of the shock and their effects were examined with local projections. In this context, it is considered appropriate to make calculations with a model without shocks at the stage of VAR model selection and diagnostics.

Akaike information criterion (AIC) suggested 7 lags, Hannan-Quinn information criterion (HQ) 2 lags, Schwarz information criterion (SC) 1 lag for lag selection in the VAR model created using financial variables. Although parsimonious VAR models are generally preferred and it is believed that it is appropriate to choose lag according to SC and HQ information criteria, Kilian [23] has stated that impulse response curvature will decrease in models whose lag number is underestimated. Accordingly, the author suggested that the use of the AIC criterion be used to more accurately predict high-order VAR processes.

Table 6.2: VAR Model Without Shock Variables Residuals - ARCH Test for Heteroskedasticity, BG Test for Serial Autocorrelation and Jarqe-Bera Test for Normality

	Chi-squared	df	p-value
ARCH Test with 7 Lags	5201.4	700	0.0000
Breusch- Godfrey LM Test With 7 Lags	238.35	112	0.0000
Jarque-Bera Normality Test	186848	8	0.0000

Table 6.3: Characteristic Roots of VAR Model Without Shock Variables

1st Root	2nd Root	3rd Root	4th Root	5th Root
0.8079	0.8079	0.7849	0.7849	0.7619
6th Root	7th Root	8th Root	9th Root	10th Root
0.7619	0.7465	0.7465	0.7313	0.7313
11th Root	12th Root	13th Root	14th Root	15th Root
0.6984	0.6902	0.6902	0.6688	0.6688
16th Root	17th Root	18th Root	19th Root	20th Root
0.6612	0.6612	0.6603	0.6208	0.6208
21st Root	22nd Root	23rd Root	24th Root	25th Root
0.6137	0.6137	0.5923	0.5923	0.5353
26th Root	27th Root	28th Root	28th Root	
0.5353	0.5311	0.5311	0.5311	

However, when the trial was made for all lag orders from 1 to 20, autocorrelation was observed in residuals and residual volatility showed heteroskedasticity structure. In this process, Breusch Godfrey LM test for serial autocorrelation and ARCH test for heteroskedasticity were applied to the residues for each model with lag order. Therefore, it was found appropriate to set the lag order as 7 as suggested by AIC. In 6.2 results of ARCH test and Breusch Godfrey LM test are given for the model with lag order 7. Although the lag order is selected high, when the characteristic roots of the VAR system are examined in 6.3, it is seen that all the roots are less than 1, that is, the system is stationary.

Table 6.4: R-Squared and F-statistics of VAR Model Without Shock Variables

	R-Squared	Adjusted R-squared	F-statistic	p-value
XU100 Equation	0.0910	0.0781	7.0770	0.0000
USD/TRY Equation	0.0712	0.0581	5.4250	0.0000
CDS Equation	0.1720	0.1603	14.6900	0.0000
Implied Volatility Equation	0.1826	0.1711	15.8000	0.0000

In this thesis, the coefficients of the financial variables in the VAR system will not be examined in detail, and the R-Squared and F-statistics of the system equations are given in the table 6.4. It is seen that the R-Squared values are quite low, especially in the XU100 and USDTRY equations, and it is understood that the explanatory power of the system is weak. However, since the effects of the variables defined as the shock variables that are wanted to be examined in the thesis, the power of financial variables to explain each other in the VAR system is not given much importance. Residual diagnostics of equations are given in Appendix A.

6.4 Principal Component Analysis of the Yield Curve

In order to examine the effect of the yield curve as a whole, adding the principal components of the returns directly into the VAR model can be used as an alternative method instead of "Functional VAR". Principal component analysis enables the basic properties of multidimensional data to be explained with much less number of dimensions. The method is about calculating the new axes that constitute the highest variance in the data space. In the new axes created in this way, the data is reflected in many dimensions, but many of its distinguishing features can only be examined in a few dimensions. [21] In this sense, adding the data to the VAR model by reducing it to a few dimensions will create a situation similar to using the general movement of the curve as data by adding the function parameters to the model in the "Functional VAR" method.

The model was also run with the principal components of all interest rate changes on decision announcement days, except for only selected interest rate changes. Principal component analysis was applied to all interest rate changes with an interval of 0.05 years, but the first 4 maturities, ie 0.20 years, were not included in the analysis. The reason for this is that the deviations on the short side of the yield curve, which is because there are no short-term transactions every day, not to affect the analysis.

According to the Principal component analysis, it is understood that the first 3 components explain 93.55 percent of the data's properties. The variance explanation percentages of the first five components are below.

Table 6.5: Principal Component Analysis on Yield Data

	Variance	Explained Percent
1.st Component	12.40	78.05%
2.nd Component	1.50	9.44%
3.rd Component	0.96	6.06%
4.th Component	0.53	3.35%
5.th Component	0.30	1.86%

For this reason, it will be sufficient to use the first three components in the model, similar to the assumption that the most important components of the yield curve are level, slope and curvature in the Nelson Siegel model. By using principal component analysis on 180-dimensional return data created with a maturity interval of 0.05 years, it is possible to use most of the features of all these data with only 3-dimensional data. However, it is not possible to say that these three components show the same features as level, slope and curvature. These components can only be evaluated as components that depend on these data and are completely mathematically created, and their meanings are not taken into account. When examining the effect of the whole movement of the curve on other variables, it will be necessary to use these components as a whole. Their individual significance in the yield curve and PCA model will not be important. However, in raw yields model individual effects will be analyzed.

6.5 Raw Yield Data

Inoue and Rossi [20] stated that it is possible to use the returns obtained directly from the market instead of the yield curve parameters in the model. However, which maturities will be chosen among the yields will gain importance in terms of examining the effects of the curve. In this case, adding data to the model in a large number of terms may be appropriate in order to examine different movements in the curve within the model, as there will be a high correlation between the movements in the near-terms, it will greatly increase the confidence interval of their estimated parameters.

Finally, in this study, instead of the parameters of the yield curve function, the method of directly adding the returns to the VAR model is also included. The yields are not derived directly from the securities traded in the market, but are based on fixed maturities on the yield curve created by using these securities. Because there are no transactions in the bond market every day in every security. For example, even if the 6-month maturity security is traded every day, since its maturity will change every day, basing it on a fixed point on the curve will better reflect the change in market expectations.

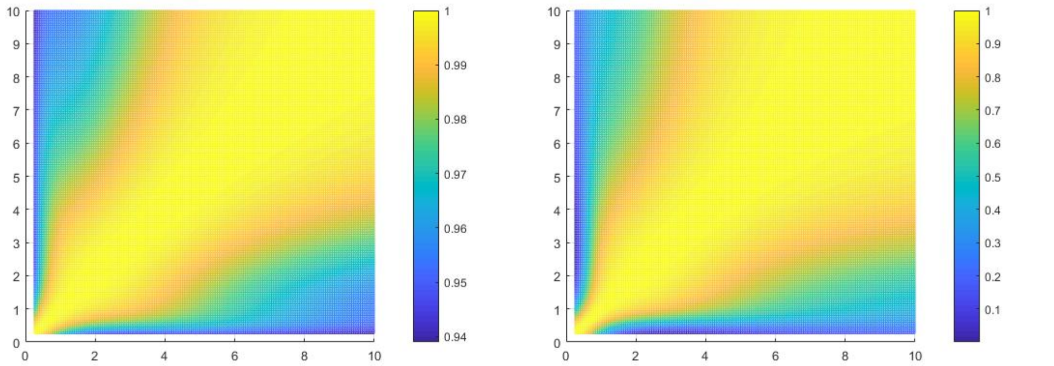
Nelson Siegel and Svensson functions are used to create a smooth yield curve. For this reason, it is inevitable that there will be a correlation between the movements in the near term, even when the daily changes of these functions are taken. The inter-maturity correlation matrix of daily interest rate changes using the Nelson Siegel function is shown as a heat map below. In order to examine the direction of the effects of the individual movement in interest rates for the raw yield model, in order to examine individual effects of different maturities it will be necessary to choose maturities with less correlation between them.

In the charts 6.3 and 6.4, the 10-year maturity is divided into 200 equal parts, but the shortest 3-month segment is not included in the heatmap. The reason for this is that the movement in very short maturities can be misleading, as the number of days without bonds is quite high in very short maturities.

While the first chart shows the correlation matrix of daily interest rate changes throughout the data set process starting from 2013, the second chart shows the correlation matrix of interest rate changes on MPC announcement days, which I use use only as shock variable in this process. When both graphs are analyzed together, the maturity-based correlation of daily interest rate changes has decreased considerably for MPC announcement days. This shows that the surprise effect of the MPC announcements affects the yield curve more than the other days. This supports the main assumption of this study, the changes in the bond rates in the market from 14:00 on the same day to 14:00 on the next day is mostly due to the announcement and other effects on bond yields in this period are negligible.

In the correlation matrices created for the yields obtained from the Svennson model in 6.4, as in the Nelson Siegel correlation matrix, there is a great difference between the correlation matrix created only for MPC explanations, compared to the correlation matrix in which the return changes in each day are examined. The correlation between return changes on only MPC announcement days much lower.

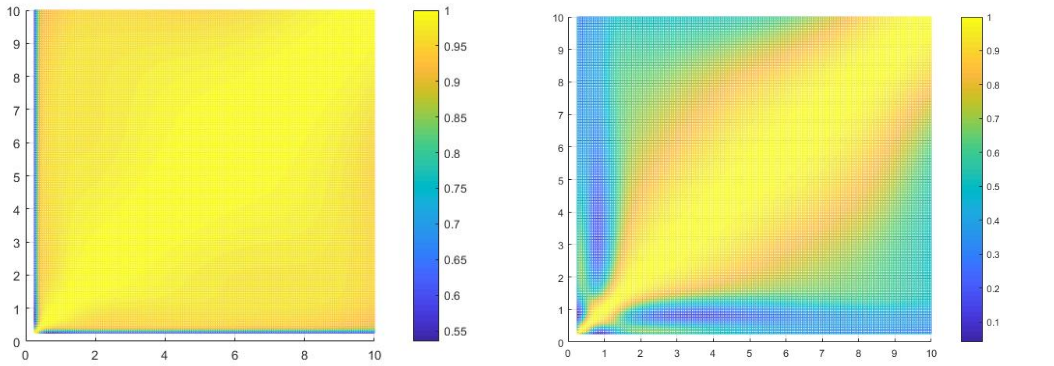
Also a different picture emerges when the same heatmap is created for the Svensson model in 6.4, which has the second hump parameters. Since the model allows for the second hump, daily movements allow large changes to occur in long-term interest rates. Therefore, a relatively symmetrical correlation matrix is formed. The second hump affects the longest terms more than the medium-long terms. However, considering that there are no bonds for every period in the longest maturities, it cannot be said that this movement only reflects the change in market expectations.



