UNIVERSITAT DE BARCELONA

Essays on Macroeconomic Policies and Redistribution

Karen Davtyan

PhD in Economics

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2016

PhD in Economics | Karen Davtyan

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PhD in Economics

Thesis title:

Essays on Macroeconomic Policies and Redistribution

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Date:

March 2016

UNIVERSITAT DE BARCELONA

To my family

Acknowledgements

First and foremost, I would like to express gratefulness to my thesis advisors Raul Ramos and Josep Lluis Carrion-i-Silvestre. My collaboration with Raul has started since the beginning of my admission to the UB. During all this time, he has always provided me his support, and I want to express my most heartfelt gratitude to him for that. I deeply appreciate the trust he has shown me, and I am very grateful to him for his guidance, continuous support and responsiveness. I am also very grateful to Josep Lluis for his support, scientific advice, and insightful discussions and suggestions.

A special thanks to Enrique Lopez-Bazo. He has always provided me his support and encouragement. I am also very grateful to him for his advice and recommendations. I would like to thank Vicente Royuela for many insightful discussions and comments. I also want to thank Bibiana Barnadas for her advice and continuous support. I would also like to thank the whole AQR research group.

I would like to thank the director of the PhD program Elisabet Viladecans-Marsal and Jordi Roca from UB Economics for their continuous support and encouragement. I am grateful to them for their efforts and enthusiasm continuously to improve the PhD program.

I would like to express my gratefulness to Gernot Müller for inviting me as a visiting researcher to the chair of International Macroeconomics and Finance at the University of Tübingen. I am very gratefully to Gernot Müller for his valuable comments and suggestions that have helped me to improve my research work substantially. I would also like to thank the other members of the chair for their helpful comments and suggestions.

I am very grateful to the Government of Catalonia for the FI scholarship that I received during three years of my PhD program.

I would like to thank all my friends and colleagues from the UB. I have shared a lot of great moments with them.

Finally, I am extremely grateful to my family. They have sacrificed a lot to provide me this opportunity to study in the PhD program and they have supported me along the way. My love and gratitude for them can hardly be expressed in words. I dedicate this thesis to my family.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1. Background and Motivation

The recent financial crisis has hit countries and shaken financial systems all over the world. This has led to the implementation of large scale fiscal expansionary interventions. The massive bailouts of the banking system have further burdened fiscal balances and rise considerable concern about fiscal solvency of some countries. Many governments want to keep deficits under control by cutting spending and raising taxes. As a result, it could lead to an enormous wealth transfer from tax payers to the financial system. Expansionary fiscal policies might also bring a huge shift in resources among groups which causes worries about growing income inequality within countries (Piketty, 2014). Consequently, this can undermine political stability since people perceive such measures as an unfair redistribution of resources. Moreover, calls for redistribution could arise, and they might lead to fiscal policies that undermine economic progress and deteriorate fiscal performance.

Redistributive mechanisms are usually described through political economy arguments that specify some transmission channels between income inequality and economic growth (Acemoglu and Robinson, 2008; Benabou, 2000; Neves and Silva, 2014). In the political economy arguments, the redistribution of income is implied to be implemented through fiscal policy by taxation and government spending. However, income is redistributed also via monetary policy. Economic activities are regulated by macroeconomic policies, which include both fiscal and monetary policies. They are used for comparatively different macroeconomic objectives. Fiscal policy is usually used to foster aggregate demand while monetary policy is generally used to control inflation. However, fiscal and monetary policies also affect the same economic activities, such as redistribution of income.

Monetary policy can affect the distribution of income through different transmission channels. Inflation has a direct effect on income inequality through changes in the real valuation of financial and non-financial assets. An unexpected fall in interest rates and an increase in inflation tend to hurt savers and benefit borrowers. Studies based on the data on the United States of America demonstrate that inflation hits richer and older households whose asset holdings are typically imperfectly insured against surprise inflation (Doepke and Schneider, 2006). Inflation is also harmful to the poorest part of the population. This is because poorer households tend to hold a larger fraction of their income in cash, implying that both expected and unexpected increases in inflation make them even poorer Albanesi (2007). Thus, through some channels monetary policy could reduce income inequality while via the others it might increase inequality. The total distributive impact of monetary policy is not certain.

To respond to the global financial crisis, currently, many central banks have substantially lowered their policy rates until it has hit the effective zero lower bound. They have also resorted to unconventional monetary policy measures to overcome the crisis. However, the implementation of unconventional monetary policy might also change the income distribution. The policy measures can increase the financial and the businesses income of high-income households. At the same time, they could also restore labor earnings for low-income households. Consequently, unconventional monetary policy might affect income inequality though its overall distributional impact is not certain as in the case with the distributive effect of conventional monetary policy.

1.2. Objectives and Structure of the Thesis

Talking into account all the aforementioned considerations, the general objective of the doctoral thesis is to evaluate the distributive effects of macroeconomic policies. In particular, the thesis aims to assess the distributional impact of fiscal policy, conventional and unconventional monetary policies. The conducted research on the evaluation of these macroeconomic policies is consecutively presented in the following three chapters. The thesis also contains a final chapter with the concluding remarks.

The objective of **Chapter 2** is to analyze the interrelations among economic growth, income inequality, and fiscal performance. The interrelations among these variables are very complex. They are affected through different channels. The transmission channels and the reduced form relations between inequality and growth are empirically tested using mainly cross-section and panel data for single-equation analyses (Ehrhart, 2009; Neves and Silva, 2014). Controlling for economic growth, the relationship between income inequality and fiscal performance is generally studied through single-equation analysis too (Larch, 2012). In the cases of the usage of these variables in single-equation analyses, it is very likely to face the endogeneity problem of independent variables. This issue is usually overcome by the application of instrumental variables. However, it is quite challenging to find proper instruments.

The contribution of this chapter is to analyze these interrelations jointly in a system, examining also transmission channels among them. All the variables are regarded as endogenous within the framework of the structural vector autoregression methodology. This allows exploring dynamic interactions among the variables and feedback effects on each other. For this area of the research, this approach has not been examined in the literature in a systematic way and there are only a few related works (Ramos and Roca-Sagales, 2008; Roca-Sagales and Sala, 2011).

The empirical analysis is conducted for the Anglo-Saxon countries: the United Kingdom (UK), the United States of America (USA), and Canada. These countries implement relatively independent fiscal policies, which are not generally bounded by intergovernmental treaties, such as European Fiscal Compact. The economies of these countries are generally characterized by relatively low levels of government regulation and high levels of income inequality. In addition, considering these countries with similar backgrounds can provide further insights by comparing the obtained results among them.

The chapter provides new evidence on interrelations among economic growth, income inequality, and fiscal performance by employing the longest possible consistently measured data on income inequality on a country basis. The obtained results show that income inequality has negative effect on economic growth in the case of the UK while its effect is positive in the cases of the USA and Canada. The results also indicate that the increase in income inequality worsens fiscal performance for all the countries.

The academic literature (among others, Afonso et al., 2010; Doerrenberg and Peichl, 2014; Wolff and Zacharias, 2007) generally views fiscal policy as a measure to address growing income inequality, which is a widespread concern nowadays (e.g., discussed in the popular book by Piketty (2014)). Although the income distribution could also be affected by monetary policy, the distributive effects of monetary policy have not broadly been discussed in the literature (Coibion et al., 2012; Saiki and Frost, 2014; Villarreal, 2014). Taking this into account, the objective of **Chapter 3** is to contribute to the discussion in this research area by evaluating the effect of monetary policy on income inequality.

The distributional effect of monetary policy is estimated in the case of the USA, where the dynamics in income inequality has mainly been driven by the variation in the upper end of distribution since early 1980's (Congressional Budget Office, 2011). The chapter uses an inequality measure that represents the whole distribution of income, and in this respect, it complements the work by Coibion et al. (2012) who use economic inequality measures that do not cover the top one percent. To identify a monetary policy shock, the chapter employs contemporaneous identification with ex-ante identified monetary policy shocks as well as log run identification. In particular, a cointegration relation has been determined among the considered variables and the vector error correction methodology has been applied for the identification of the monetary policy shock. The obtained results indicate that contractionary monetary policy decreases the overall income inequality in the country. These results could have important implications for the design of policies to reduce income inequality by giving more weight to monetary policy.

In the wake of the global financial crisis, central banks have generally begun to implement unconventional monetary policy together with conventional policy measures. The main purpose of unconventional monetary policy is to decrease long term interest rates in order to support private borrowing of households and businesses, consequently, stimulating aggregate demand and real economic activity. There are already numerous studies on the impact of unconventional monetary policy measures on financial market (e.g., D'Amico and King, 2010; Gagnon et al. 2010; Joyce et al., 2011). There are also papers on the macroeconomic effect of unconventional monetary policy (e.g., Baumeister and Benati, 2013; Chunget al., 2012; Gambacorta et al., 2014; Lenza et al., 2010). However, the distributive effect of unconventional monetary policy has not been essentially examined yet. The objective of **Chapter 4** is to fill this gap by evaluating the distributive impact of unconventional monetary policy in comparison with the distributional effect of conventional monetary policy.

The distributional effects of conventional and unconventional monetary policies are evaluated for the USA. They are assessed by the impulse response functions and the variance decomposition. The distributive impact of conventional monetary policy is explored through contractionary policy shocks. At the same time, the distributional effect of unconventional monetary policy is studied via expansionary policy shocks. The obtained results indicate that conventional monetary policy reduces income inequality while unconventional monetary policy raises it. In particular, the distributive impact of conventional monetary policy is stronger. Nevertheless, its effect on the lower part of income distribution is not significant whereas unconventional monetary policy has a significant impact on it. The results also show that the both conventional and unconventional monetary policies increase inequality in the upper part of income distribution.

The variance decomposition analysis is also implemented in the chapter. This analysis assesses the relative importance of conventional and unconventional monetary policy shocks in the variation of Gini index of income inequality. The obtained results indicate that the unconventional monetary policy shock explains the higher share of the variation in Gini index than the conventional monetary policy shock.

The summary of all the obtained results of the thesis and the policy implications are provided in **Chapter 5**. This final section also includes the future lines of research.

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Chapter 2: Interrelation among Economic Growth, Income Inequality, and Fiscal Performance: Evidence from Anglo-Saxon Countries[1]

2.1. Introduction

Since the pioneering contribution by Kuznets (1955), suggesting a non-linear relationship between inequality and growth (inequality first increases and later decreases during the process of economic development, being known as the Kuznets curve), there has been a growing interest in analyzing the relationship between both variables (Eicher and Turnovsky, 2003). However, theoretical papers as well as empirical applications have produced controversial results, and economic theory does not have a clear cut answer to the relation between inequality and growth.

The effect of inequality on growth also depends on the way fiscal policy responds to income inequality. Political debates evolve around decisions on spending and taxation, the channels of the redistribution of resources, which affect fiscal performance. Depending on the decision about government spending and taxation, fiscal policy has different impact on inequality and growth. Therefore, fiscal policy is an important transmission channel between income inequality and economic growth. In addition to fiscal policy channel, different transmission channels between inequality and growth are specified in the literature such as socio-political instability, which might affect investment. Thus, the interrelations among economic growth, income inequality, and fiscal performance are very complex, which are affected through different channels.

[1] The analysis described in this chapter is associated with the academic paper that has been accepted for publication by Review of Public Economics (August, 2015). The research carried out in the chapter has been presented in the AQR-IREA seminar (September, 2013), international conference of the Courant Research Centre and the Ibero-America Institute of Economic Research (July, 2014), the 15th IWH-CIREQ Macroeconometric workshop (December, 2014), and SAEe symposium (December, 2015).

The validity of the transmission channels and the reduced form relations between inequality and growth are empirically tested, using mainly cross-section and panel data (Ehrhart, 2009; Neves and Silva, 2014). Especially, they are usually tested through single-equation analyses. The relationship between income inequality and fiscal performance, with the consideration of economic growth, is generally studied through single-equation approach too, as in the empirical analysis by Larch (2012). In the case of the usage of these variables in a single-equation analysis, it is highly likely to face the problem of the endogeneity of independent variables. This issue is usually overcome with the application of instrumental variables but it is quite challenging to find proper instruments.

The objective of the chapter is to analyze the interrelations among economic growth, income inequality, and fiscal performance jointly in a system, examining also transmission channels among them. All the variables are considered as endogenous by applying the structural vector autoregression methodology. This approach allows exploring dynamic interactions among them and feedback effects on each other. For this area of the research, this approach has not been explored in the literature in a systematic way and there are only a few related works (Ramos and Roca-Sagales, 2008; Roca-Sagales and Sala, 2011).

The chapter also tries to overcome another issue that has been found in the literature related to the estimation of the interrelations among economic growth, income inequality, and fiscal performance. In particular, because of the lack of comparable inequality data, researchers often have to mix different classifications of data together, which is inappropriate, according to Knowles (2005). The careful attention is payed to this issue. Thereby, the chapter provides new evidence on interrelations among growth, inequality, and fiscal performance by using the longest possible consistently measured comparable data on income inequality on a country basis.

The empirical analysis is implemented for the Anglo-Saxon countries, the United Kingdom (UK), the United States of America (USA), and Canada. These developed countries implement relatively independent fiscal policies, which are not generally bounded by intergovernmental treaties, such as European Fiscal Compact. Their economies are generally characterized by comparatively low levels of government regulation and high levels of income inequality. In addition, considering these countries with similar backgrounds can provide further insights from comparing the results for each of them. The chapter finds that income inequality has negative effect on economic growth in the case of the UK. The effect is positive in the cases of the USA and Canada. The increase in income inequality worsens fiscal performance for all the countries.