(a) Correlation matrix of yields obtained with Nelson Siegel function for the whole data set

(b) Correlation matrix of yields obtained with Nelson Siegel function only for MPC announcements

Figure 6.3: Correlation Matrices of Yields Obtained By Nelson SİegeI Model



(a) Correlation matrix of yields obtained with Svensson function for the whole data set

(b) Correlation matrix of yields obtained with Svensson function only for MPC announcements

Figure 6.4: Correlation Matrices of Yields Obtained By Svensson Model

When the heat maps are examined, it is noteworthy that the most intense movement is seen between a maturity of less than 1 year and a maturity of 3-4 years. Interest rate changes in other maturities mostly move together. For this reason, adding many maturities together in the model, as in the traditionally established models, may increase the confidence interval of the estimated parameters in VAR model. Since the change in the yield curve can be narrowed down to a very small extent as seen in the Principal Component analysis, when using raw yield changes in the model, it is more appropriate to choose maturities with low correlation so that the yield data contains the same features as little as possible.

However, even in this case, it is observed that the correlations increase as the maturities get longer and the difference between maturities decreases. For this reason, it was thought that it would be appropriate to use maturities with a low number of interest rates to be used in the model and a long-term difference between them. In this part of the study, first of all, the model to be established with maturities of 6 months, 2 years, 5 years and 9 years, similar to the traditionally used interests, will be examined. The reason why shorter maturities are not used in the model, which is expected to resemble traditional models, is that that part of the curve does not fit well on days when there is no value in shorter maturities. The reason why 9 years is used as the longest term, not 10 year, is the same.

6.6 Conclusion

In this section, the variables to be used in VAR models are examined. It was explained how the independent variables of the analysis were obtained and it was seen that the variables to be used did not have a clear trend after the specified procedures. In addition, the shock variable data to be used in other VAR models other than the yield curve VAR model has also been examined. It is stated that for the Principal component model, the best three component data that reflect the general characteristics of the data will be used. In the VAR model to be used with raw yields, it has been observed that four different maturities were chosen in order to reduce the correlation between the data in order to examine the individual effects of maturities.

CHAPTER 7

IMPULSE RESPONSES OF MONETARY POLICY ANNOUNCEMENTS AND FINANCIAL VARIABLES

7.1 Introduction

In this thesis, three different VAR models were created with three different shock data based on the same assumptions. Names will be used as abbreviations to avoid confusion with models. The model in which Yield curve parameters are used as shock data will be referred to as "Yield Curve Model", the model in which principal components are used as shock data "PCA model" and finally the model in which yields are used directly as shock data will be referred to as "Raw Yield Model".

First of all, the model created with the yield curve parameters as in Rossi[20] will be examined. Then, the model created with the three-dimensional data obtained by principal component analysis, which can be an alternative to Yield Curve Model, and then the models created with raw yields will be examined. It is understood that each model is successful in similar degrees in terms of examining the effects of MPC announcements on financial markets. However, the results of all models will be analyzed separately. In addition, individual maturity effect will be analysed for raw yields model.

The number of lags used in the models is 7 as stated in the previous chapter. Model results will be given as impulse response graphs for each shock separately. In the models each shock represents a unique structure. Therefore, the effects of each shock need to be reported separately. In order not to report the results of each of the 131 shocks discussed in this study, only the results of the shocks that occurred in 2020 will be reported. However, for Yield Curve and Raw Yield Model, graphs of the coefficients of interest rates at different maturities will be included. In addition, 68% and 95% confidence interval lines according to Newey West standard errors are shown in the graphs.

Since the specific results of each shock must be shown for the models created with yield curve parameters and principal component analysis data, only the MPC and inflation report announcements for 2020 will be included in this part of the study. Table 7.1 includes information about the dates of these shocks, the decisions taken for MPC decisions, market

Table 7.1: Explanations on all MPC decisions and other shocks in 2020

Shock Date	Policy Rate Before Decision	Policy Rate After Decision	Average Expectation of Policy Rate	Description	The interpretation of the market according to the news just after the decision
16.01.2020	12.00	11.25	11.38	MPC Decision	This decision is mostly in accordance with the market expectation.
30.01.2020				Inflation Report	The announcement that supports the easing expectations.
19.02.2020	11.25	10.75	10.89	MPC Decision	This decision is mostly in accordance with the market expectation.
17.03.2020	10.75	9.75	Not available	MPC Decision	The market thought that this cut was an early decision to cut interest rates at the current inflation rate.
22.04.2020	9.75	8.75	9.29	MPC Decision	Rate cut was more than expected, but, considering the effects of covid on the economy, it was not perceived very negatively by the market in terms of risks.
30.04.2020				Inflation Report	Inflation forecast is trimmed and expectation of easing slightly raised after this announcement.
21.05.2020	8.75	8.25	8.14	MPC Decision	This decision is mostly in accordance with the market expectation.
25.06.2020	8.25	8.25	7.95	MPC Decision	With this decision, which was taken while the market was expecting a decrease in interest rates, there was an expectation that the Central Bank's inflation expectations would increase and that a tight stance would begin. It was perceived positively in terms of risks to the Turkish lira.
23.07.2020	8.25	8.25	8.25	MPC Decision	This decision is mostly in accordance with the market expectation.
29.07.2020				Inflation Report	Most of the explanations are perceived as dovish by the market.
7.08.2020				Main funding rate changed to upper band of corridor	This means an implicit interest rate increase in order to control inflation.
20.08.2020	8.25	8.25	8.51	MPC Decision	This decision is mostly in accordance with the market expectation.
24.09.2020	8.25	10.25	8.35	MPC Decision	It appears that most of the market expects interest rates to remain constant. It is said to be a positive decision in terms of risks.
22.10.2020	10.25	10.25	11.89	MPC Decision	This decision is considered as a surprise by the market whose expectation was a hike. However this decision is also a signal to use of upper band of the interest rate corridor.
28.10.2020				Inflation Report	Defended last policy decision by mentioning the uncertainity, however, It has also been mentioned that inflation is in an upward trend.
19.11.2020	10.25	15.00	14.60	MPC Decision	There are explanations that the decision is important in terms of supporting the Turkish Lira and keeping inflation under control. Which is said to supports turkish lira in terms of market risks.
24.12.2020	15.00	17.00	16.53	MPC Decision	It is understood that the decision increased the expectations for the Central Bank to control inflation.

expectations before the decision according to the surveys, and the explanations for inflation reports. Only the dates of the shocks will be included in the graphs where the effects of the shocks will be examined.

Note: Impulse response graphs for each Central Bank announcements in 2020 are available at the end of this chapter.

7.2 VAR Model with Yield Curve Parameters (Yield Curve Model)

Firstly, the impulse responses created with 2 lags for all MPC decisions of the model in 2020, inflation report statements and some developments that will affect the main interest rate in the monetary policy to be applied, are given A.4 and 7.5. When the model results are examined, it is seen that significant results cannot be obtained in most of the results at the 95 percent significance level. It is understood that significant results can be obtained for only a few days.

Although the decision on 16.01.2020 was close to the expectations according to the comments of the market after the decision, it is understood that it had a negative effect on the BIST 100 index only for the eighth day in the model results and caused a decrease in implied volatility for the first day and the fourteenth day. Another meaningful result is that the inflation report on 30.01.2020 caused a decrease in CDS's and USD/TRY exchange rates. While the statements on this date were supportive of the expansionary monetary policy, it was understood that these statements were perceived positively by the market due to the pandemic developments. On 19.02.2020, although it was said that the decision was expected by the market to a large extent, it had an increasing effect on CDS and implied volatility. According to the model results, the decision had consequences that increased the risks in the market and then affected the exchange rate negatively. As of 19.02.2020, there are sources indicating that the expansionary stance of the Central Bank will continue, while it is understood that this situation increases the market risks in the model. In addition, after the announcement on 17.03.2020, the BIST 100 index decreased with a very limited significance. 30.04.2020 announcement and 21.05.2020 affected yield curve in a similar way, therefore model predictions of these two announcements are very close. CDS and implied volatility is raised in both announcements but their nearly significant on the first day at 95 percent significance level. However, on the contrary, implied volatility seems to have entered a downward trend again on the ninth day. Similar results were also obtained on other days, that is, it is a situation caused by the overall model. In the continuation of the explanations, the ninth day movements in implied volatility will not be interpreted.

The decision on 25.06.2020 was to keep the interest rate constant, contrary to market expectations. Although the effects of this decision on the market are not statistically significant, it is seen that it is positive for CDS. The decision on 23.07.2020 is in line with market expectations. It is understood that after the previous MPC decision, the expansion expectations in the market decreased. The decision on this date does not have significant consequences according to the model. Although there were comments that the statements on 29.07.2020 increased the expectations for expansion, the effect of these statements on the market was found to be mostly insignificant in the model. On 07.08.2020, a change was made in the funding interest method and an implicit interest rate increase was made by switching to funding to the upper band. However, it is understood that the development on this date is mostly expected by the market according to the model. However, stock market affected because of this regulation after the tenth day but the effect is not clearly significant in 95 percent significance level. In the MPC decision dated 20.08.2020, the interest rates were kept constant in line with the market expectations. USD/TRY exchange rate decreased after the sixth and eighth day according to the model results. Also, stock market index is also decreased because of the announcement after eight days according to model. It is seen that the decision dated 24.09.2020 has a significant negative effect on CDS for the first day. It is understood that this decision was in the direction of an increase in interest rates contrary to expectations and was perceived as a positive decision in terms of market risks. However, in the next decision dated 22.10.2020, it is understood that although the market expects an interest rate hike again, the interest rate was surprisingly kept constant and some of the effects of the previous decision were reversed. In the inflation report dated 28.10.2020, there was a perception that the previous decision was defended and the market was not affected according to the model. A major interest rate hike was made on 19.11.2020. This increase is expected by the market to a large extent according to the surveys. In the market comments after the decision, it is understood that the decision is considered important for the long-term control of inflation and is positive in terms of risks. According to the model results, it is seen that it only causes a decrease in CDS and at the level of 68 percent significance for a few days. The interest rate increase on 24.12.2020 was perceived positively by the market in terms of long-term risks and caused a decrease in CDS in the model.

The significance level of the model results is mostly insufficient. Due to the rigidity of the assumptions made and the fact that there are many variables that affect the markets in Turkey, the volatile course of the markets is a factor in this regard. It is not possible to increase the significance further with the existing data and this modeling method. In addition, it is seen that the effects of the announcement affect some variables on unexpected days (for example, the ninth day on implied volatility) and not on other days. For this reason, it is important to examine the models created with other shock variables.

7.3 VAR Model with Principal Components as Shock Data (PCA Model)

Impulse responses of the VAR model created with the shock data obtained by principal component analysis are included in 7.6 and 7.7. Although the model results look similar compared to the model created with the yield curve, detailed explanations will be made.

According to PCA Model, the effects of the decision taken on 16.01.2020, which was in line with the market expectations, are mostly statistically insignificant. However similar to the previous model, the eighth day effect on the stock index is present. According to the market comments after the inflation report decision on 30.01.2020, it was understood that it increased the expansion expectations, while a significant result was seen in the model results that it decreased the CDS, which is the country credit risk indicator. While the decision dated 19.02.2020 is seen in parallel with the expectations according to the market comments, it is concluded that it increases the CDS according to the model. While it is seen that the decision dated 17.03.2020 increased the implied volatility after a few days and decreased stock price index at the eighth day, it is understood that the decision to decrease the interest rate was too early according to the market comments. The fact that the decision dated 22.04.2020 is not perceived negatively by the market supports the fact that there is no significant effect on CDS and implied volatility variables in the model. However, the eighth day effect on the stock price index is present as the previous announcement. After the inflation report dated 30.04.2020, it is seen that CDS were affected upwards, and that the announcements had an increasing effect on risks. Stock price index on the other hand increased on the tenth day. Although it is understood that the decision dated 21.05.2020 is in line with the expectations according to the market comments, but it affected the USD/TRY exchange rate negatively on the fourth and the sixth days. The decision dated 25.06.2020 permanently reduced CDS for the first day and the eleventh day at a significance level of 68 percent in the model results. Although the decision dated 23.07.2020 did not have a significant effect on CDS and volatility, it is thought that it is an unexpected situation that the exchange rate increased at the fifth and the seventh days. A similar situation can be seen in the inflation report dated 29.07.2020. While it is understood that the explanations increased the expectations that the Central Bank would act dovish, it is seen that the all financial variables affected negative but not on the announcement date but after a while. As in the model established with yield curve parameters, it is seen that the daily effect of the change in the funding rate application dated 07.08.2020 is insignificant with the exception of stock market index which is affected positively at the ninth day. The decision dated 20.08.2020 is a statement in line with the expectation but has a downward effect on the implied volatility on the first and the second day but in 68 percent significance level. Also it affected stock market negatively on the eighth day. While it is understood that the decision dated 24.09.2020 was perceived positively in terms of market risks according to market comments model results are mostly insignificant. It is seen that the decision dated 22.10.2020 has an increasing effect on CDS at first and this is in line with the market comments, which consider this announcement as a negative surprise. It is understood that the inflation report announcements dated 28.10.2020 do not have a significant effect on the financial markets in the model for 95 percent significance level. Despite the positive perception of the announcement dated 19.11.2020, it is understood that its effect on CDS decreases significantly only for 68 percent significance level. In addition, this decision also caused an increase in the BIST 100 at the eighth day. The decision dated 24.12.2020 was perceived positively by the market. According to the model results, this situation is seen in effect on CDS at first day. The exchange rate decreased after a while of this announcement significantly. This announcement affected all financial variables positively for Turkey, according to model.

7.4 VAR Model with Raw Yields as Shock Data (Raw Yield Model)

When the results of the announcement dated 16.01.2020 are examined, there is mostly no significant result, but an increase is observed in implied volatility on the eighth and ninth days, as in other models. However, this increase is not significant at the 95 percent level. It is seen that the announcement dated 30.01.2020 had an upward effect on the CDS on the first day and on the second day. The announcement on 19.02.2020 increases the CDS on the first and the second day, while decreasing the USD/TRY rate. While the decision dated 17.03.2020 decreases the stock index, it does not have a significant effect on other variables. This decision, which was perceived as an earlier interest rate cut than expected, had an upward impact on the USD/TRY rate and CDS at the 68 percent significance level. The decision dated 22.04.2020 had a negative impact on the stocks on the first day, causing the USD/TRY rate to rise. The rate cut in this dated decision is more than what the surveys expected. While the inflation report announcements dated 30.04.2020 did not have a significant effect on other variables, it had an upward effect on CDS in the first day. The decision dated 21.05.2020 did not affect the financial variables in general. The decision dated 25.06.2020 caused a decrease in CDS at a close level, although not at the 95 percent significance level. Although the decision of 23.07.2020 did not have significant effect on the the first day, it is seen that the stock index increased on the eighth day, the USD/TRY exchange rate on the fifth and the seventh days, and the CDS on the second and the fifth days. While the decision dated 29.07.2020 had an upward effect on CDS on the first day, there was no significant effect on the USD/TRY rate on the first day, but it had an upward effect on the third day, but again on the seventh day. The implicit interest rate hike, which was not announced as the MPC decision with the implementation change dated 07.08.2020, had an upward effect on the BIST 100 index on the first day, but did not cause a significant change in other variables, but caused a decrease in implied volatility on the ninth day. The decision dated 20.08.2020 caused an increase in USD/TRY on the first day, while it caused a decrease in CDS on the fifth day and an increase in implied volatility on the ninth day. The decision dated 24.09.2020 caused a decrease in CDS in the first two days, in accordance with the market announcements. However, no significant effect was observed in other variables. While the decision of 22.10.2020 caused an increase in CDS in the first two days, it caused a similar effect on the eleventh day, and also caused an increase in implied volatility on the seventh day. In the USD/TRY exchange rate, a situation that is difficult to interpret is observed. According to the model, while the exchange rate was negatively affected on the first day at a significance level of 68 percent, it was affected upwards in the following days. Inflation report announcements dated 28.10.2020 affected CDS from the fourth day to the seventh day at the 95 percent significance level, and the USD/TRY rate upwards on the second day at the 68 percent significance level. The announcement dated 19.11.2020 had an upward effect on the stock index on the first and eighth days, and a downward effect on CDS on the first and eleventh days. The decision dated 24.12.2020 had a downward effect on implied volatility on the first day and did not have a significant effect on other financial variables.

7.5 Comparison of VAR Models

When all three models are examined together, various similarities and differences can be seen in the effects of the announcements. For the announcement dated 16.01.2020, the stock index decreases on the eighth day in all models, and the implied volatility increases on the eighth and ninth days. Only in the PCA Model, the USDTRY rate is also affected. Other variables were not affected. This situation can be interpreted as this decision, which came at the level expected by the market, was effective on the eighth day, although it did not have an effect on the first days. The announcement dated 30.01.2020 causes a decrease in CDS on the first day according to all model results. However, in the Raw Yield Model, an opposite effect is seen on the second day of this movement. The decision dated 19.02.2020 indicates the effect of the first and the second day increase in CDS in all models. However, there are differences between the models for the effects on other variables. The decision dated 17.03.2020 had a downward effect on the eighth day stock index in all models. It is known that this decision is an interest rate cut that precedes market expectations. The effect on the stocks can only be explained as the decrease in the return expectations depending on the exchange rate expectations of the foreign investors and accordingly the stock sales. In addition, although the decision is not at the 95 percent significance level in the models, it is seen that CDS and implied volatility increase in the following days. It is seen that the decision dated 22.04.2020 caused a decrease in the stock index on the eighth day, as in the previous announcement. In addition, on the eighth day, CDS and implied volatility also increased in every model, although not at a high significance level. When all models are examined together, it is seen that the announcement of the inflation report dated 30.04.2020 caused an increase in CDS on the first day, and when the market comments are examined, it is seen that the decision affected the expectations in the direction of expansionary monetary policy. No significant effects are seen in other variables. Although the decision dated 21.05.2020 is not at the 95 percent significance level, there is a second, third and eleventh day increase in the exchange rate according to the PCA and Raw Yield Models at a close level, the first day increase in implied volatility according to the Yield Curve Model, and the sixth day increase in CDS according to the PCA Model. The decision dated 25.06.2020 caused an increase in implied volatility in all models on the eighth day, and on the contrary, a decrease in the first and eleventh day in CDS. This move in CDS is also in line with market comments. While the announcement dated 23.07.2020 points to an increasing effect in the stock index on the eighth day in PCA and Raw Yield Models, this situation is not seen in the Yield Curve Model. However, it is seen that it causes an increase in exchange rate after the fifth day in all models and an increase in CDS at a significance level of less than 95 percent. While the inflation report statements dated 29.07.2020 caused a decrease in the stock market after the third day in PCA and Yield Curve Models, it caused an increase in the exchange rate on the fourth, fifth, seventh and tenth days, and it also caused an increase in CDS in the PCA and Raw Yields Model on the first day, implied. In volatility, on the other hand, it is seen that it causes an increase after the seventh day. Although the same results cannot be obtained in all models, it is seen that this announcement, which is perceived as expansionist, has an increase in risk indicators, an increase in the exchange rate, and a decrease in stock values. While the implementation change dated 07.08.2020 showed an increasing effect on the stock index in PCA and Raw Yield Models on the first day, it did not have a significant effect on other variables. However, in the following days, it is seen that it causes a decrease in implied volatility, especially on the ninth and eleventh days. The decision dated 20.08.2020 causes a decrease in the stock index on the eighth day in all models. It is also seen that this decision at the 68 percent significance level caused a decrease in the exchange rate after the fourth day. In PCA and Raw Yield Models, it is seen that this decision also increased CDS on the eighth day. The results for this decision were found difficult to interpret compared to the general results. It is seen that the decision dated 24.09.2020 caused a decrease in CDS on the first day in all models. Although the interest rates were not expected, it was seen as a risk-reducing factor in this period. The decision dated 22.10.2020 increased the implied volatility on the eleventh day at the significance level of 68 percent in all models. More importantly, this decision, which was perceived as more expansionary than expected, had an increasing effect on the CDS on the first day. In Implied volatility, the first day rise effect is only seen in the Yield Curve Model. Inflation report statements dated 28.10.2020 indicate an increase at the 68 percent significance level in all models after the fifth day. However, it has been understood that similar results can be obtained in decisions made with expectations in general. It also increased CDS on the second and seventh days only in the Raw Yield Model. The announcement dated 19.11.2020 was an interest rate increase in line with the expectations and increased the stock index in the Raw Yield Model on the first day, but decreased the CDS. There is no significant result at the 95 percent level in other models. It is clearly seen that the decision dated 24.12.2020 has a lowering effect on CDS in all models. This situation is also suitable for market interpretations.

In general, when the models are examined together, there is compatibility between the effects on the first day of CDS. The direction of CDS in these models is generally the same as the market expectations. It is not possible to say something so precise for other variables. A general similarity is the movement of the stock index on the eighth day for some decisions. This situation can be interpreted as the delayed reaction of stocks to the decisions. However, it cannot be said that this movement is in line with the expectations in the market comments. Consistent movements were observed in the USD/TRY exchange rate and implied volatility at a significance level of 68 percent. In general, in market interpretations, it has been observed that the risk factors increase and the exchange rate reacts with a delay on the days when the interest rate increase is expected to fight inflation, while the CDS reacts with a delayed response on the same day, sometimes on the same day and sometimes with a delayed response. However, such a definite interpretation cannot be made about the effects on the stock index.

AIC is used to compare the predictions of the models created with different shock variables. Since the impulse responses of the shock variables were obtained with each local projection and each impulse response was not estimated with the same regression, the AIC is calculated for each impulse response separately. Since the shock in the Raw Yield Model consists of four parameters, not three as in other models, it is appropriate to make the comparison with AIC in order not to penalize the excess parameters.