The rest of the chapter is organized as follows. Section 2.2 discusses the interrelations and the channels among economic growth, income inequality, and fiscal performance. Section 2.3 presents the data while Section 2.4 describes the empirical methodology and provides the results. Section 2.5 contains concluding remarks and policy implications.

2.2. Interrelations among Economic Growth, Income Inequality, and Fiscal Performance

In this section, the chapter discusses each link of the interrelations among economic growth, income inequality, and fiscal performance by reviewing the related literature. First, the chapter describes the literature on the relationship between income inequality and economic growth. Next, the literature on inequality and fiscal performance is discussed. The chapter also describes the literature on fiscal performance and economic growth.

2.2.1. Income Inequality and Economic Growth

In this area of research, one of the mostly studied relations is between income inequality and economic growth. Barro (2000) brings evidence of a negative relationship between inequality and growth for poor countries and a positive relationship for rich countries. Analogously, Galor and Moav (2004) argue that while income inequality positively affects economic growth at the stages of physical capital accumulation, later the process is reversed at the stages of human capital accumulation. In addition, generally it is found that long-run relation between inequality and growth is negative while the short-run effect of inequality on growth is positive. In the case of the usage of nonparametric estimation methods, Banerjee and Duflo (2003) find that changes in inequality in any direction are associated with subsequent lower growth rates.

The meta-analysis by de Dominicis et al. (2008) permits to conclude that, although policy conclusions are clearly different, probably it is misleading to simply speak of a positive or negative relationship between income inequality and economic growth when looking at the available studies. Differences in estimation methods, data quality, sample coverage, and the initial level of income are some of the factors that could affect the estimated impact of income inequality on economic growth (Castells-Quintana and Royuela, 2014).

Exploring the relation between politics and growth through endogenous growth model, Alesina and Rodrik (1994) find that higher degree of inequality of wealth and income leads to the greater rate of taxation (redistribution) and to the lower economic growth. That is, the more unequal distribution of resources in society leads to lower rate of economic growth, and the link between them is given by redistributive policies. Their empirical results show that inequality in land and income is negatively correlated with subsequent economic growth. They indicate that the important line of research can be the study of dynamic interconnection between income distribution and growth since they are consecutively affect each other.

Alesina and Perotti (1996) explore another transmission channel for the negative relation between income inequality and economic growth. They state income inequality leads to socio-political instability that creates uncertainty in the politico-economic environment, decreasing investment. That is, inequality and investment are negatively related whereas the latter is an important factor for growth. Alesina and Perotti (1996) test their hypotheses, using a bivariate simultaneous equation model in an index of socio-political instability and investment.

Persson and Tabellini (1994) theoretically model that unequal distribution of income in a democratic society produce redistributive economic policies that decrease investment and subsequently economic growth. Their empirical results indicate a negative relation between initial income inequality and subsequent economic growth. Thus, investment could be a link between inequality and growth. Persson and Tabellini (1994) assert that the transmission channel of fiscal policy should also be carefully investigated since government interventions caused by distributional conflicts lead to decrease in investment and consequently to decline in growth. That is, a link between a redistribution policy and economic growth should be further explored as well.

2.2.2. Income Inequality and Fiscal Performance

Economic recessions accompanied with high inequality lead to political pressure, which causes discretionary government spending. The various groups of a country may try to change established inequality through public spending during recessions. Lower income groups demand more transfers while groups with higher incomes want to obtain tax benefits through lighter taxation. The redistribution is influenced by the relative power of each group in the political decision making process Milanovic (1999). In the long run, this conflict can lead to excessive debt if the government pays for these transfers to certain groups without taxing others. In the short term, an economic boom increases government income, making easier to pay more transfers to all groups while in a recession the government with lower disposal income prefers to borrow or raise taxes to ease tensions in the groups.

Larch (2012) argues that fiscal performance is influenced by the different degrees of income inequality. In particular, he shows that countries with higher degree of income inequality are prone to run deficits and accumulate government debt. To explain fiscal performance, Larch (2012) uses econometric analyses with single-equation regression models through explanatory variables such as income inequality and economic growth, which is risky since they are not exogenous, and there is a problem of endogeneity.

2.2.3. Fiscal Performance and Economic Growth

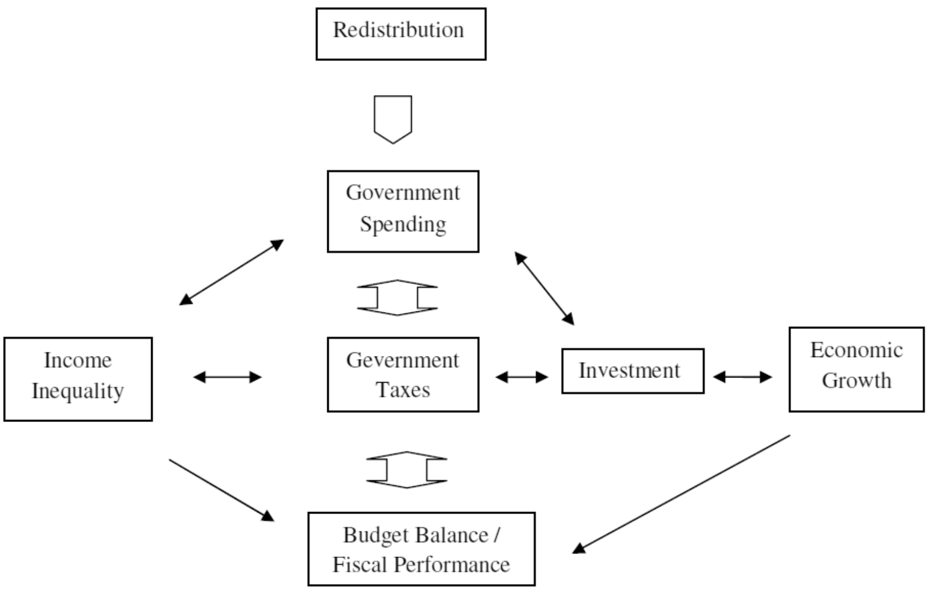
Fiscal performance reflects fiscal policy discipline, and it is significantly affected by the volatility of fiscal policy. As shown by Woo (2011), income inequality leads to the volatility of fiscal policy, which in turn dampens economic growth. That is, he discusses the fiscal policy volatility channel for the negative link between inequality and growth. Woo (2011) considers this channel by separately examining the links between income inequality and fiscal volatility, the latter and growth, and eventually inequality and growth. In the work the negative relation between macroeconomic volatility and growth has also been considered. The studies of the relations between income inequality and economic growth through the fiscal policy volatility channel are conducted by single-equation econometric modeling techniques. However, by studying the isolated relations among them, important information is missed, and there is an endogeneity problem[2]. These concerns are addressed by Muinelo-Gallo and Roca-Sagales (2013) who examine mutually influential relationship between income inequality and economic growth via the fiscal policy channel by considering the systems of structural equations. They employ a system of seemingly unrelated regressions and a simultaneous regression model in their econometric analysis. The systems of structural equations approach to macroeconomic modeling is arguably fundamentally flawed whereas vector autoregression (VAR) models are generally less ambitions macroeconomic modeling approach that performs as good as or better than structural equation systems for analyzing macroeconomic activity (Green, 2002). In the context of the topic, VAR modeling approach is employed by Ramos and Roca-Sagales (2008), and Roca-Sagales and Sala (2011). However, they mainly focus on the examinations of the fiscal policy effects on GDP while the chapter directly explores the interrelations among growth, inequality, and fiscal performance.

To show the interrelations among the discussed variables, Figure 2.1 is provided. It illustrates the complex mutual interrelations being considered in the analysis. From the diagram, the complex mutual interrelations among the

[2] Woo (2011) tries to address this endogeneity problem through instrumental variables regressions.

variables can be seen. Some of the isolated relations among them have extensively been studied in the literature. As previously mentioned, the objective is to study and analyze those interrelations jointly in a system, being the main contribution of the chapter.

Figure 2.1: Interrelations among the Variables



2.3. Data

The empirical analysis is implemented for the Anglo-Saxon countries, the UK, the USA, and Canada. These countries are highly developed and they conduct relatively independent fiscal policies, which are not generally bounded by intergovernmental treaties, such as European Fiscal Compact. The economies of these countries are generally characterized by the low levels of the government regulation, the small shares of the public sector, and by free markets. They are among the most economically free countries of the world. Particularly, according to the latest annual report on Economic Freedom of the

World (Gwartney et al., 2014), the corresponding chain-linked indices[3] for the UK, the USA, and Canada are 7.92 (9), 7.81 (14), and 8.11 (4), respectively. Similarly, for instance, for 1990, these chain-linked indices of Economic Freedom of the World are 8.08 (6), 8.35 (3), and 8.09 (5) for the UK, the USA, and Canada, respectively.

The economically free Anglo-Saxon countries are characterized with the economic model that fosters innovations and competitive advantages, stimulating growth and creating jobs in a country. However, the impact of the economic model on the overall prosperity in the society might be ambiguous. In particular, it is asserted that this economic model is less redistributive and leads to higher income inequality and poverty in Anglo-Saxon countries compared to other developed countries that employ other economic models such as Nordic and Continental European models.

The UK, the USA, and Canada are relatively homogeneous and similar in backgrounds to compare the empirical results obtained for them. Each of the countries was under British rule, and they have a common law legal system. Migration and trade flows among them were high over the twentieth century (Atkinson and Leigh, 2013). Thus, the consideration of these countries in the analysis could give additional inferences from the comparison of the results for each of them. Nevertheless, the countries have their own specific features. Especially, the UK has comparatively higher level of taxation and it spends relatively more on the welfare state. Besides, the UK has adopted some social programs used within European continental economic models (Putten, 2005).

2.3.1. Income Inequality Data

In the empirical analysis, a lot of attention is payed to the usage of consistently measured comparable data on income inequality. This is very important because scarcity and diversity of the data on income inequality are one of the

[3] The index of Economic Freedom of the World measures the degree of the supportiveness of economic freedom by the policies and institutions of countries (Gwartney et al., 2014). The values of the index range from 0 (the lowest) to 10 (the highest). That is, higher values denote greater degrees of economic freedom. Based on index values, country ranks are also provided. They are presented in parentheses next to index values.

major difficulties for empirical analyses in this research area. First of all, income inequality datasets generally are not fully available for considered periods and shorter than time series usually used in macroeconomic analyses (e.g., for economic growth). In addition, income inequality can be measured based on gross or net (disposable) income, and the unit of measurement can be an individual or a household. Therefore, it is expectable to get quite different measures of income inequality, depending on which of these classifications are used. Emphasizing this, Knowles (2005) stresses the importance of the usage of consistently measured inequality data.

Because of the lack of comparable inequality data, researchers often have to mix different classifications of data together, as indicated by Knowles (2005). However, he argues that this is inappropriate and shows that the empirical results found in these cases are not robust. He also points out that the estimates in the cross-country analysis on inequality and growth are highly sensitive to the sample of countries included. In addition, data on inequality usually come from different sources, and they are not automatically comparable since differences in underlying survey methodologies might impair the comparability. Taking all these arguments into account, the chapter tries to use the longest possible consistently measured comparable data on income inequality on a country basis. Depending on their availability, the chapter accordingly selects the same ranges for the other time series used in the empirical analysis. In line with all these objectives, the data sources are correspondingly chosen.

2.3.2. Dataset

All the data are annual and range over the period from 1960 to 2011. As an income inequality measure, Gini coefficient (GINI) is used in the empirical analysis since it provides the broadest coverage across time and countries. Gini coefficients are taken from the OECD dataset and UNU-WIDER, World Income Inequality Database (WIID 3.0b), September 2014. The chapter uses these sources for Gini coefficients because by far they have the most comprehensive set of income inequality data. The chapter employs the longest possible inequality data based on disposable income, which are the most appropriate to use in empirical analyses, as argued by Knowles (2005) based on theoretical considerations. Besides, Gini coefficients on disposable income are mainly the longest available series of income inequality data (available mainly in the OECD database). However, if they are from different sources or they are missing for the considered period, the chapter correspondingly adjusts (shifts) Gini coefficients based on net income from different sources or the coefficients that are derived from gross income towards the longer series of Gini indices on disposable income from the OECD database. The shifting of the series towards the series from the OECD database is implemented based on the averages of the overlapping values of the series. The chapter carries out these adjustments since the combined series generally have the same dynamics and trends, and that is simply shifting the series towards each other. Nevertheless, special care regarding this approach is taken to use possibly compatible data on Gini indices[4].

Data on economic growth (GRGDPC) are taken from the World Development Indicators of the WB and from the version 8.1 of Penn World Table (Feenstra et al., 2015). The time series for economic growth are the annual growth rates of real GDP per capita. As a measure of fiscal performance[5], the chapter uses general government net lending/borrowing expressed as a percentage of GDP (NLB). It is from Federal Reserve Bank of St. Louis (FRED) and OECD. Additionally, the chapter also considers other variables to explore transmission channels among the main variables. Total investment (SI) and general government spending[6] (SG) are expressed as shares of GDP and they are from

[4] As a robustness check for the inequality data, the empirical analysis is also implemented with imputed Gini coefficients for disposable income (analogous to the indices used in the rest of the chapter) from Solt´s inequality database (Solt, 2009). The chapter uses its latest available fifth version, SWIID. As a Gini index for disposable income, the chapter considers a mean value of its 100 imputed coefficients. The obtained outcomes of the estimations are generally similar to the results of the paper.

[5] In line with Larch (2012), the chapter estimates the effect of income inequality on fiscal performance (discussed in Section 2.2) but in a multi-equation context. As a measure for fiscal performance, Larch (2012) uses budget balance. The chapter actually employs the same index but it uses the term "general government net lending/borrowing", following the OECD terminology, where these data mainly come from.

[6] As government spending, the chapter considers general government final consumption expenditure. The chapter has also tried to use its augmented version with current transfer

the World Development Indicators of the WB. Total tax revenue is presented as a percentage of GDP (TAXES) and it is from Federal Reserve Bank of St. Louis (FRED) and OECD. The detailed definitions of the variables are provided in Table 2.1, and the general statistical characteristics of the variables are presented in Table 2.2. The evolution of the variables is depicted in Figure 2.2.

Table 2.1: The List of Abbreviations and Their Detailed Definitions

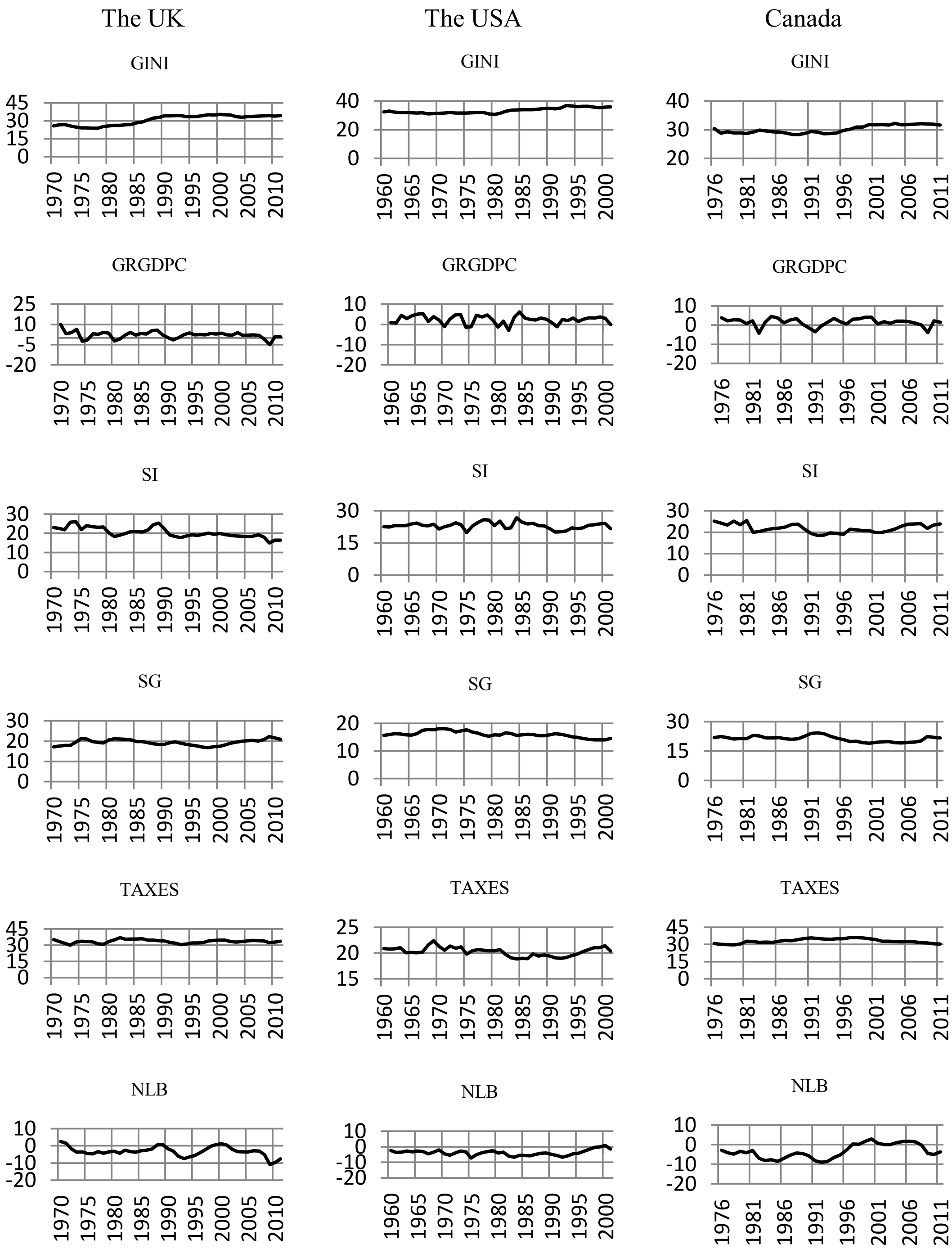
Abbreviations	Definitions as Specified in the Source of the Data
GINI	Gini coefficient of disposable income inequality (in percentages)
GRGDPC	Annual percentage growth rate of GDP per capita based on constant local currency. Aggregates are based on constant 2005 U.S. dollars.
SI	The percentage share of gross capital formation (private and public, total) in GDP
SG	The percentage share of general government final consumption expenditure (total) in GDP
TAXES	Total tax revenue as a percentage of GDP
NLB	General government net lending/ borrowing as a percentage of GDP

payments in the empirical analysis. However, the results do not generally change. Thus, the government final consumption, which includes social transfers in kind (OECD, 2010), generally reflects redistributive fiscal policies.

Table 2.2. Descriptive statistics

Aggregate Indices for the Observed Initial Series													
		GINI		GRGDPC		SI		SG		TAXES		NLB	
Countries	Range	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
UK	1970-2011	30.77	4.17	2.16	2.14	20.39	2.61	19.35	1.40	33.48	1.57	-3.18	2.81
USA	1960-2011	34.18	2.46	2.03	2.14	22.69	1.86	15.98	1.03	19.95	1.13	-4.46	2.54
Canada	1976-2011	30.14	1.36	1.55	2.12	21.88	1.98	21.28	1.44	32.97	1.91	-3.39	3.57

Figure 2.2: The Evolution of the Initial Variables



2.4. Empirical Analysis

Considering the current state of this research area, the chapter explores the interrelations among economic growth, income inequality, and fiscal performance jointly through structural VAR modeling, taking also into account transmission channels among them. This approach allows tackling the endogeneity problem among the variables and to study them in a system. In addition, structural VAR models also allow recovering underlying economic shocks and to examine dynamic interactions among the variables and feedback effects on each other through impulse response functions.

In order to use structural VAR modeling approach properly, the order of integration of the time series should be checked first. If their order of integration is zero and the series are stationary, the empirical analysis can immediately be implemented. Otherwise, stationary transformation for the series should first be performed and, then, structural VAR modeling approach should be applied. Thus, in the empirical analysis, first, the order of integration of the time series is checked and depending on the obtained results, the further is implemented.

2.4.1. Stationary Transformation

The chapter checks the order of integration of the time series with the augmented Dickey-Fuller test[7]. The null hypothesis is tested that a series has a unit root against its stationarity. Depending on the characteristics of the series, the chapter performs the test with an intercept or without any deterministic term. The results of the test are presented in Table 2.3. As can be seen, the time series of the variables are not stationary (they are integrated of order 1) except for the series of economic growth. In contrast to the variables, which are given at a point in time, economic growth relates to a previous period. Therefore, to provide maximal comparability for all of the data for the empirical analysis, the index for economic growth is brought to base (to its starting value for each

[7] Along with the augmented Dickey-Fuller test (Dickey and Fuller, 1979), the chapter also uses Phillips-Perron test (Phillips and Perron, 1988) to check the stationarity of the time series. In all the cases, it provides analogous results.

of the series). That results in the nonstationary series, as can be observed from Table 2.3. Thus, all the time series are now nonstationary.

The chapter makes stationary transformation for the time series before using them in the empirical analysis. Two common ways of stationary transformation are differencing and detrending, which can be implemented in different ways. One of the widely used detrending methods is Hodrick-Prescott (HP) filter[8] (Hodrick and Prescott, 1997), which is a smoothing method to obtain a long-term trend component of a series. The HP filter also renders stationary time series that are difference stationary and integrated of higher order (King and Rebelo, 1993). Taking also into account that all the variables are relative quantities, the chapter de-trends the series by the HP filter to also provide economic meaning to the variables after their stationary transformation. In any cases, the stationary transformation is also implemented by the first order differencing but the obtained results generally show the same dynamic behavior. Therefore, the series detrended by the HP filter are used in the empirical analysis.

For the ratio variables, the detrending is implemented by subtracting the HP filter from the actual series. These detrended series show percentage points deviations from their long-term means. For the base index of economic growth, detrending is carried out by dividing the series by the HP filter and subtracting one (all this expression is also multiplied by 100). In this case, the detrended series show percentage deviations from their long term means. Then, the augmented Dickey-Fuller test is again implemented to check whether the stationary transformation of the time series is successful. Since the series are detrended now, no deterministic term is used for the test. As indicated by the test results in Table 2. 4, all the series are stationary now and the structural VAR analysis can already be implemented.

[8] The usage of the Hodrick-Prescott filter can be found, for example, in the works by Ball and Mankiw (2002), Juillard et al. (2006), and Pytlarczyk (2005).

Table 2.3: The Augmented Dickey-Fuller Test for the Initial Time Series

The UK

Variables	Test Values	Critical Values 1%	5%	10%	P-Values
SG	0.20	-2.62	-1.95	-1.61	0.74
SI	-2.03	-3.61	-2.94	-2.61	0.27
GRGDPC (initial index)	-4.06	-2.62	-1.95	-1.61	0.00
GRGDPC (base index)	-0.52	-3.61	-2.94	-2.61	0.88
GINI	-0.82	-3.60	-2.94	-2.61	0.80
TAXES	-0.34	-2.62	-1.95	-1.61	0.56
NLB	-1.71	-2.62	-1.95	-1.61	0.08

The USA

Variables	Test Values	Critical Values 1%	5%	10%	P-Values
SG	0.11	-2.61	-1.95	-1.61	0.71
SI	-0.54	-2.61	-1.95	-1.61	0.48
GRGDPC (initial index)	-5.20	-3.57	-2.92	-2.60	0.00
GRGDPC (base index)	-0.79	-3.57	-2.92	-2.60	0.81
GINI	0.53	-3.57	-2.92	-2.60	0.99
TAXES	-0.79	-2.61	-1.95	-1.61	0.37
NLB	-0.88	-2.61	-1.95	-1.61	0.33

Canada

Variables	Test Values	Critical Values 1%	5%	10%	P-Values
SG	-0.32	-2.63	-1.95	-1.61	0.56
SI	-0.37	-2.63	-1.95	-1.61	0.55
GRGDPC (initial index)	-3.37	-2.63	-1.95	-1.61	0.00
GRGDPC (base index)	-0.42	-3.64	-2.95	-2.61	0.90
GINI	-0.80	-3.63	-2.95	-2.61	0.81
TAXES	0.01	-2.63	-1.95	-1.61	0.68
NLB	-1.94	-3.64	-2.95	-2.61	0.31

Table 2.4: The Augmented Dickey-Fuller Test for Detrended Time Series

The UK

Variables	Test Values	Critical Values 1%	5%	10%	P-Values
SG	-5.73	-2.62	-1.95	-1.61	0.00
SI	-5.37	-2.63	-1.95	-1.61	0.00
GRGDPC (base index)	-4.78	-2.62	-1.95	-1.61	0.00
GINI	-4.75	-2.63	-1.95	-1.61	0.00
TAXES	-3.83	-2.62	-1.95	-1.61	0.00
NLB	-4.54	-2.62	-1.95	-1.61	0.00

The USA

Variables	Test Values	Critical Values 1%	5%	10%	P-Values
SG	-5.38	-2.61	-1.95	-1.61	0.00
SI	-5.37	-2.61	-1.95	-1.61	0.00
GRGDPC (base index)	-5.55	-2.61	-1.95	-1.61	0.00
GINI	-6.02	-2.61	-1.95	-1.61	0.00
TAXES	-6.48	-2.61	-1.95	-1.61	0.00
NLB	-6.67	-2.61	-1.95	-1.61	0.00

Canada

Variables	Test Values	Critical Values 1%	5%	10%	P-Values
SG	-3.90	-2.63	-1.95	-1.61	0.00
SI	-3.57	-2.63	-1.95	-1.61	0.00
GRGDPC (base index)	-3.69	-2.63	-1.95	-1.61	0.00
GINI	-4.26	-2.63	-1.95	-1.61	0.00
TAXES	-4.89	-2.64	-1.95	-1.61	0.00
NLB	-4.03	-2.63	-1.95	-1.61	0.00

2.4.2. VAR Specification

For each country, the interrelation among economic growth, income inequality, and fiscal performance, measured by government net lending/borrowing, are examined by the structural VAR methodology. The VAR specification approach is conditioned on a compromise between a parsimonious model and the one that does not have omitted variable bias. Therefore, the chapter considers benchmark and extended structural VAR specifications. The benchmark specification that is the most parsimonious and the basic one includes the main variables of this study: economic growth, income inequality, and fiscal performance (GRGDPC, GINI, NLB). The extended model also allows exploring transmission channels among them, and it additionally contains government spending, investment, and taxes (SG, SI, GRGDPC, GINI, TAXES, NLB).