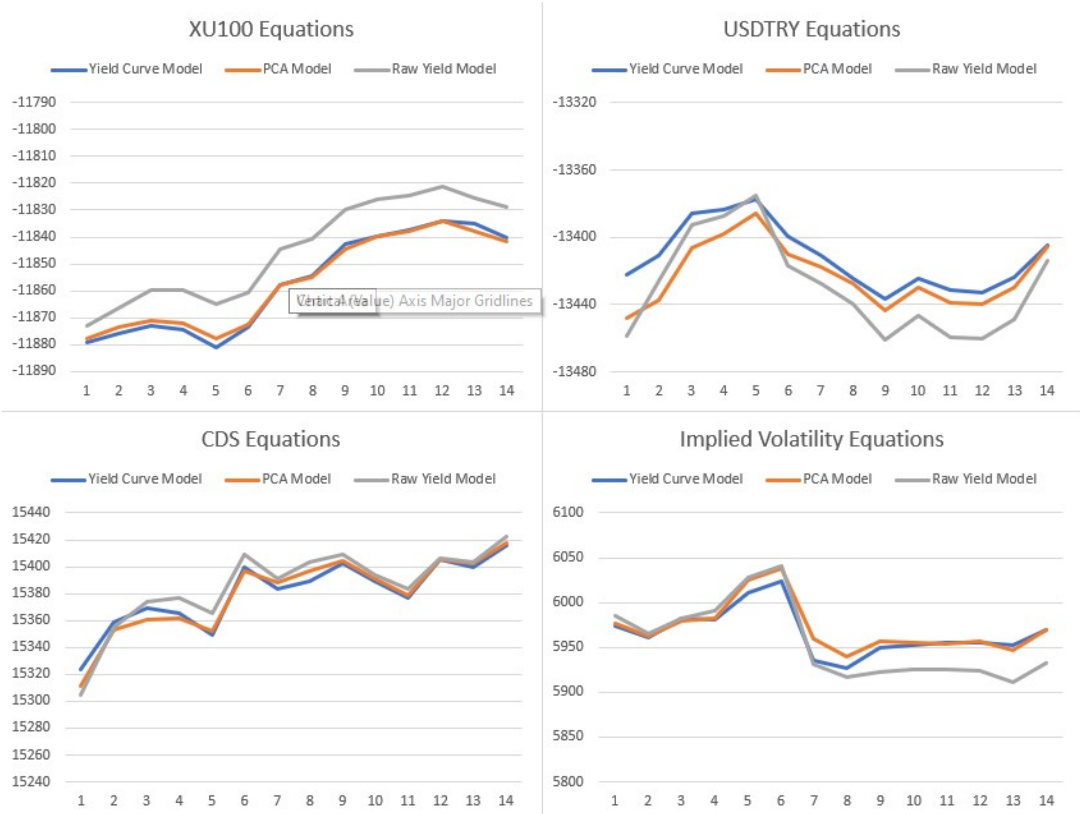


Figure 7.1: AIC Values Calculated for Each Impulse Response of the Models

When the models are compared with the AIC, it is seen that the performances of the Yield Curve Model and the PCA Model are quite close to each other, while the Raw Yield Model generally differs from the other two but in a different direction according to the equations.

In the XU100 index equation, it is seen that the Yield Curve Model performs slightly better in the first impulse responses and the PCA model performs slightly better in the ongoing impulse responses, while the performance of the Raw Yield Model is considerably lower than the other two models. In the USD/TRY equations, the PCA model generally performs better than the Yield Curve model, while the Raw Yield model is the best performing model for the first day and for the equations after the fifth day. In CDS equations, it is seen that the performance of the PCA Model for the first few impulse responses and the Yield Curve Model for the ongoing impulse responses are higher. However, on the first day, the model that performed the best for the impulse response was the Raw Yield model. In the Implied Volatility equation, the Yield Curve Model performs best for the first few impulse responses, while the Raw Yield Model is the most successful model in the ongoing impulse responses.

7.6 Individual Effects of VAR Model Shock Parameters

The advantage of the model established with raw yields is that it allows the examination of the individual effects of the maturity-based yield changes resulting from the announcement.

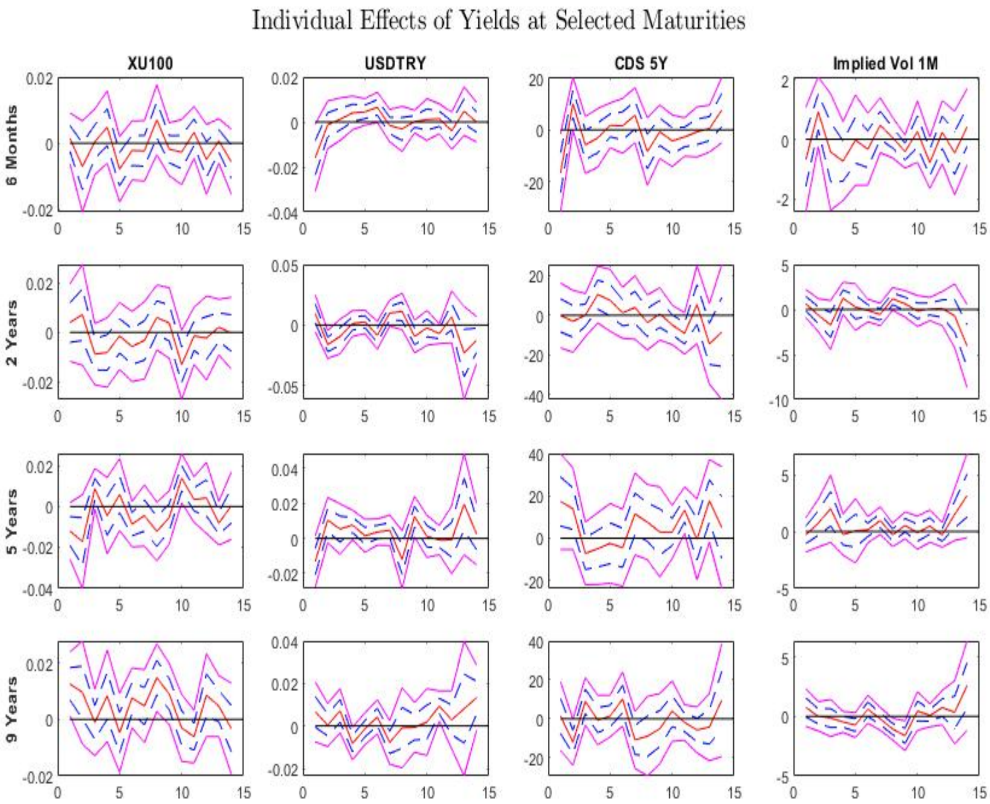


Figure 7.2: Raw Yields as Shock Data Model Results, Individual Effects of Maturities

Evaluating the individual significance of the shock parameters in the PCA model will be unimportant since it does not contain clear information about the characteristics of the curve of the variables. However, for the Yield Curve Model, the individual significance of the Nelson-Siegel curve parameters within the VAR model will be examined similarly.

When the individual shock effects of announcements according to maturity in 7.2 is analyzed, it is seen that the increase in the shortest maturities shows a significant decrease at the first day in CDS at the 95 percent significance level but also a significant increase at the second day. In addition, it is seen that the rise in short-term (6-months) interest rates also has a downward effect on the exchange rate level, at a significance level of 95 percent. However, it has an increasing effect on the fifth and the sixth day at again 68 percent significance level. It is observed that the short-term interest rate does not affect other variables significantly. 2 years maturity bond rate changes has a decreasing effect on the exchange rate at the second day but an increasing effect on the seventh day. Also, this rate change affects implied volatility at the eighth day. Positive 5 years maturity bond rate changes affects stock price index positively at the eleventh day, increases exchange rate at the third and the tenth day and also increases CDS at the eleventh day. Longest term bond rate changes effects on financial variable are mostly insignificant. However, it seem that this change decreases implied volatility at the ninth day. It is considered difficult to interpret these results, as no obvious relationships between shorter

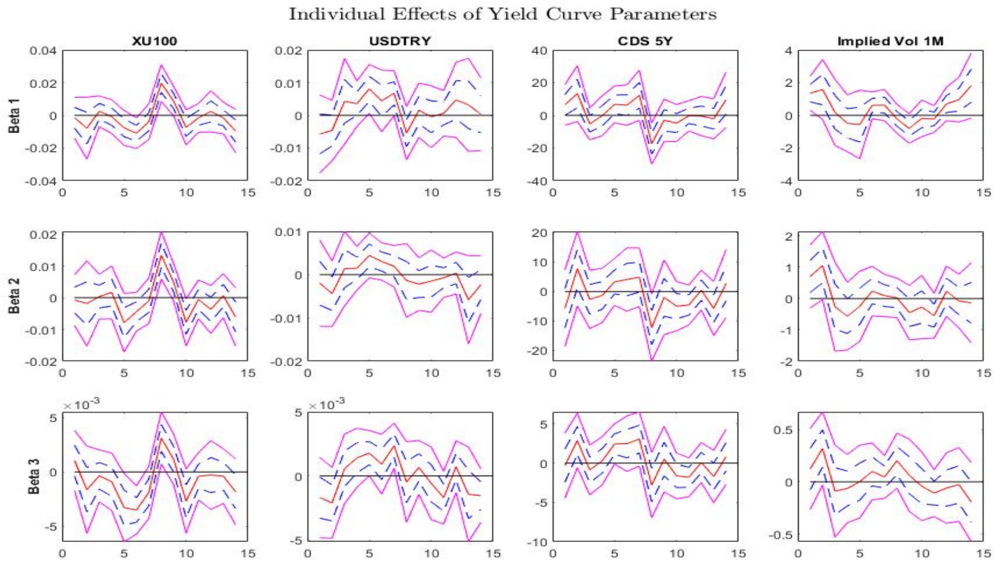


Figure 7.3: Yield Curve Parameters as Shock Data Model Results, Individual Effects of Nelson Siegel Parameters

and longer maturities effects have been observed. In addition, the effects of some maturities may deviate from the original direction in the following days.

7.3 shows the individual effects of Yield Curve Model. It is seen that the stock index was positively affected by the increase in all β parameters on the eighth day. However, it is difficult to make an economic explanation of this upward effect. Exchange rates are affected upward by β_3 increase on the seventh day. CDS, on the other hand, is affected negatively by the increase in β_1 on the eighth day. Implied volatility is affected upward by the increase in β_1 at the first day. In general, it is seen that the individual effects of the parameters give mixed results that are difficult to interpret, as are the individual effects of the raw yields.

7.7 Conclusion

Due to the assumptions of the VAR model, each announcement is considered as a unique and versatile shock. For this reason, all announcements were examined one by one. It has been observed that the effect of each announcement on financial markets is the same in all models at some level.