In general, the VAR model of order p, denoted VAR(p), can be expressed as:

$$y_t = A_0 + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t, \qquad (2.1)$$

where y_t is $(n \times 1)$ vector containing each of the n variables included in the VAR; A_0 is an $(n \times 1)$ vector of intercept terms; A_i are $(n \times n)$ matrices of coefficients; and e_t is an $(n \times 1)$ vector of error terms[9]. In the case of the benchmark model, $n = 3$ and it contains $GRGDPC, GINI, NLB$ variables. In the case of the extended model, $n = 6$ and it includes $SG, SI, GRGDPC, GINI, TAXES, NLB$ variables.

It is assumed that the vector of error terms is a n-dimensional white noise process, i.e., $E(e_t) = 0$, $E(e_t e_t') = \Omega$, and $E(e_t e_s') = 0$ for $s \neq t$, where Ω is a $(n \times n)$ symmetric positive definite matrix. Since error terms are serially uncorrelated with constant variances and the right hand side of the VAR(p) equation (2.1) contains only predetermined variables, each equation in the system can be estimated by ordinary least squares (OLS). Moreover, these estimates are consistent and asymptotically efficient (Enders, 2004). This is true not only in the case of stationary variables, but also in the case when some

[9] It should be noted that any VAR(p) can be rewritten as a VAR(1), which is known as the companion form of the VAR(p).

variables are integrated (Sims et al., 1990). Based on this, some researchers estimate VAR models in levels ignoring non-stationarity issues. A drawback of this approach is that, while the autoregressive coefficients are estimated consistently, this may not be true for other quantities derived from these estimates (Kamps, 2005). Especially, Phillips (1998) shows that impulse responses and forecast error variance decompositions based on the estimation of unrestricted VAR models are inconsistent at long horizons in the presence of nonstationary variables. Impulse response analysis is one of the main tools for policy analysis in the case of VAR models and it is widely used in the chapter. Therefore, the chapter employs only stationary series for estimations in the current research work.

2.4.3. Structural VAR Identification

Little can be learned about the underlying economic structure of the aforementioned VAR models in their standard forms unless identifying restrictions are imposed since these models are reduced form models. The shocks of this reduced form model are not generally economically meaningful because they are linear combinations of structural shocks. The underlying structural model is obtained by pre-multiplying both sides of the unrestricted VAR by the $(n \times n)$ B matrix:

$$By_t = \Gamma_0 + \Gamma_1 y_{t-1} + \Gamma_2 y_{t-2} + \cdots + \Gamma_p y_{t-p} + \varepsilon_t, \qquad (2.2)$$

where $\Gamma_i = BA_i$ for $i = 0, \dots, p$ and $\varepsilon_t = Be_t$, which describes the relation between the structural disturbances ε_t and the reduced form disturbances e_t (or equivalently $e_t = B^{-1}\varepsilon_t$). It is assumed that the structural disturbances ε_t are white noise and uncorrelated with each other, i.e., their variance-covariance matrix is diagonal. The matrix B describes the contemporaneous relation among the variables contained in the vector y_t. That is, there are more parameters in the structural model (2) than in the reduced form VAR presented in (1). Therefore, without restrictions on the parameters of the structural model, it is not identified. There are number of alternative identification procedures proposed in the literature. In this empirical work, the chapter applies the widely used recursive approach originally proposed by Sims (1980) that restricts B (and correspondingly B^{-1}) to a lower triangular matrix. That is, this identification scheme, also known as Cholesky decomposition, imposes a recursive causal structure from the top variables to the bottom variables. While this recursive approach enables uniquely identifying the structural VAR model, it has n! possible orderings in total. Though economic reasoning usually allows selecting an appropriate ordering, the sensitivity of the dynamic properties of the model to alternative orderings of the variables should be checked.

For the ordering of the variables in the benchmark specification (GRGDPC, GINI, NLB), it is natural to assume that contemporaneously government net lending/borrowing does not impact economic growth and income inequality but it is affected by them. The contemporaneous impact of economic growth is not usually distributionally neutral and it affects income inequality. On the other hand, growth likely responds to changes in inequality only in the long term due to the considerable transmission mechanisms, such as capital accumulation (Benabou, 1996, Perotti, 1996, Ramos and Roca-Sagales, 2008). That is, economic growth should come first in the model. In any case, the chapter also estimates the VAR model with the reverse order of growth and inequality, but the results do not change significantly. Thus, the ordering of the variables for the basic VAR model is as follows: GRGDPC, GINI, NLB.

The ordering of the variables in the case of the extended VAR model (SG, SI, GRGDPC, GINI, TAXES, NLB) is mainly in line with Ramos and Roca-Sagales (2008) since they use a similar VAR model. In addition to the basic variables, the chapter also includes government spending, investment, and taxes in the model. As in the basic case, it is still reasonable to assume that contemporaneously government net lending/borrowing does not influence the considered variables but it is affected by them. Contemporaneously investment impact economic growth (Alesina and Perotti, 1996) and consequently the other variables except of government spending, which is planned in advance. Thus, the extended VAR model has the following ordering of the variables: SG, SI, GRGDPC, GINI, TAXES, NLB.

2.4.4. Impulse Response Functions

Impulse response functions (IRFs) are intuitive tools to analyze interactions among variables in the benchmark and the extended VAR models. To see this and keep things simple, VAR(1) can be considered for any case without loss of generality since any VAR(p) can be rewritten as a VAR(1). Firstly, it should be expressed in its vector moving average (VMA) representation by using recursive substitution:

$$y_t = A_0 + \sum_{i=0}^{\infty} A_1^i e_{t-i} \tag{2.3}$$

To trace the economic impact of an impulse to one of the variables on itself and on the rest of the variables in the system, it is required the VMA representation based on the orthogonal structural shocks instead of the reduced form disturbances, which are correlated with each other. Therefore, by using the expression for the reduced form disturbances e_t, (3) is rewritten as:

$$y_t = A_0 + \sum_{i=0}^{\infty} A_1^i B^{-1} \varepsilon_{t-i} \tag{2.4}$$

It can be written in a more compact form as:

$$y_t = A_0 + \sum_{i=0}^{\infty} \Phi_i \varepsilon_{t-i} \tag{2.5}$$

By updating this equation, the responses of y_{t+i} to one unit impulse at time *t* are obtained. If each element of Φ_i is graphed against *i* periods (these elements are called impact multipliers), it is possible to obtain the response of each variable in the system from the impulse to the different structural shocks. Thus, IRFs describe how the VAR system reacts over time to one unit shock in a variable assuming that there is no other shock in the system during that period.

The structural shocks, which are considered as one-standard deviations to the variables, are recovered and they get their natural economic meaning. They are identified by the Cholesky decomposition, which requires imposing the ordering of the variables that describes the contemporaneous relations among them. The chapter specifies the ordering of the variables based on economic reasoning. As mentioned above, the ordering of the variables in the benchmark VAR model is as follows: GRGDPC, GINI, NLB, while for the extended model is the following: SG, SI, GRGDPC, GINI, TAXES, NLB.

The chapter studies the dynamic interrelations among the variables through the IRFs with one-standard error bands, which allows assessing the statistical significance of the results. The chapter presents them as graphical representations of impact multipliers over 10 periods, during which they converge to 0, indicating that underlying time series are stationary. In tabulated format, we also provide accumulated impact multipliers (with corresponding standard errors), which are viewed as long run multipliers when they are consider over long periods. The chapter accumulates them over 2, 5, and 10 periods. Thus, the accumulated impact multipliers over 10 periods could be regarded as long run (total) effects whereas the graphical representation of impact multipliers might reveal the short term dynamic interrelations of the variables.

2.4.5. Empirical Results

As discussed, VAR methodology allows considering all the variables as endogenous and to refrain from such a strong assumption as the exogeneity of any of the variables (Lütkepohl and Krätzig, 2004). Therefore, the chapter includes all the variables as endogenous in the VAR models. Besides, there is deterministic variable in the models. The chapter makes the stationary transformation of the data. Moreover, deterministic terms do not affect the IRFs (Lütkepohl and Krätzig, 2004), which are the empirical tools of the analysis. Taking into account the results of the information criteria (especially relying on Schwarz criterion) and the limitations of the available time series, the chapter uses the first-order VAR models[10], which are estimated by OLS[11].

[10] The first-order VAR models are also employed in the closely related works by Ramos and Roca-Sagales (2008), and Roca-Sagales and Sala (2011).

2.4.5.1. Benchmark Specification

From the IRFs presented in Figure 2.3, it can be seen that the structural shock of one standard deviation[12] in economic growth leads to approximately 0.1 percentage points increase in income inequality in the case of the UK and to around 0.15 and 0.07 percentage points declines in income inequality in the cases of the USA and Canada respectively. The shock in economic growth results in the rises of government net lending/borrowing by approximately 0.5, 1.0, and 1.2 percentage points for the UK, the USA, and Canada respectively. While the positive effect of the growth on government net lending/borrowing is expectable because of the anticipated rise in government revenues, the effect of the growth shock on inequality is not unambiguous as indicated by the results[13].

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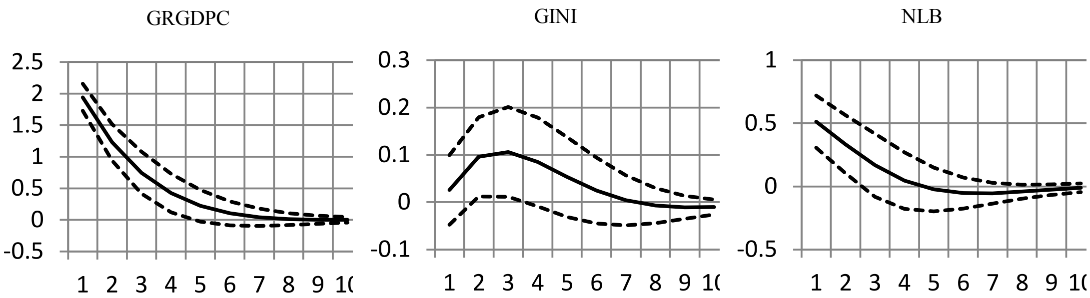
[11] The chapter implements the robustness check for the estimation results. It is carried out for the IRFs in different dimensions. First of all, the chapter tries some other alternative orderings for the contemporaneous relations among the variables. The analysis is also implemented by using generalized impulse response functions, which are invariant to the orderings of the variables in VAR models (Pesaran and Shin, 1998). Besides, the chapter uses different samples for the benchmark and extended specifications by employing rolling and recursive schemes, and by just excluding the last parts of the samples since the financial crisis of 2008. In all the cases, the results do not change significantly.

[12] As described in Subsection 2.4.3, all deviations and changes in the variables (after their stationary transformation) are in relation to their long-term means.

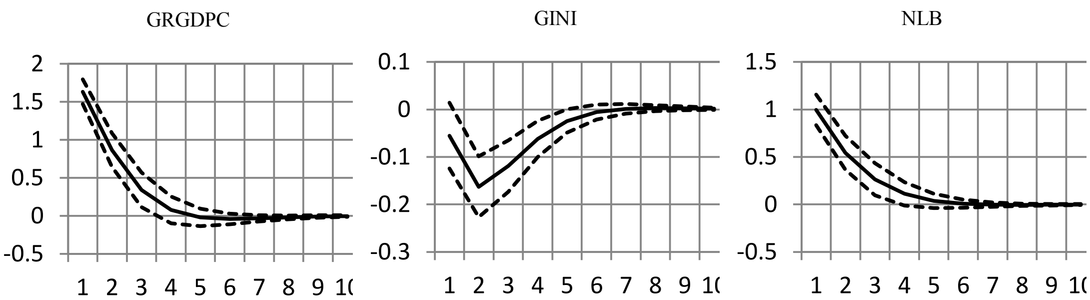
[13] The accumulated responses over 2, 5, and 10 periods are presented in Table 2.5 after the ordinary IRFs.

Figure 2.3: IRFs to a Shock to Economic Growth

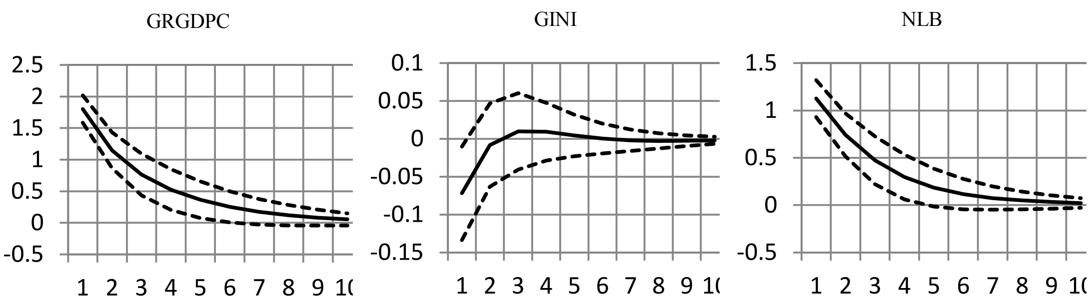
The UK



The USA



Canada

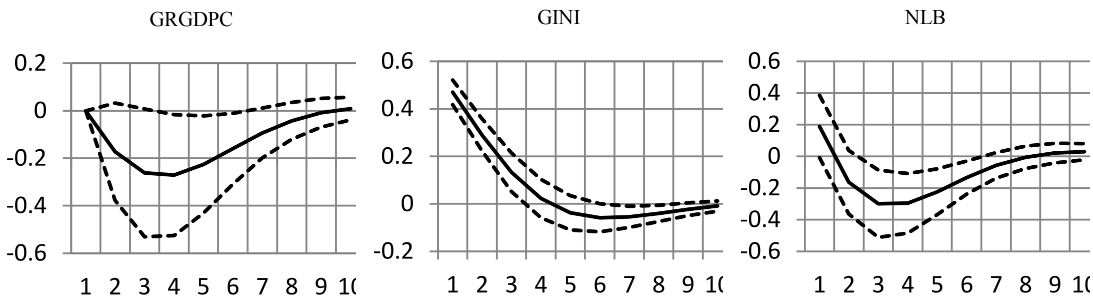


It would not be correct to view the IRFs of inequality to the growth shock in the countries through the concept of the Kuznets curve. That would require observing the relation between growth and inequality in a country for a longer term. Instead, the chapter interprets these IRFs through the disaggregation of economic growth. Based on the production function, economic growth could be generally attributable to the growth in technology, capital, and labor. So, the impact of the growth shock on inequality could depend on the structure of the increase in labor that contributes to the economic growth. For instance, if the increased labor consists of many people with low level of income, it can reduce inequality due to the earnings of these employees. Thus, for the considered countries, the differences in the IRFs of inequality to the growth shock might be due to the distinct structures in their labor increases.

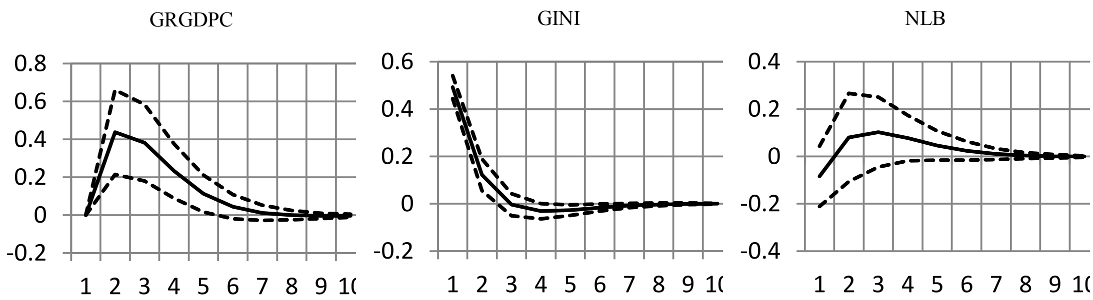
As can be observed from Figure 2.4 and Table 2.5, a structural shock to income inequality induces to the decline in economic growth by accumulated 0.17 percent over two periods for the UK and to the increases in growth by accumulated 0.44 and 0.32 percent over two periods for the USA and Canada respectively. These results underline that the relation between inequality and growth is not definite and that is outlined in the literature. The negative effect of inequality on growth is asserted in the works such as Alesina and Rodrik (1994) and Persson and Tabellini (1994). The positive effect of inequality on growth for the USA and Canada is in line with Barro's (2000) evidence that this relationship is positive for developed countries. In particular, Partridge (2005) shows that inequality are positively related to long run growth in the USA, and that is in line with the empirical results, which are obtained for the comparatively long time period. The differences in these effects for the Anglo-Saxon countries could be explained by the distinctions between the UK and Anglo-American economic models. In particular, the former probably shares some common features with European continental economic models and spends relatively more on the welfare state.

Figure 2.4: IRFs to a Shock to Income Inequality

The UK



The USA



Canada

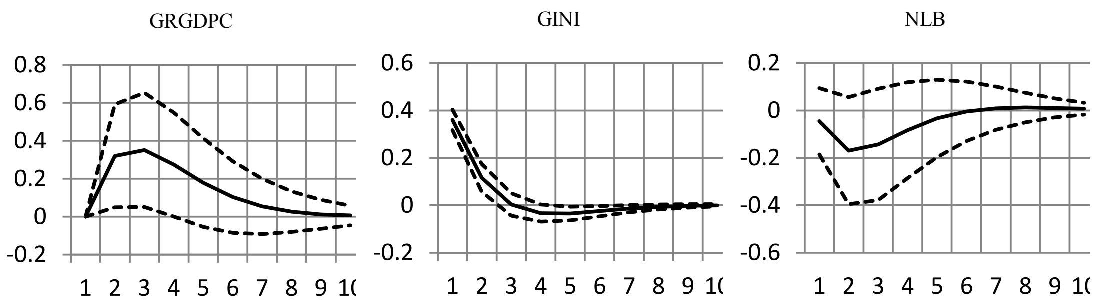


Table 2.5: Accumulated IRFs to Shocks to Economic Growth and Income Inequality

		Shock to Economic Growth			Shock to Income Inequality		
Countries	Periods / Variables	2	5	10	2	5	10
The UK	GRGDPC	3.170 (0.43)	4.561 (1.22)	4.715 (1.63)	-0.172 (0.20)	-0.932 (0.90)	-1.228 (1.08)
	GINI	0.122 (0.14)	0.366 (0.35)	0.366 (0.45)	0.761 (0.10)	0.879 (0.29)	0.695 (0.33)
	NLB	0.848 (0.39)	1.038 (0.91)	0.854 (0.99)	0.026 (0.37)	-0.794 (0.78)	-0.941 (0.72)
The USA	GRGDPC	2.498 (0.32)	2.895 (0.74)	2.783 (0.77)	0.437 (0.22)	1.164 (0.59)	1.213 (0.60)
	GINI	-0.218 (0.11)	-0.423 (0.18)	-0.421 (0.17)	0.615 (0.09)	0.553 (0.14)	0.525 (0.13)
	NLB	1.539 (0.28)	1.951 (0.57)	1.948 (0.60)	-0.004 (0.25)	0.223 (0.48)	0.260 (0.49)
Canada	GRGDPC	2.951 (0.43)	4.603 (1.28)	5.284 (2.06)	0.320 (0.27)	1.124 (1.01)	1.324 (1.44)
	GINI	-0.080 (0.10)	-0.056 (0.17)	-0.065 (0.19)	0.476 (0.08)	0.410 (0.15)	0.361 (0.14)
	NLB	1.867 (0.37)	2.819 (0.97)	3.114 (1.43)	-0.215 (0.31)	-0.476 (0.81)	-0.441 (1.02)

Note: Standard errors are in the parentheses.

As can be seen from Figure 2.4 and Table 2.5, the rise in inequality generally leads to the reduction of government net lending/borrowing in all the countries. For Canada, it is clear government net lending/borrowing decreases over the all periods with around 0.2 percentage points minimal reduction. In the case of USA, it initially declines until approximately 0.1 percentage points and it increases afterwards. In contrast, the inequality shock initially increases government net lending/borrowing in the UK and then, the shock steeply reduces it until the lowest point of 0.3 percentage points in the third period, by preserving its negative impact over the subsequent periods. These negative effects of the inequality shock on government net lending/borrowing are much more obvious in the case of the extended specification for the UK and the USA. These impacts are almost totally negative within it, and the total reductions over 10 periods are 0.7 and 0.18 percentage points in the UK and the USA respectively[14].

In general, the estimation results indicate that there are other variables that influence the dynamics and interrelations among economic growth, income inequality, and fiscal performance. Therefore, the VAR model is extended by the other variables and the empirical analysis is also implemented with it.

2.4.5.2. Extended Specification

In the cases of shocks to economic growth and income inequality, the IRFs of the extended model have almost the same results as in the benchmark scenario. Therefore, the chapter only provides the IRFs in the cases of shocks to government spending, investment, and taxes. Besides, in the graphical representation, only the relevant IRFs are provided. In case of the table representation, all the accumulated IRFs are provided.

As can be seen from Figure 2.5, a government spending shock decreases economic growth by around 1.5, 1.2, and 1.4 percent in the UK, the USA, and Canada, respectively. That is, it is possible to observe the crowding out effect for all the countries. Perotti (2004) finds similar effects (opposite for the USA) for the UK and Canada for the subsamples more closely related to the estimation periods. As can be seen from Table 2.6, over two periods the government spending shock decreases income inequality by accumulated 0.39 percentage points in the UK but it raises inequality by accumulated 0.17 and 0.06 percentage points in the USA and Canada. This result for the UK corroborates the corresponding finding provided by Ramos and Roca-Sagales (2008). In the case of Sweden, the similar effects of a government spending shock on growth and inequality are found by Roca-Sagales and Sala (2011). The results for the USA and Canada indicate that the impact of government

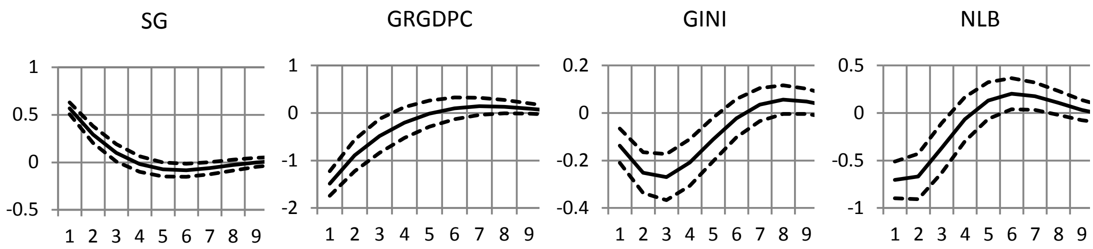
[14] The IRFs of these results are not provided in the chapter to keep it compact.

spending on inequality depends on the composition of government spending, particularly on the proportion of transfer payments in it. On the contrary, the impact government spending shock on government net lending/borrowing is unambiguous. As expected, it reduces government net lending/borrowing in all the countries. Especially, as can be noticed from Figure 2.5, it reduces government net lending/borrowing by around 0.7, 0.9, and 1.0 percentage points in the UK, the USA, and Canada respectively.

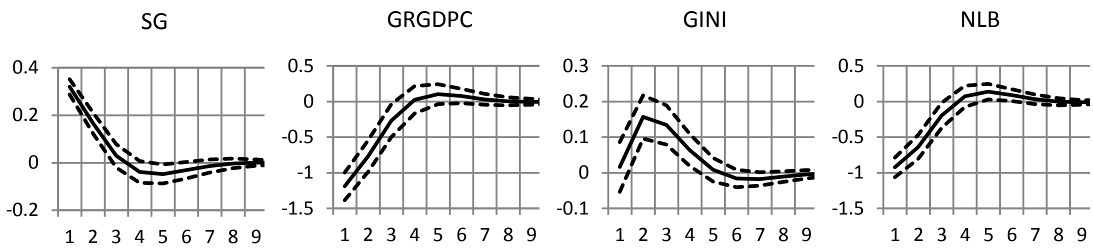
From Figure 2.6, it can be observed that as expected, an investment shock boosts economic growth by approximately 0.6, 0.7, and 0.4 percent in the UK, the USA, and Canada respectively. It decreases inequality by nearly 0.11 and 0.13 percentage points in the UK and Canada respectively. For the UK, Ramos and Roca-Sagales (2008) obtain similar results using public investment. In the case of the USA, the impact of the investment shock on inequality is slightly positive but it is highly insignificant to assess this effect. In all the countries, the investment shock similarly leads to around 0.4 percentage points rise in government net lending/borrowing. The economic interpretations of these effects of the investment shock are similar to the explanation of the impacts of the growth shock due to the direct positive effect of investment on economic growth.

Figure 2.5: IRFs to a Shock to Government Spending

The UK



The USA



Canada

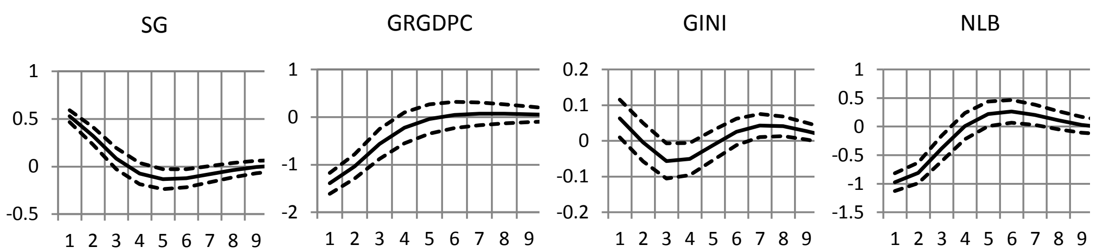
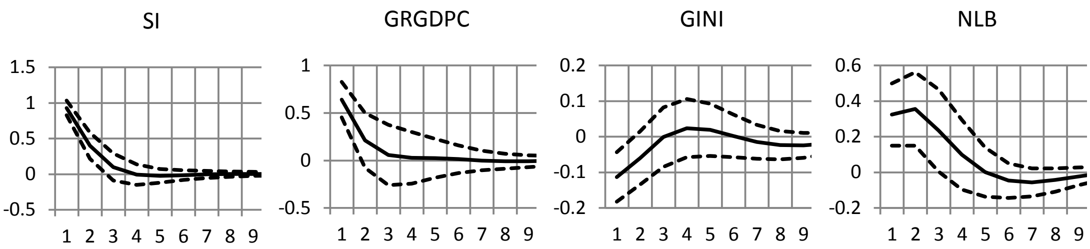
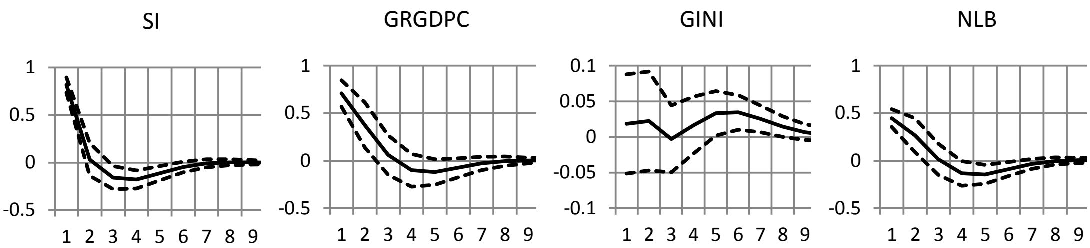