Although the effects are expected to be seen on the first day, for most of the MPC announcements, especially the first-day effects on the stock market and the exchange rate is not significant. This may be due to the model's rigid assumptions. These effects may have been overlooked, especially since the bond market yield curve movement, which is used as a shock indicator of MPC decisions, is a daily movement and the bond market is a much shallower market than stock and exchange rate markets. However, in order to conduct more detailed research, it will be necessary to work with much higher-frequency data. In this case, the bond market yield curve, which is used as the model shock parameter, will also have to be reconsidered, or the interest derived from or implied in a completely different and more liquid market will have to be used. Because the shock variable should be a higher frequency data than other variables. It is difficult to say that such a market exists in Turkey. For example, although the USD/TRY futures market examined in this study is a very liquid market, it has been stated that it would not be appropriate to use the implied interest since it is highly differentiated from other markets, especially in the short term, and implies very volatile interests in itself. This study may need to be done to narrow the confidence intervals of the findings.

Although there was no significant effect on the stock index and implied volatility for the previous days, significant effects were observed after the eighth and even the tenth day. Such effects make it difficult to interpret the model results, especially when they diverge from the effects observed for the preceding days. These movements can be interpreted as the correction of excessive movements in the first days or as delayed effects. For example, the eighth-day effect seen in the BIST 100 index and the eighth-day effects seen in the implied volatility could not be interpreted from an objective point of view.

Among the results, the financial variable with the most significant results for the first few days was CDS premiums. This financial instrument, which is the insurance of the default risk of Eurobonds, is also an indicator of the general market risks in the country in terms of default. At the same time, this market is mostly shallower compared to other markets used in the analysis. Transaction volumes and frequency are lower than other financial data used in this study. This factor is thought to be important in obtaining significant results. In 2020, decisions were perceived as risky in periods when the policy rate decreased more than expected. The reason for this is the opinion that Turkey is a country that regularly has a current account deficit and finances capital inflows and foreign trade deficit, and that the risks are increased due to the negative effects of falling interest rates on capital movements. In all the models created, it is understood that unexpected interest rate decreases by Central Bank generally have a negative effect on CDS for the first few days, or on the contrary, CDS is positively affected in unexpected interest rate increases. On the other hand, the Implied Volatility indicator, which is used as an indicator of market volatility, showed similar movements on the dates when statistically significant results were obtained.

The reaction of the USD/TRY exchange rate to monetary policy shocks is mostly statistically insignificant for the first few days. However even though not at the 95 percent significance level for each announcement, it is observed that it increases after four or five days in unexpected expansionary policies similar to the first day effects on CDS, and the decrease after four or five days in unexpected contractionary policies. Although similar effects were observed in some models on the first day for some announcements, such a thing was not observed in general, and results pointing to the opposite were also observed. In addition, for some announcements, it can be said that the opposite of the CDS' movement on the first day is seen in the BIST 100 index. This situation is thought to be due to the fact that foreign investors are active in the BIST 100 index and the country's risk level is considered important in the investment decisions of these investors.

7.8 Impulse Response Graphs For Each Central Bank Announcements in 2020

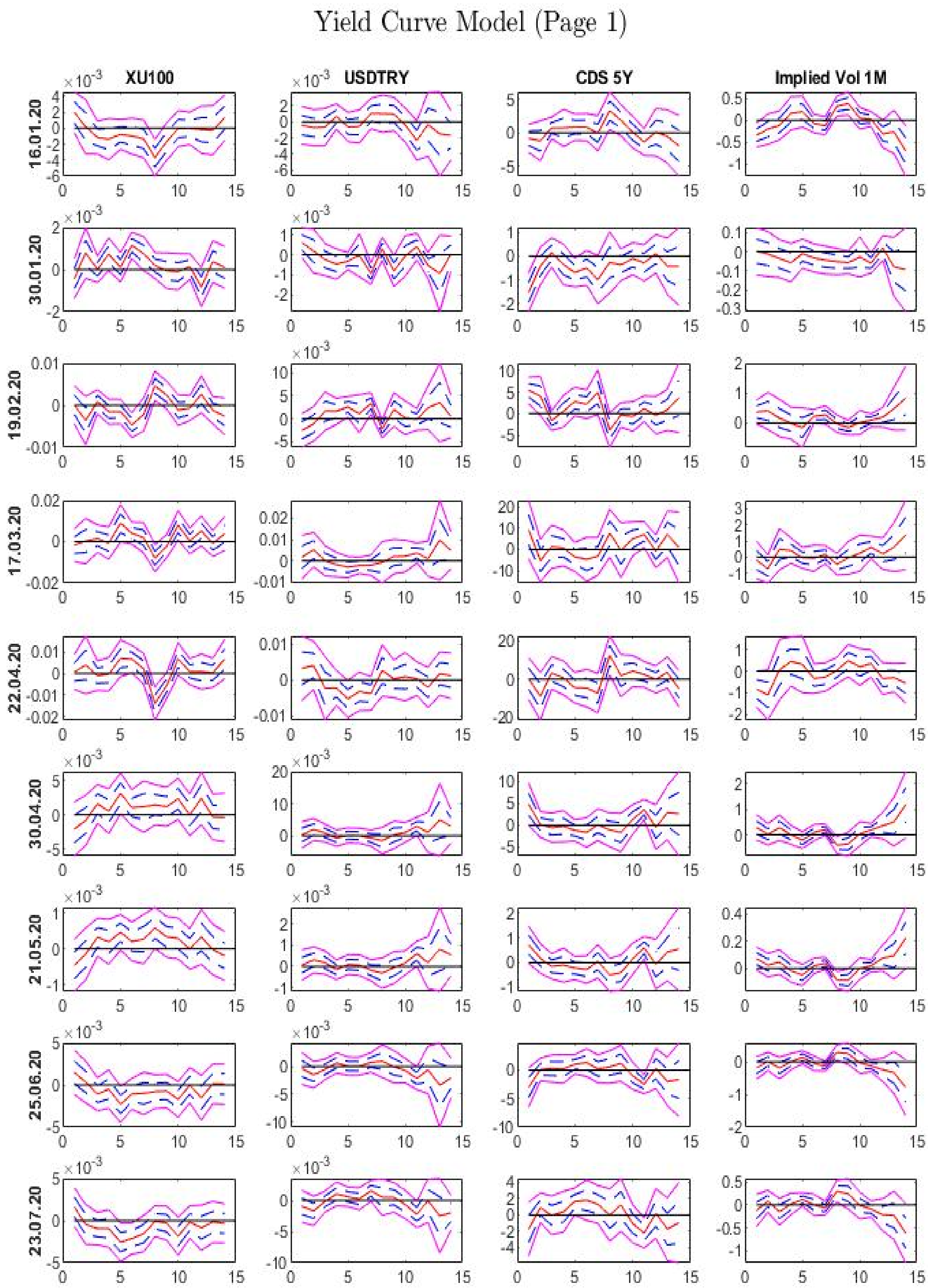


Figure 7.4: Yield Curve Model Results (16.01.2020-23.07.2020)

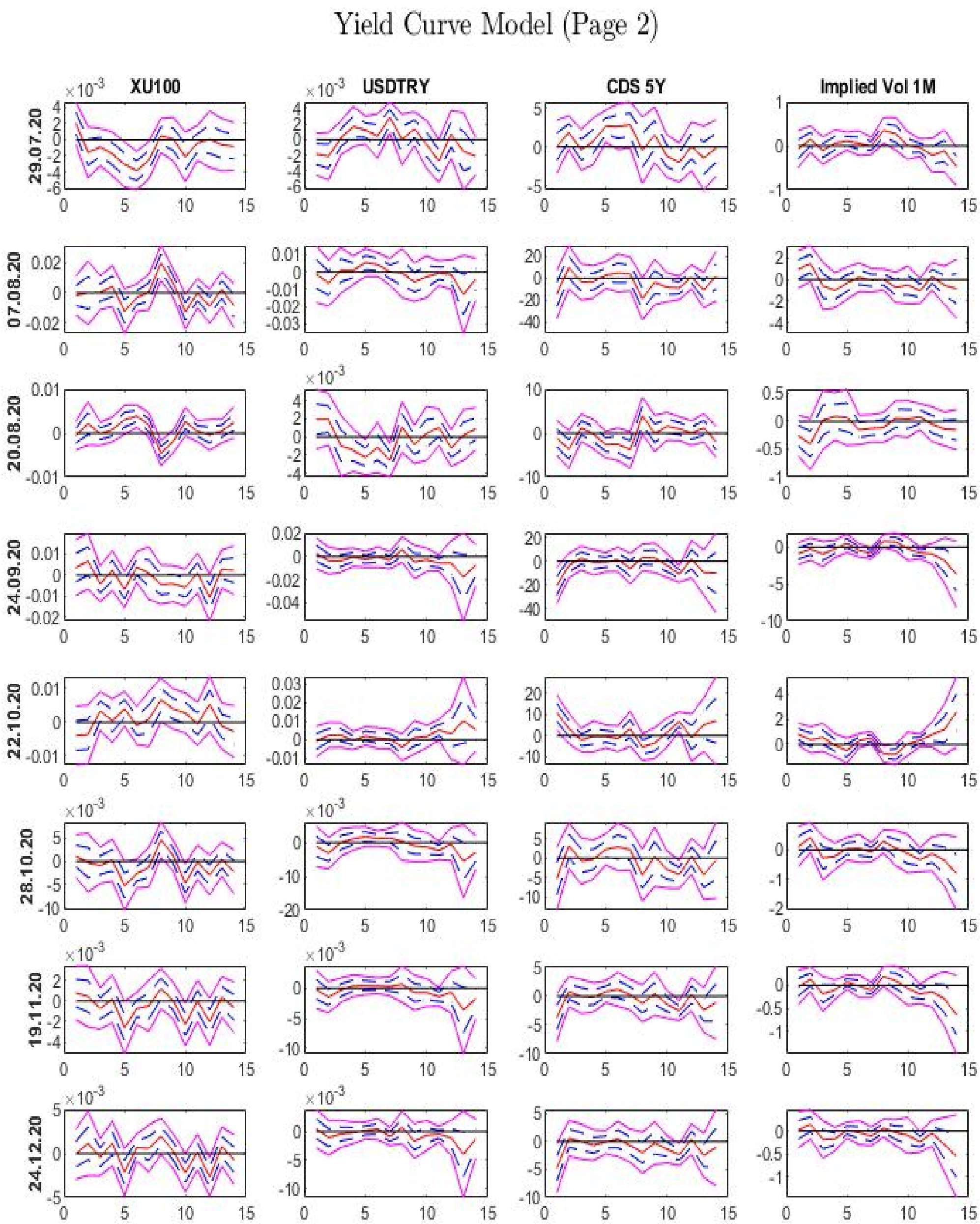


Figure 7.5: Yield Curve Model Results (29.07.2020-24.12.2020)

PCA Model (Page 1)