Figure 2.6: IRFs to a Shock to Investment

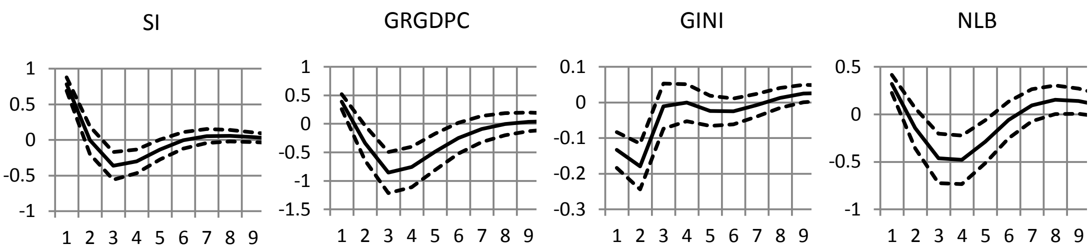
The UK



The USA



Canada



As can be seen from Table 2.6, over two periods a shock to taxes increases economic growth by accumulated 0.2 percent in the UK but it reduces growth by accumulated 0.3 and 0.4 percent in the USA and Canada. Blanchard and Perotti (2002) find a similar effect in the case of the USA. Since taxes include direct as well as indirect taxes, the relation between growth and taxes is not definite as it is indicated by the results. As can be observed from Figure 2.7, the shock to taxes leads up to nearly 0.14 percentage points rise in income inequality in the UK and Canada whereas the impact is very insignificant in the USA. That is, in general, the effect of indirect taxes, which increases inequality, prevails over the impact of the usually progressive direct taxes, which reduce inequality. For a large panel of countries, Martínez-Vázquez et al. (2012) find that direct taxes reduce income inequality while indirect taxes increase it. Ramos and Roca-Sagales (2008) provide evidence that indirect taxes raise inequality in the UK whereas Roca-Sagales and Sala (2011) obtain analogous results for Sweden. From Figure 2.7, it can be also seen that the shock to taxes increases government net lending/borrowing by approximately 0.9, 0.5, and 0.2 percentage points in the UK, the USA, and Canada respectively. As expected, the increase in tax revenue raises government net lending/borrowing in all the countries.

2.5. Conclusion

In this chapter, the interrelations among economic growth, income inequality, and fiscal performance are explored through structural VAR models. The transmission channels among the variables are also examined. The longest possible consistently measured comparable data on income inequality are used for the UK, the USA, and Canada, and new evidence on the interrelations among growth, inequality, and fiscal performance are provided.

The empirical analysis for the Anglo-Saxon countries reveals that there are generally some differences in the obtained results for the UK, and the USA and Canada. This could be explained by the differences between the UK and the Anglo-American economic models. With comparatively higher level of taxation and spending on the welfare state, the UK probably shares some common features with European continental economic models.

Income inequality has negative effect on economic growth in the case of the UK. The effect is positive in the cases of the USA and Canada. Income inequality generally reduces government net lending/borrowing for all the countries.

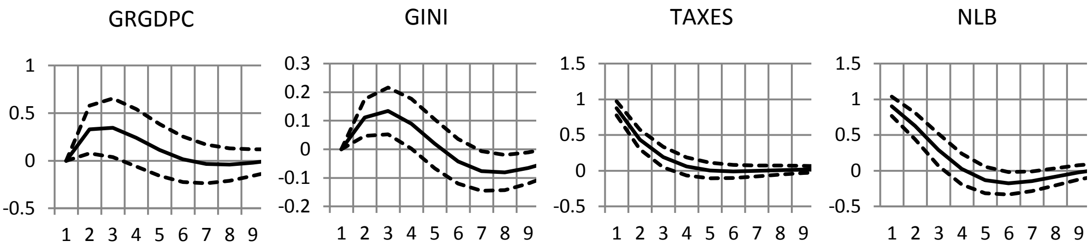
Economic growth leads to the increase of income inequality in the case of the UK and to the decline of inequality in the cases of the USA and Canada. At the same time, economic growth improves government net lending/borrowing in all the countries. Because of the direct positive effect of investment on economic growth, their impacts on the other variables are mostly similar.

Government spending leads to the decline in inequality in the UK but to its increase in the USA and Canada. In addition, government spending reduces growth through crowding out and worsens fiscal performance in all the countries. This distributional effect of government spending could depend on the proportion of the resources designed for the reduction of inequality.

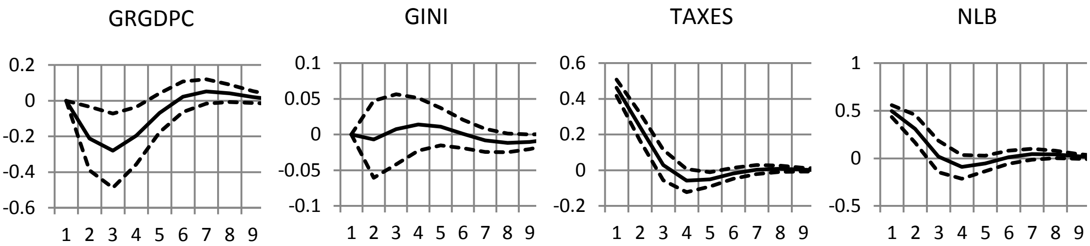
An increase in tax revenues generally raises income inequality in all the considered countries. Taking into account that taxes include direct taxation, which generally reduces inequality, and indirect taxation, which increases inequality, it can be inferred that the effect of indirect taxation outweighs. Therefore, this distributive impact of taxation should be considered during the design of fiscal policy measures aimed to reduce income inequality.

Figure 2.7: IRFs to a Shock to Taxes

The UK



The USA



Canada

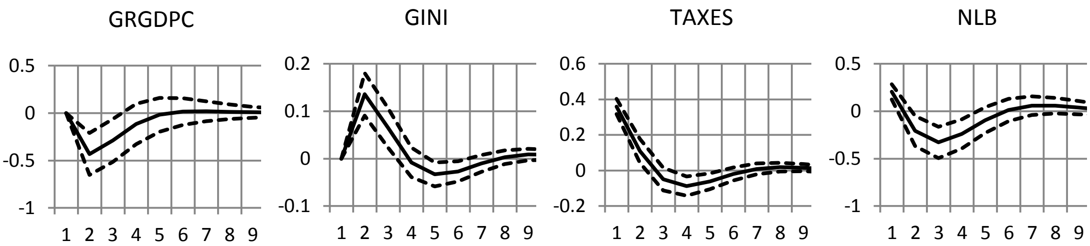


Table 2.6: Acc. IRFs to Shocks to Gov. Spending, Investment, and Taxes

		Shock to Government Spending			Shock to Investment			Shock to Taxes		
Countries	Periods / Variables	2	5	10	2	5	10	2	5	10
The UK	SG	0.862	0.870	0.714	0.039	0.159	0.267	0.004	0.292	0.554
		(0.13)	(0.30)	(0.34)	(0.07)	(0.24)	(0.30)	(0.07)	(0.26)	(0.35)
	SI	-1.561	-1.868	-1.744	1.331	1.400	1.395	0.095	0.265	0.322
		(0.34)	(0.72)	(0.77)	(0.23)	(0.58)	(0.67)	(0.18)	(0.62)	(0.82)
	GRGDPC	-2.380	-3.077	-2.564	0.850	0.962	0.957	0.329	1.029	0.956
		(0.51)	(1.28)	(1.49)	(0.41)	(1.09)	(1.34)	(0.25)	(1.06)	(1.53)
	GINI	-0.389	-0.979	-0.833	-0.173	-0.130	-0.209	0.112	0.355	0.048
		(0.14)	(0.35)	(0.43)	(0.12)	(0.29)	(0.38)	(0.06)	(0.29)	(0.44)
	TAXES	0.337	0.481	0.568	0.421	0.657	0.659	1.311	1.563	1.596
		(0.28)	(0.57)	(0.60)	(0.26)	(0.50)	(0.56)	(0.19)	(0.50)	(0.65)
	NLB	-1.372	-1.677	-1.180	0.681	1.017	0.845	1.529	1.715	1.303
		(0.38)	(0.86)	(0.73)	(0.33)	(0.74)	(0.65)	(0.27)	(0.75)	(0.82)
The USA	SG	0.488	0.431	0.385	0.049	0.292	0.368	-0.014	-0.050	-0.131
		(0.06)	(0.15)	(0.18)	(0.05)	(0.14)	(0.20)	(0.04)	(0.12)	(0.15)
	SI	-1.183	-0.849	-0.819	0.849	0.398	0.346	-0.100	-0.304	-0.157
		(0.22)	(0.33)	(0.25)	(0.19)	(0.31)	(0.32)	(0.14)	(0.27)	(0.22)
	GRGDPC	-1.959	-2.097	-1.992	1.086	0.925	0.819	-0.212	-0.756	-0.615
		(0.36)	(0.69)	(0.56)	(0.31)	(0.63)	(0.70)	(0.18)	(0.56)	(0.47)
	GINI	0.173	0.380	0.330	0.041	0.088	0.172	-0.007	0.026	-0.010
		(0.10)	(0.17)	(0.16)	(0.11)	(0.16)	(0.19)	(0.05)	(0.13)	(0.13)
	TAXES	-0.447	-0.409	-0.401	0.392	0.421	0.431	0.707	0.627	0.622
		(0.15)	(0.26)	(0.22)	(0.14)	(0.25)	(0.27)	(0.10)	(0.23)	(0.19)
	NLB	-1.562	-1.546	-1.441	0.716	0.454	0.333	0.809	0.684	0.804
		(0.26)	(0.48)	(0.39)	(0.21)	(0.43)	(0.49)	(0.15)	(0.41)	(0.35)
Canada	SG	0.852	0.730	0.495	0.258	0.921	0.669	0.175	0.397	0.305
		(0.13)	(0.36)	(0.35)	(0.10)	(0.37)	(0.39)	(0.07)	(0.21)	(0.14)
	SI	-1.142	-1.071	-0.942	0.780	-0.022	0.141	-0.350	-0.674	-0.562
		(0.23)	(0.42)	(0.36)	(0.22)	(0.45)	(0.41)	(0.15)	(0.26)	(0.17)
	GRGDPC	-2.427	-3.256	-2.973	0.057	-2.045	-2.312	-0.431	-0.853	-0.789
		(0.41)	(1.08)	(1.33)	(0.36)	(1.12)	(1.44)	(0.22)	(0.64)	(0.59)
	GINI	0.059	-0.060	0.088	-0.313	-0.347	-0.314	0.136	0.159	0.142
		(0.09)	(0.16)	(0.16)	(0.09)	(0.16)	(0.18)	(0.05)	(0.09)	(0.07)
	TAXES	-0.043	-0.154	0.040	0.421	0.472	0.590	0.470	0.272	0.305
		(0.14)	(0.25)	(0.28)	(0.14)	(0.27)	(0.31)	(0.09)	(0.15)	(0.13)
	NLB	-1.785	-1.941	-1.340	0.174	-1.056	-0.635	-0.003	-0.665	-0.482
		(0.29)	(0.71)	(0.70)	(0.24)	(0.76)	(0.77)	(0.19)	(0.44)	(0.29)

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Chapter 3: Income Inequality and Monetary Policy: An Analysis on the Long Run Relation[15]

3.1. Introduction

Nowadays there are widespread concerns regarding growing income inequality and different fiscal policy measures are discussed to address it (Chapter 2). However, monetary policy can also affect the distribution of income although its redistributive effects have not extensively been discussed. The objective of the chapter is to contribute to this discussion by evaluating the effect of monetary policy on income inequality.

Redistributive mechanisms are usually described through political economy arguments that specify some transmission channels between income inequality and economic growth (Acemoglu and Robinson, 2008; Benabou, 2000; Muinelo-Gallo and Roca-Sagales, 2011; Neves and Silva, 2014). In the political economy arguments, the redistribution of income is implied to be implemented through fiscal policy by taxation and government spending. However, income is redistributed also via monetary policy. Economic activities are regulated by macroeconomic policies, which include both types of policies. Though fiscal and monetary policies are used for comparatively different macroeconomic objectives (commonly to increase aggregate output and to control inflation, respectively), they also affect the same economic activities, such as redistribution, and are in constant interaction with each other.

[15] The research carried out for this chapter has substantially benefited from my research stay in the chair of International Macroeconomics and Finance at the University of Tübingen from September to December 2015. I gratefully acknowledge helpful comments and suggestions from Gernot Müller, who is head of chair and was my academic supervisor during the research stay. I am also grateful to the other members of the chair for their comments and suggestions during the presentation of this research work there. The analysis of this chapter has also been presented in the seminar of the research group AQR-IREA of the UB.

High inflation can create uncertainty, raise expectations of future macroeconomic instability, disrupt financial markets, and lead to distortionary economic policies (Romer and Romer, 1998). According to Bulir (2001), preceding inflation raises income inequality in following periods. As Albanesi (2007) demonstrates, a higher inflation rate is accompanied by greater income inequality. Accordingly, Villarreal (2014) shows that contractionary monetary policy decreases income inequality in Mexico. On the contrary, Coibion et al. (2012) find that contractionary monetary policy tends to raise inequality in earnings and total income in the USA.

The estimated effect of monetary policy could depend on the inequality measure used in the empirical analysis. That is, the estimated effects might differ if the inequality measure is from another data source and it does not represent the whole income share of population, particularly the top one percent. In the USA, the dynamics of income inequality has mainly been driven by the variation in the upper end of distribution since early 1980's (Congressional Budget Office, 2011). The chapter evaluates the distributional effect of monetary policy in the USA by using the inequality measure that covers the whole income distribution, including the top one percent.

The chapter finds a cointegration relation among real output, prices, the federal funds rate, and Gini index of income inequality. Consequently, vector error correction and equivalent vector autoregression models are used for the analysis of the relationship. In order to identify a monetary policy shock, the chapter employs contemporaneous identification with ex-ante identified monetary policy shocks and log run identification. In particular, the vector error correction methodology is applied for the identification of the monetary policy shock. The obtained results show that contractionary monetary policy reduces the overall income inequality in the country.

The rest of the chapter is organized as follows. Section 3.2 reviews the related academic literature while Section 3.3 discusses the empirical methodology. Section 3.4 describes the data and Section 3.5 provides the results. Section 3.6 contains the concluding remarks.

3.2. Literature Review

There are not many empirical papers devoted to the examination of the effect of monetary policy on income inequality in academic literature (Coibion et al., 2012; Saiki and Frost, 2014; Villarreal, 2014). The distributive impact of fiscal policy has been considered in the literature (among others, Afonso et al., 2010; Doerrenberg and Peichl, 2014; Wolff and Zacharias, 2007) more than the distributive effect of monetary policy. However, there are some insightful papers discussing different aspects of distributive effects of monetary policy and they are discussed thoroughly below. In addition, these distributive effects, which are evaluated in the considered literature, are summarized in Table 3.1.

Using cross-country data, Bulir (2001) provides evidence that preceding inflation raises income inequality in following periods. He argues that the total impact of inflation on inequality takes some time to be revealed. His analysis indicates that the positive effect of price stability on income inequality is nonlinear. That is, the initial decline in hyperinflation substantially reduces inequality whereas the further effects of the reductions in lower levels of inflation consecutively decrease. Bulir (2001) concludes that price stabilization is beneficial for reducing income inequality not only via its direct effect but also indirectly through boosting money demand and preserving the real value of fiscal transfers.

Using cross-country panel data, Li and Zou (2002) find that inflation deteriorates income distribution and economic growth. They also show that inflation increases the income share of the rich and insignificantly reduces the income shares of the middle class and the poor.

Albanesi (2007) provides cross-country evidence of positive correlation between inflation and income inequality. She also builds a political economy model in which income inequality is positively related to inflation in equilibrium because of a distributional conflict in the determination of fiscal and monetary policies. The model implies that in equilibrium low income households have more cash as a share of their total consumption, in line with empirical evidence (Erosa and Ventura, 2000). Therefore, low income households are more exposed to inflation. Particularly, Easterly and Fischer

(2001) bring empirical evidence, using data from 38 countries that the poor are more probably than the rich to indicate inflation as a top national concern. The model built by Albanesi (2007) also implies that households with more income have a greater power in the political process. As a result, for the government it is easier to finance its spending through positive seigniorage than via increased taxation, which requires parliamentary approval. Thus, according to Albanesi (2007), this leads to inflation in equilibrium and to its positive relation with income inequality.

Romer and Romer (1999) consider the influence of monetary policy on poverty and inequality in the short run and the long run. Using single equation time series evidence for the USA, they find that expansionary monetary policy is associated with better conditions for poor (decreased inequality) in the short run. On the contrary, examining the cross-section evidence from a large sample of countries, Romer and Romer (1999) show that tight monetary policy resulting in low inflation and stable aggregate demand growth are associated with the enhanced well-being of the poor (reduced inequality) in the long run.

Galli and von der Hoeven (2001) claim that there is a non-monotonic long run relationship between inflation and income inequality. Particularly, they argue that the relationship is U-shaped – inequality declines as inflation rises from low to moderate rates but inequality increases when inflation further grows from moderate to high levels. Their empirical analysis is implemented for the USA and a sample of 15 OECD countries.

Galbraith et al. (2007) show that in the USA, earnings inequality in manufacturing is influenced by monetary policy. The latter is captured by the yield curve measured as the difference between 30-day Treasury bill and 10-year bond rate. They find that the earnings inequality is directly influenced by monetary policy in addition to indirectly being affected by inflation and unemployment, and by recessions in general. In particular, Galbraith et al. (2007) indicate that tight monetary policy raises the inequality of earnings while expansionary monetary policy reduces it.

Coibion et al. (2012) find that monetary policy shocks account for a significant component of the historical variation in economic inequality in the USA. Their measures of economic inequality are based on the Consumer Expenditures Survey, which does not include the top one percent of the income distribution. They show that contractionary monetary policy raises inequality in labor earnings, total income, consumption, and total expenditures. In particular, the results show that the shock most significantly affects expenditure and consumption inequality. Coibion et al. (2012) also explores different channels through which monetary policy affects economic inequality.

For Korea, Kang et al. (2013) find that inflation improves economic inequality in the short run but it has no significant impact on inequality in the long run. They also show that GDP growth decreases economic inequality. Their results indicate that there is no significant relation between real interest rate and inequality though real interest rate and poverty are positively correlated.

Saiki and Frost (2014) provide evidence that unconventional monetary policy raises income inequality in Japan in the short run. In particular, they show that by increasing the monetary base, unconventional monetary policy widens income inequality through resulting higher asset prices, benefiting the rich who usually hold these equities and acquire capital gains. Saiki and Frost (2014) conclude that while unconventional monetary policy tends to help to overcome the global financial crisis, it could have a side effect in terms of increased income inequality.

Villarreal (2014) finds that contractionary monetary policy decreases income inequality in Mexico. He uses different identification schemes for monetary policy shocks. Generally, all his results indicate that an unanticipated increase in nominal interest rate reduces income inequality over the short run. Villarreal (2014) interprets the differences of his results for Mexico from the ones obtained by Coibion et al. (2012) for the USA by the existence of such a level of financial frictions in Mexico that the benefits of inflation stabilization are higher than its costs.

Nakajima (2015) claims that while monetary policy affects prices and real economic activity, it also has redistributive impact. In order to control for these main effects of monetary policy, the chapter includes prices and real GDP into the considered models. As a monetary policy tool, the federal funds rate is used. Besides, these three variables are commonly incorporated in monetary policy models (Bernanke and Mihov, 1998; Christiano et al., 1996; Peersman and Smets, 2001; Uhlig, 2005). To assess the distributional effect of monetary policy, a measure of income inequality is also included in the analysis.

Table 3.1: The Estimated Effects of Contractionary Monetary Policy on Economic Inequality in the Literature

Cross-Country Evidence	Time Series Evidence for a Country
- (66 countries; Romer and Romer, 1999) - (75 countries; Bulir, 2001) - (46 countries; Li and Zou, 2002) - (51 countries; Albanesi, 2007)	+ (USA; Romer and Romer, 1999) + (USA; Galbraith et al., 2007; Coibion et al., 2012)
	- (Japan; Saiki and Frost, 2014) - (Mexico; Villarreal, 2014)

The chapter aims to contribute to the existing literature. In particular, the chapter compliments the work by Coibon et al. (2012) in evaluating the distributive effect of monetary policy by considering the measure of income inequality when it includes the top one percent of income distribution. The results show that the choice of the inequality measure has substantial impact on the evaluation of the distributive effect of monetary policy.

3.3. Empirical Methodology

The examination of the distributional effects of monetary policy is implemented through multiple time series analysis. This analysis allows tackling the endogeneity problem among the variables and studying their interrelations. The considered vector autoregression of the order *p*, VAR(p), is the following[16]:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t, \qquad (3.1)$$

where y_t is the vector of endogenous variables, A_is are (4×4) coefficient matrices and $u_t = (u_{1t}, \cdots, u_{4t})'$ is an error term. It is assumed that the error term is a zero-mean independent white noise process with positive definite covariance matrix $E(u_t u_t^{'}) = \Sigma_u$. That is, error terms are independent stochastic vectors with $u_t \sim (0, \Sigma_u)$. In the specification of the model, the vector of endogenous variables y_t consists of real GDP, prices, the federal funds rate, and income inequality measure: $y_t = (Y_t, P_t, R_t, Z_t)'$.

For the cointegrated variables, the equivalent vector error correction model of order *p-1*, VECM(p-1), should be used:

$$\Delta y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{p-1} \Delta y_{t-(p-1)} + u_t \qquad (3.2)$$

whereΔy_t denotes the first order differences of y_t, $\Gamma_i = -\left(A_{i+1} + \cdots + A_p\right)$ for $i = 1, \dots, p-1$, $\Pi = -\left(I_k - A_1 - \cdots - A_p\right)$. The rank of $\Pi = \alpha\beta'$ equals to the number of cointegration relations (r). α and β are matrices of loading and cointegration parameters, respectively. The term $\alpha\beta' y_{t-1}$ is the long run part, and $\Gamma_j s$ $(j = 1, \dots, p-1)$ are short run parameters.

Analogously, it is possible from the parameters of VECM(p-1) to determine the coefficients of VAR(p):

$$A_1 = \Gamma_1 + \Pi + I_k,\ A_i = \Gamma_i - \Gamma_{i-1} \text{ for } i = 2, \dots, p-1;\ A_p = -\Gamma_{p-1}. \qquad (3.3)$$

[16] The notations are in line with the representations used by Lütkepohl (2005).

In both cases, deterministic terms could be included in the models as following:

$$y_t = \mu_t + x_t \tag{3.4}$$

where μ_t is a deterministic part and x_t is a stochastic process that can have a VAR or VECM representation. As a deterministic part could be such terms as a constant, a linear trend, or dummy variables.

Reduced-form disturbances are linear combinations of structural shocks:

$$u_t = B\varepsilon_t \tag{3.5}$$

where ε_t is a (4×1) vector of structural innovations and B is a (4×4) matrix of parameters. That is, $4^2 = 16$ parameters are required for identification. $\frac{4^2}{2} + \frac{4}{2} = 10$ restrictions are given by estimation. $\frac{4(4-1)}{2} = 6$ restrictions are necessary for just identification. There are different identification approaches that require out of sample information. The identification approaches used in the chapter are presented below.

One of the most commonly employed identification approaches is Cholesky decomposition. It imposes the following contemporaneous restrictions on the matrix B:

$$\begin{pmatrix} u_Y \\ u_P \\ u_R \\ u_Z \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 \\ b_{41} & b_{42} & b_{43} & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_Y \\ \varepsilon_P \\ \varepsilon_R \\ \varepsilon_Z \end{pmatrix} \tag{3.6}$$

Analogously, long run restrictions (Blanchard-Quah, 1989) on the following total impact matrix are also low-triangular:

$$\left(I_4 - A_1 - \cdots - A_p\right)^{-1} B \tag{3.7}$$

The zeros in these low-triangular matrices provide 6 required restrictions for just identification.

In the case of VECM, restrictions for identification are placed on the contemporaneous impact matrix and the long run impact matrix (Lütkepohl, 2005). There can be at most r shocks with zero long run impact (transitory effects) and at least *(4-r)* shocks with permanent effects. Contemporaneous and long restrictions for transitory and permanent shocks provide enough restrictions for just identification.

As shown in the next section, there is only one cointegration relation among the variables. Therefore, there is only one shock with transitory effects (Lütkepohl, 2005). Following Duarte and Marques (2009), it is assumed that prices have transitory effects on the other variables. That is, the elements of the column of price shocks in the long run impact matrix are zeros. Taking into account that the matrix is singular, it only counts for 3 independent restrictions. In addition, it is also assumed that income inequality and real GDP do not have permanent effects on monetary policy rule. For the final required restriction (6 in total), it is assumed that inequality does not contemporaneously affect prices. Thus, the restrictions placed on the contemporaneous impact matrix and the long run impact matrix are the following:

$$B = \begin{pmatrix} * & * & * & * \\ * & * & * & 0 \\ * & * & * & * \\ * & * & * & * \end{pmatrix} \quad and \quad \Xi B = \begin{pmatrix} * & 0 & * & * \\ * & 0 & * & * \\ 0 & 0 & * & 0 \\ * & 0 & * & * \end{pmatrix} \tag{3.8}$$

As a robustness check for these restrictions, another identification scenario is also considered in the empirical analysis. In order not to restrict long run effects of monetary policy and its channels on income inequality, it is now assumed that inequality has temporary impact on the other variables. Again, it is assumed that in the long run, the policy rule is solely driven by monetary policy shocks. In line with the previous identification restrictions, it is also assumed that prices do not have permanent impact on real output. Thus, no restriction is imposed on the contemporaneous impact matrix. Since there is only one shock with transitory effects that is not necessary (Lütkepohl, 2005).That is, only restrictions on the long run impact matrix are imposed:

$$B = \begin{pmatrix} * & * & * & * \\ * & * & * & * \\ * & * & * & * \\ * & * & * & * \end{pmatrix} \quad and \quad \Xi B = \begin{pmatrix} * & 0 & * & 0 \\ * & * & * & 0 \\ 0 & 0 & * & 0 \\ * & * & * & 0 \end{pmatrix} \tag{3.9}$$

3.4. Data

The empirical analysis is implemented for the USA. One of the major difficulties for empirical analyses of the distributional effects of monetary policy is the scarcity of the data on income inequality. Therefore, a lot of attention is paid in the chapter to the usage of consistently measured comparable data on income inequality. As an inequality measure, Gini coefficient is used since it provides the broadest coverage across time. The data source is the OECD. Gini coefficients are expressed in percent and they are for disposable income. The usage of Gini coefficients for disposable income (i.e., after taxes and transfers) allows controlling for the distributional effects of fiscal policy. The time series of Gini index is available only on the yearly frequency and, consequently, the series for the other variables are also considered on the annual basis.