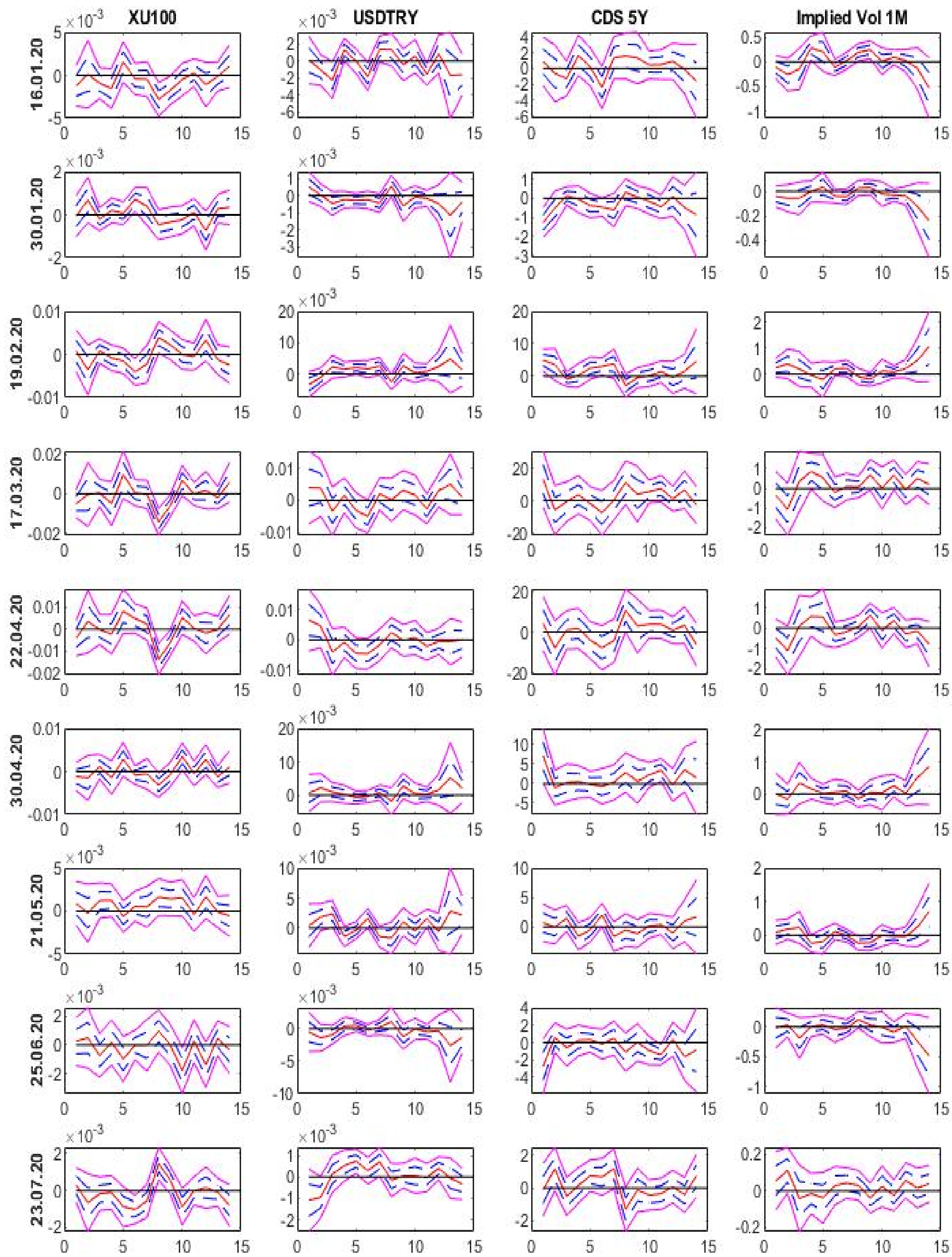


Figure 7.6: Principal Components as Shock Data Model Results (16.01.2020-23.07.2020)

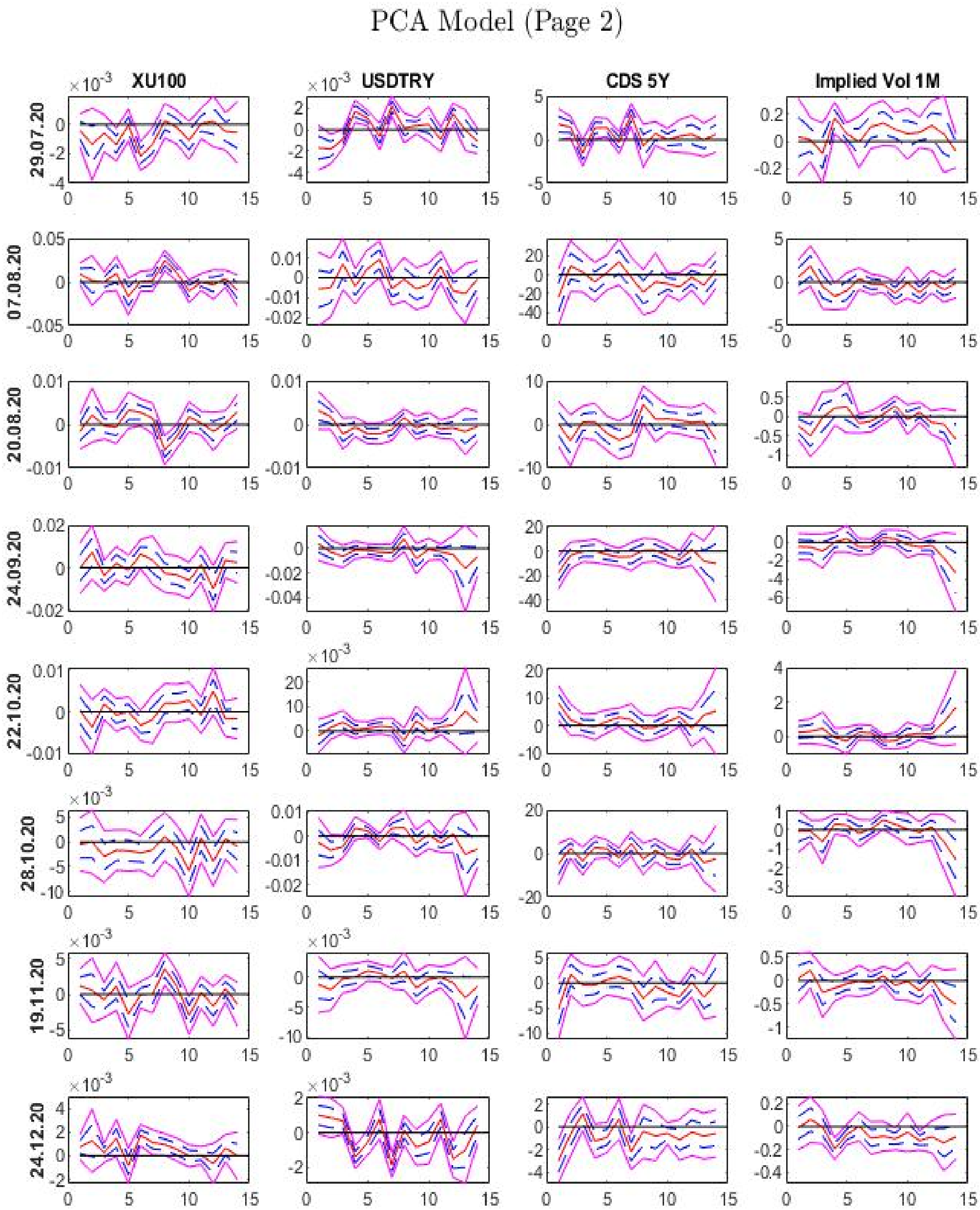


Figure 7.7: Principal Components as Shock Data Model Results (29.07.2020-24.12.2020)

Raw Yield Model (Page 1)

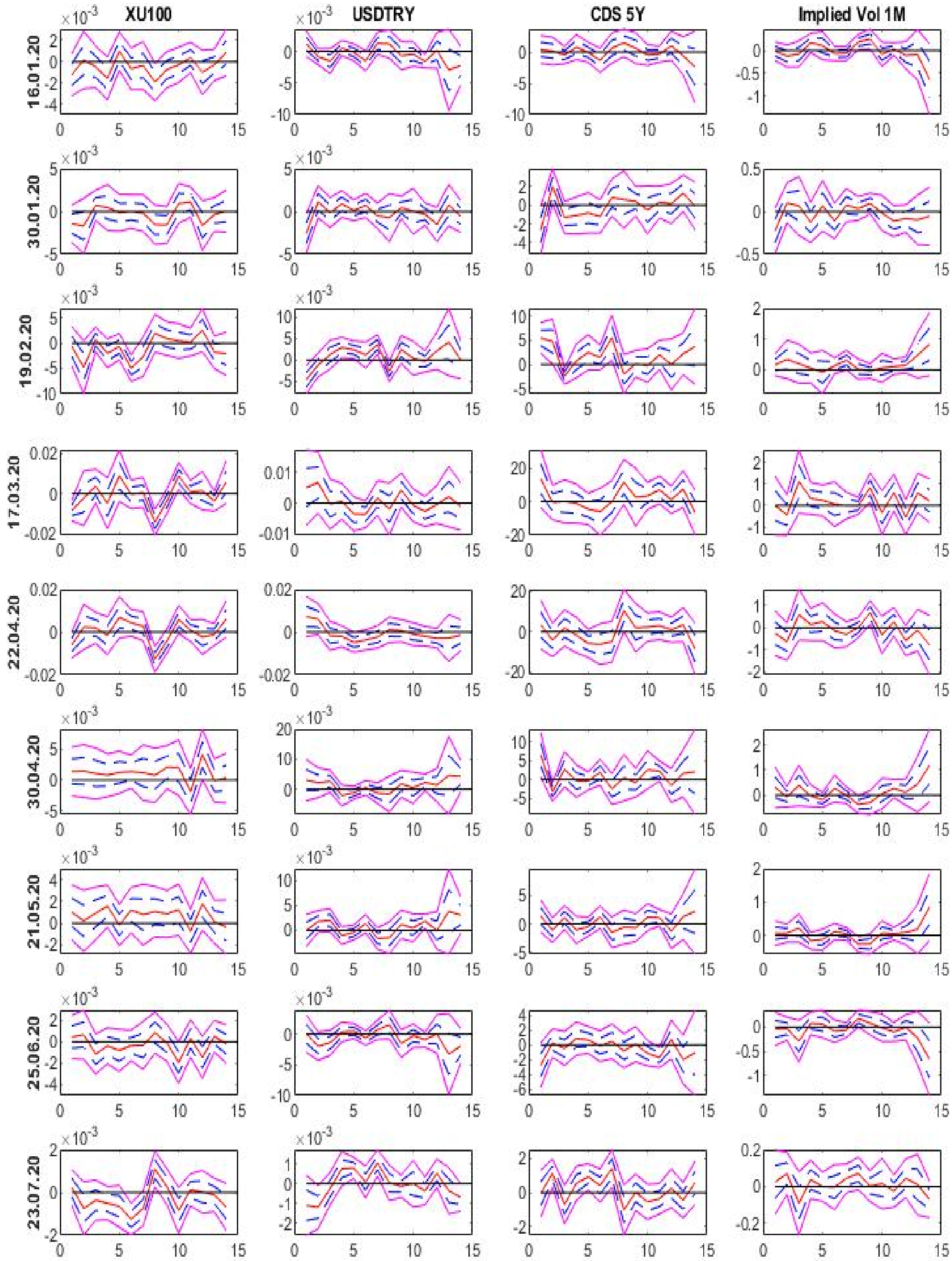


Figure 7.8: Raw Yield as Shock Data Model Results, Maturities of yields are 6 months, 2 years, 5 years and 9 years (16.01.2020-23.07.2020)

Raw Yield Model (Page 2)

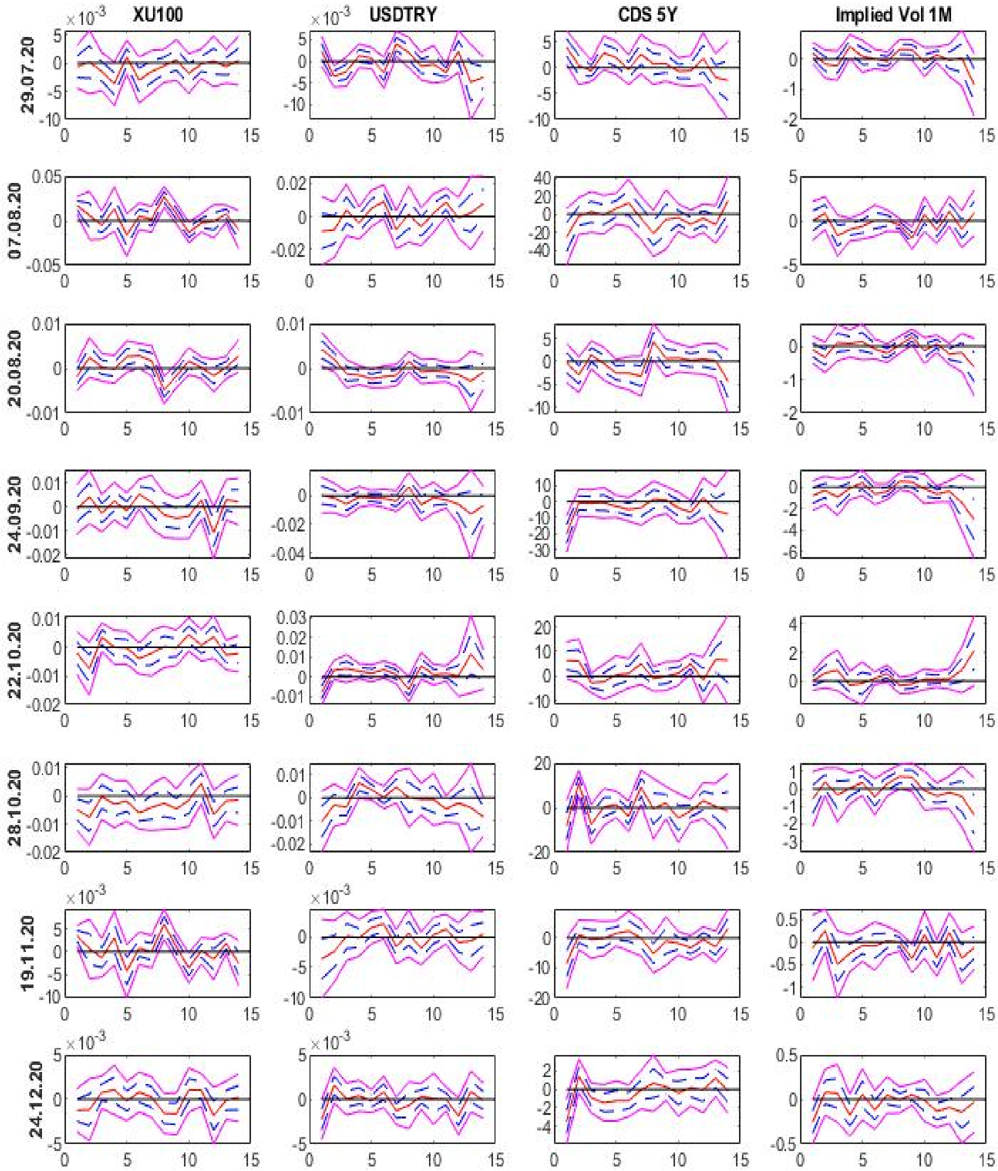


Figure 7.9: Raw Yields as Shock Data Model Results, Maturities of yields are 6 months, 2 years, 5 years and 9 years (29.07.2020-24.12.2020)

CHAPTER 8

CONCLUSION

In order to examine the daily effects of central bank announcements on financial markets, three different shock data and VAR models were constructed and the results were examined. The results in all models similar to each other. However, although some effects on financial variables tend to same direction at same day, some significant results were obtained in different days and at different levels of significance in each model. In general, it is seen that the effects on financial variables are mostly insignificant. More successful results could not be obtained due to the data used in the model and accordingly, its strict assumptions. When the models established with all the shock variables are examined together, it is difficult to say that any of them is clearly superior to the other.

When the VAR model results are examined, the effects on CDS in the first days are in line with previous studies. In other words, in cases where short-term interest rates are lowered more than expected or statements that they will be lowered, that generally perceived as expansionary, CDS react immediately in the direction of rising. For other variables, results were obtained that could indicate a direction with the same clarity in the effects of the first days. Since the confidence intervals are calculated quite wide in all VAR models, results that can be said to be statistically significant are rarely encountered. However, for example, for USD/TRY with a delay (4-5 days), similar increases and decreases were observed like with the CDS. In addition, it was observed in some models that while some variables did not have a significant movement in any direction in most of the first days, affected significantly in unexpected directions in the following days. In this case, it was not possible to explain the movements in some variables economically. Finding explanations for these movements can be considered in future studies.

In addition, apart from the analysis, which is the aim of the thesis, it is thought that the chapters about monetary policy in Turkey in the 2000s and yield curve fitting procedures are useful sections that provide summary information for readers or other researchers. Although the chapter describing the monetary policy in Turkey was created in order to provide a basis for the analysis methods and which data should be used within the integrity of the thesis, it is thought that it will be very useful in terms of understanding the monetary policy applications. In addition, no similar text has been found in previous studies on how exactly the yield curve estimation process is done. However, since it does not constitute the main subject of the thesis, the method description is kept as a summary.

There have been previous studies on the financial markets of monetary policy decisions in Turkey. However, by examining the VAR model impulse responses of the effects, their future effects were not examined one by one. In addition, the effects of the Central Bank monetary policy announcements were not handled multidimensionally in previous studies on this subject. This thesis is the first study in terms of examining multidimensional effects for Turkey. In studies conducted for Turkey in the past, the effects of monetary policy announcements have been examined unidimensionally. For example, it has been evaluated that the unexpected effect of the announcement will be seen primarily on short-term bonds, and the effects on other variables can be examined through this variable. Although a similar approach is used in this thesis, it is examined that unexpected components of monetary policy announcements will affect the yields in many maturities at the same time and how these yield changes simultaneously affect other financial variables. In this way, the depth of analysis is increased. For example, the unexpected effect of the announcement may have different effects on long, medium and short-term returns. Combinations of these effects may lead to different effects on other variables. The method used in this thesis allows these effects to be examined as well. However, since the analysis assumes that each announcement will have a unique effect, it has not been possible to generalize the effects. Instead, each announcement in the past dates had to be examined separately. In future studies, it may be considered to develop methods to generalize these effects.

Although the modeling method allows for a deeper analysis, when used with the data in this thesis, the confidence intervals remained quite wide and mostly significant results could not be obtained. In this context, modeling methods that can give successful results can be researched in further studies or different results can be obtained by using the method with different data.

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APPENDIX A

RESIDUAL DIAGRAMS OF VAR MODEL WITHOUT EXTERNAL SHOCKS

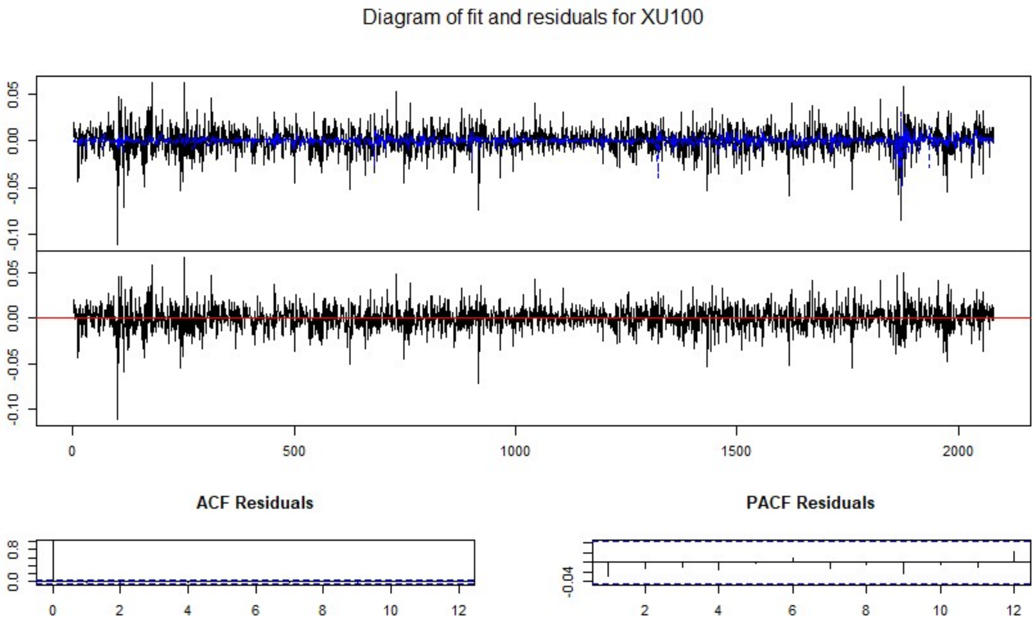

Figure A.1: Residual Diagram for XU100 Index Equation

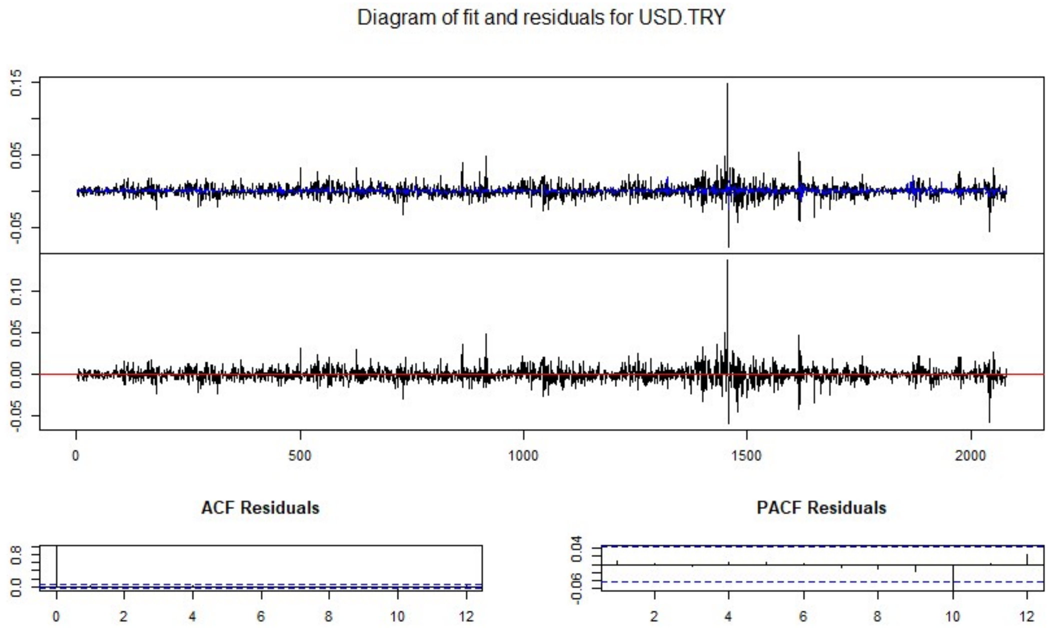

Figure A.2: Residual Diagram for USDTRY Currency Equation

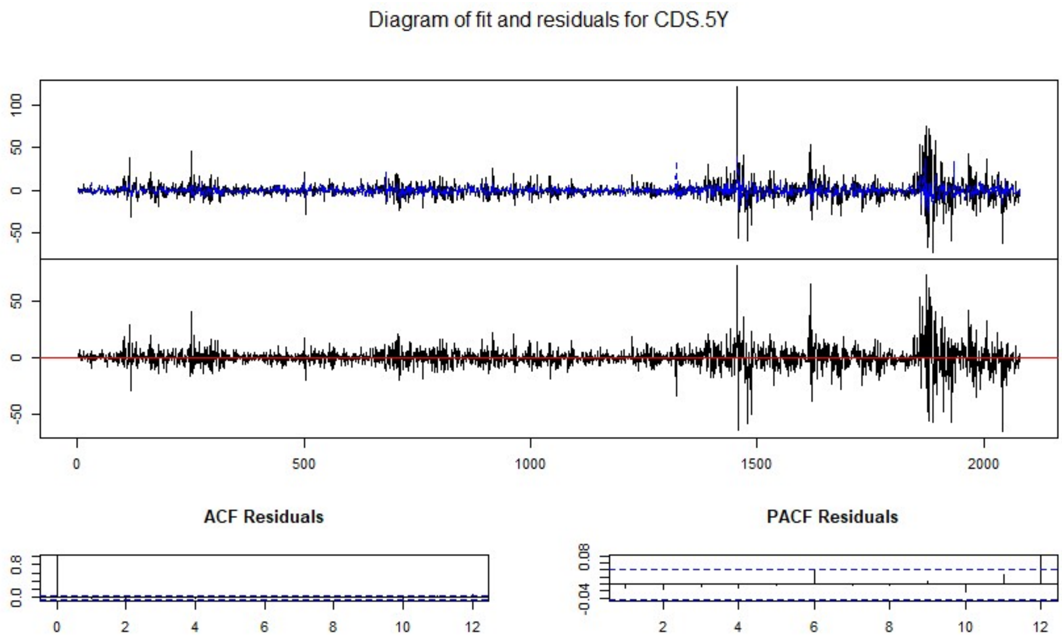

Figure A.3: Residual Diagram for CDS Equation

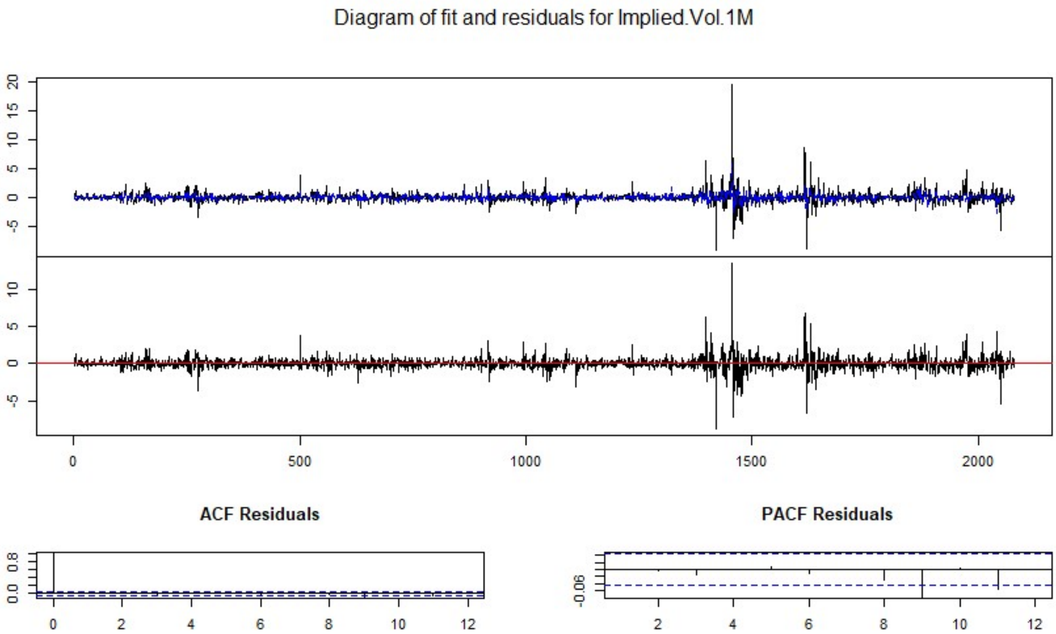

Figure A.4: Residual Diagram for Implied Volatility Equation

APPENDIX B

MATLAB CODES

```
%%Yield Curve
tauu = 0.95;
%%İnitial values for the optimization
a = nchoosek([-2,-1,0,1,2],3);
b = [];
for i = 1:length(a)
    b = [b;perms(a(i,:))];
end
inits = b*diag([10;5;10]);
butundata = xlsread(’TezVeri_NS.xlsm’,’TahvilVeri’);
yield_datatah = [];
coefstah = [];
tarihler=butundata(:,5);
ttarihler=unique(tarihler);
       for   zz=1:length(ttarihler);
           try
            datestr(ttarihler(zz)+693960)
            data=butundata(tarihler==ttarihler(zz),:);
            nelson_siegel_code;
           end
        end
```

Listing B.1: Yield Curve Loop Code

```
%VAR Model Script
data = xlsread('matlabveri.xlsx', 'matlab tahvil_raw');
shock_dim = 4;
exo_num = 0;
y_num = length(data(1,2+shock_dim:end-exo_num));


response_num = 14;
lag_num = 14;

[betas, VarCovMat, F_test_p_value_response, F_test_response, ...
    aic_response, bic_response] = local_projection_func(data, ...
    lag_num, response_num, shock_dim, exo_num);

for s_n = 1:2;
for s = 1:9;

shock = [0, shock_data(s + (s_n-1)*9,[1:(shock_dim)]), ...
        zeros(1,lag_num*(y_num+shock_dim)+exo_num)];
shock_tarih = shock_all_data(s+1 +(s_n-1)*9,2);

for j = 1:y_num;
for i = 1:response_num;

response(j,i) = shock*betas{j,i};

lower_response1(j,i) = response(j,i) ...
                    - sqrt(shock*VarCovMat{j,i}*shock');
upper_response1(j,i) = response(j,i) ...
                    + sqrt(shock*VarCovMat{j,i}*shock');
lower_response2(j,i) = response(j,i) ...
                    - 1.96*sqrt(shock*VarCovMat{j,i}*shock');
upper_response2(j,i) = response(j,i) ...
                    + 1.96*sqrt(shock*VarCovMat{j,i}*shock');
end
end
```

Listing B.2: VAR Model - Local Projection Code Part - 1

```
response = [zeros(1,y_num); response'];
lower_response1 = [zeros(1,y_num); lower_response1'];
upper_response1 = [zeros(1,y_num); upper_response1'];
lower_response2 = [zeros(1,y_num); lower_response2'];
upper_response2 = [zeros(1,y_num); upper_response2'];
%kümülatif olmayan içindir
response = response(2:end,:);
lower_response1 = lower_response1(2:end,:);
upper_response1 = upper_response1(2:end,:);
lower_response2 = lower_response2(2:end,:);
upper_response2 = upper_response2(2:end,:);
%kümülatif olmayan içindir

titl = {'XU100','USDTRY', 'CDS 5Y', 'Implied Vol 1M'};
r = zeros(response_num+1,1)';
%subplot(2,2,1);
%plot(yield_plot);
%legend('before','after');
%hold on
for i = 1:4;
subplot(9,4,i + ((s-1)*4));
plot(response(:,i),'r');
hold on
plot(lower_response1(:,i), 'b--');
hold on
plot(upper_response1(:,i), 'b--');
hold on
plot(lower_response2(:,i), 'm-');
hold on
plot(upper_response2(:,i), 'm-');
hold on
plot(r,'k-')
    if s == 1
    title(titl{i});
    end

    if i == 1;
    ylabel(shock_tarih);
    set(get(gca,'ylabel'),'fontweight','bold')
    %else
    %set(get(gca,'ylabel'),'visible','off')
    end
    sgtitle(strcat("Raw Yield Model (Page ",...
    num2str(s_n),")"),'interpreter','latex');
end
end
figure
hold off
end
```

Listing B.3: VAR Model - Local Projection Code Part - 2

```
function [betas, VarCovMat, F_test_p_value_response,...
        F_test_response, aic_response, bic_response] = ...
        local_projection_func(data, lag_num, response_num,...
        shock_dim, exo_num)
data_num = length(data);
y_num = length(data(1,2+shock_dim:end-exo_num));
offset_1 = [response_num+lag_num+1:data_num];
for j = 1:y_num;
for i = 1:response_num;
for ii = 0:lag_num+1;
offset(:,ii+1) = [(response_num -i+1 +lag_num-ii):...
                (data_num-ii -i)]';
end
tarih = data(offset_1,1);
y_data = data(offset_1,1+shock_dim + j);
x_data = ones(length(offset(:,1)),1);
x_data = [x_data data(offset(:,1),2:(shock_dim+1))];
for jj = 1:lag_num;
x_data_lag = data(offset(:,jj+1),2:end-exo_num);
x_data = [x_data x_data_lag];
end
if exo_num > 0;
    exo_data = data(offset_1,2+shock_dim+y_num:end);
    x_data = [x_data exo_data];
end
Mdl=fitlm(x_data, y_data,'Intercept',false);
aic = Mdl.ModelCriterion.AIC;
bic = Mdl.ModelCriterion.BIC;
%F test
[F_test_p_value, F_test] = coefTest(Mdl,[0,ones(1,shock_dim),...
zeros(1,length(x_data(1,:))-(1+shock_dim))]);
[EstCov,bint,b] = hac(Mdl);
coef = b;
betas{j,i} = b;
VarCovMat{j,i} = EstCov;
aic_response(j,i) = aic;
bic_response(j,i) = bic;
F_test_p_value_response(j,i) = F_test_p_value;
F_test_response(j,i) = F_test;
end
end
end
```

Listing B.4: VAR Model - Local Projection Function Code