Gini index for income inequality (GINI)[17] is measured for total population. In this respect, the chapter compliments the work by Coibon et al. (2012) in evaluating the distributive effects of monetary policy by considering the measure of income inequality when it includes the top one percent of income distribution. The results show that this augmentation of inequality measure has substantial impact on the evaluation of distributive monetary policy effects.

The definitions and the sources of the other variables are as following. The real GDP (GDP60)[18] is computed by using the data for nominal GDP and deflator from the World Bank, WB, and Federal Reserve Economic Database, FRED, respectively. For GDP deflator (GDPDX60) and CPI (CPIX60), base indices are used. The source for GDP deflator and CPI is FRED. The effective federal

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[17] In the parentheses, the abbreviated versions of the variables are mentioned in line with their usage in the empirical analysis.
[18] The number mentioned in the abbreviation is the last two digits of the base year.

funds rate (FFR) is computed as an annual average. It is expressed in percent, and its source is FRED.

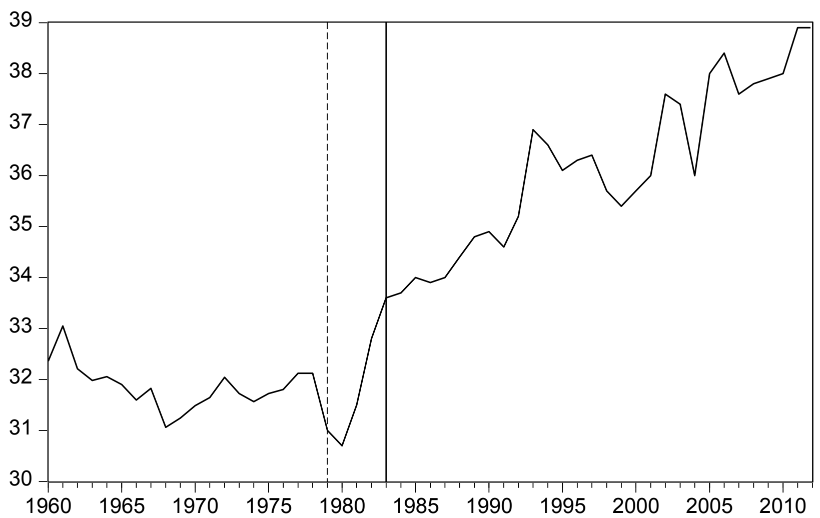
For the period from 1979 to 2012 (as it is available in the OECD database for the consistently measured index), the graphical representation of Gini coefficients is presented in Figure 3.1. Gini coefficients have an upward trend from around 1983. To present the dynamics of Gini coefficients before 1979, Gini coefficients from UNU-WIDER database are also employed from 1960 to 1978. To obtain a comparable series, Gini coefficients from UNU-WIDER database are adjusted towards the series from the OECD database. The adjustment is implemented based on the averages of the overlapping values of the series. That is, keeping the same dynamics of the series from UNU-WIDER, it is simply shifted towards the series from the OECD. The added values of the series of Gini coefficients are depicted in the same Figure 3.1. It is clearly observable a structural break in the series in around 1983.

The evolutions of the other variables are presented in Figures 3.2 to 3.5. There was a visible structural break in around 1983 in almost all the time series expect of the series for real GDP. Literature (e.g., Cutler and Katz, 1991; Galli and von der Hoeven, 2001) also states that there was a structural break in the relationship between income inequality and macroeconomic variables in the USA in around 1983. For actual estimations, the chapter uses the sample values for the period from 1983 to 2012. In addition, pre sample values (for the period 1981-1982, as it turns out during the analysis) are also used to preserve some degrees of freedom of the estimated models given the relatively short sample period. To observe the dynamics of the variables with respect to the beginning of the period, the base year for real GDP, CPI, and GDP deflator has been shifted to 1983.

Since during the period from 1983 to 2012, inflation in the USA was moderate, the relation between income inequality and inflation was probably linear. That is, that allows concentrating on the time dimension of the relationship between monetary policy and income inequality abstracting from the magnitude of the effect of inflation on inequality, which is claimed to be nonlinear along the levels of inflation by Galli and von der Hoeven (2001), and Bulir (2001). As a price index, GDP deflator is used in the empirical analysis because it measures the level of prices of all the goods and services produced in the economy. Nevertheless, the usage of CPI instead of GDP deflator would not make a significant difference since the both series are alike (Figures 3.3 and 3.4). In order to describe the general statistical characteristics of the variables used in the empirical analysis, they are presented in Table 3.2.

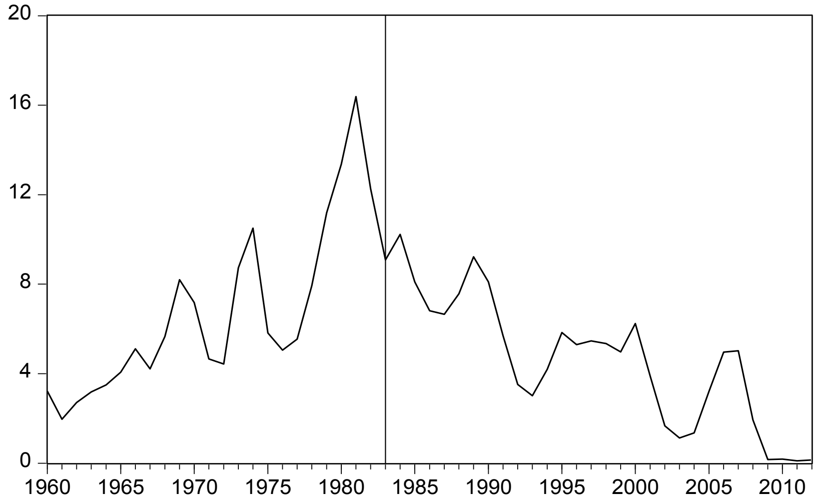
Thus, taking into account that the frequency of the data is yearly, the standard contemporaneous assumptions would be too strong. Therefore, the identification of a monetary policy shock is implemented by using the contemporaneous identification with ex-ante identified monetary policy shocks. In addition, a monetary policy shock is also identified by imposing long run restrictions. All these are discussed in detail in the next section.

Figure 3.1: Gini Coefficients (GINI)



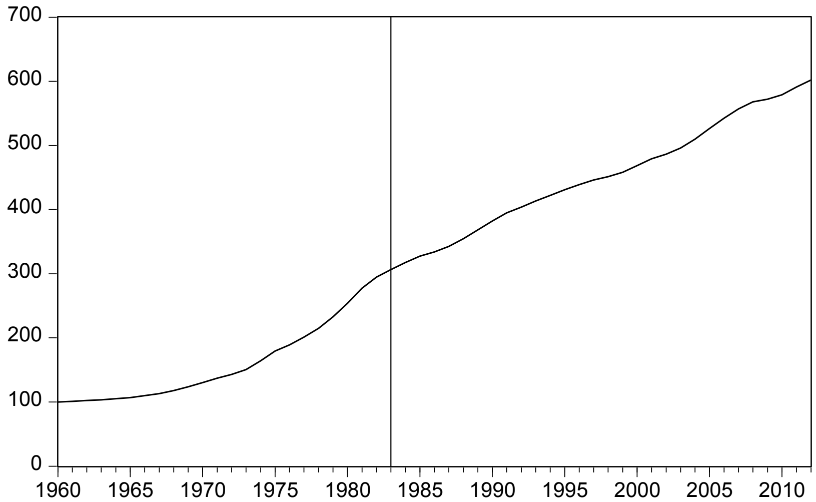
Note: The Gini coefficients are expressed in percent. They are for disposable income and total population.From 1960 to 1978, the data from UNU-WIDER are used and adjusted towards the series from the OECD for the period from 1979 to 2012.

Figure 3.2: The Effective Federal Funds Rate (FFR)



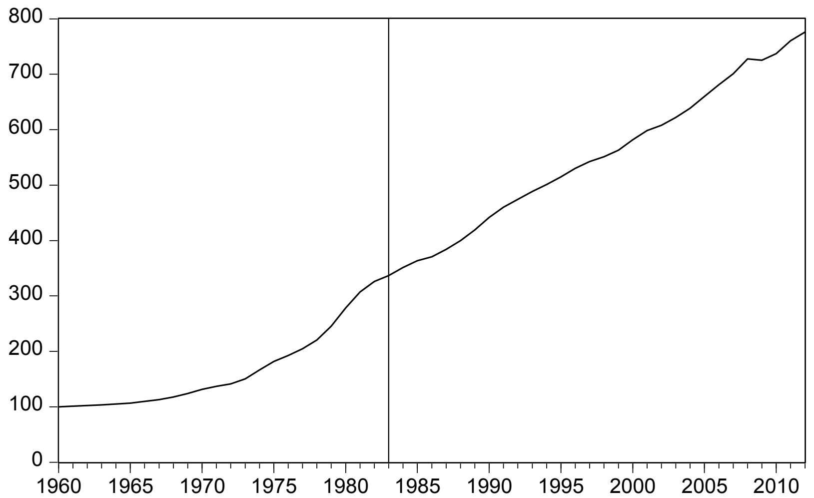
Note: The effective federal funds rate is computed as an annual average. It is expressed in percent, and its source is FRED.

Figure 3.3: GDP Deflator (GDPDX60)



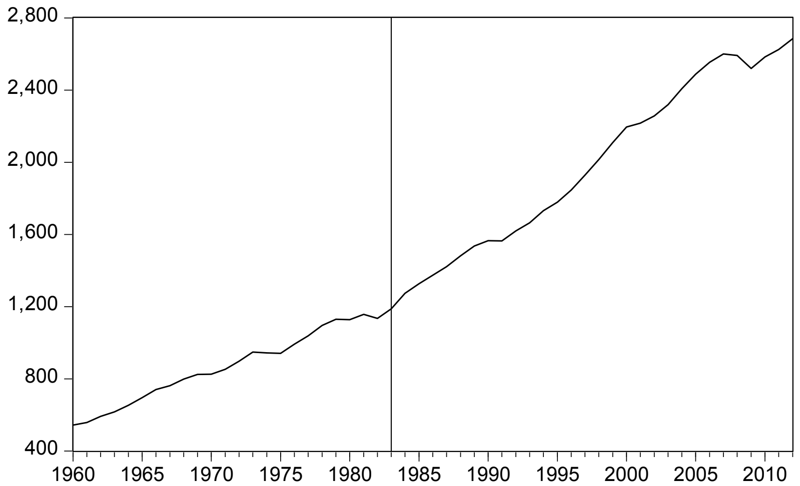
Note: The base year of the GDP deflator has been changed to 1960. The source for the initial data is FRED.

Figure 3.4: CPI (CPIX60)



Note: The base year of CPI has been shifted to 1960. The initial data are from FRED.

Figure 3.5: Real GDP (GDP60)



Note: The real GDP is in bln USD, and it is based on the prices of 1960. It is computed by using the data for nominal GDP and deflator from the WB and FRED, respectively.

Table 3.2: The Descriptive Statistics of the Variables, 1983-2012

Variables	Mean	Max.	Min.	SD
Real GDP (GDP83) (billions of USD, based on the prices of 1983)	6073.59	8227.14	3638.14	1482.36
Real GDP Growth (GRGDP) (annual percent change)	2.93	7.25	-2.77	1.86
GDP Deflator (GDPDX83) (annual average index, 1983=100)	147.63	196.46	100	28.99
GDP Deflator (GDPD) (annual percent change)	2.41	3.93	0.76	0.85
The Federal Funds Rate (FFR) (effective, annual average, in percent)	4.64	10.23	0.1	2.92
Gini Coefficient (GINI) (in percent)	36.16	38.9	33.6	1.63

3.5. Empirical Analysis

3.5.1. Cointegration Analysis

Natural logarithmic transformations are implemented for the variables: real GDP (GDP83L), GDP deflator (GDPDX83L) except for Gini coefficient (GINI) and the federal funds rate (FFR)[19]. Visual inspection of the time series shows that they have apparent trends and consequently, they cannot be stationary. The formal augmented Dickey-Fuller test (Dickey and Fuller, 1979) is implemented to check that and determine the orders of integration of the series. The test is carried out as for the levels of the variables as well as for their first differences[20]. The results are provided in Tables 3.3 and 3.4. The

[19] In the parentheses, the notations of the variables are mentioned as they are used in the empirical analysis. The letter L indicates the performed natural logarithmic transformation.
[20] Similar results are obtained by applying Phillips – Perron test (Phillips and Perron, 1988).

results of the augmented Dickey-Fuller test reveal that all the time series are not stationary[21] and that they are integrated of order one.

If the time series are cointegrated, they should be modeled through the error correction methodology or the corresponding VAR representation. Particularly, VECM will be employed if they are cointegrated because the chapter aims to explore the dynamic interactions among the variables. Johansen methodology (Johansen, 1995) is carried out in order to check whether the series are cointegrated. To implement the cointegration test, the order of VECM or the corresponding VAR model should be determined since they are equivalent representations if there are no restrictions imposed on the cointegration relation. The order of VECM is one less than the order of VAR model.

Since the considered sample is relatively short, the specification approach is to determine the most parsimonious model possible. The order of VAR/VECM is selected based on the statistical analysis of the residuals. That is, the order is specified in such a way that VAR/VECM provides an adequate representation of the underlying data generation process. Tests for residual autocorrelation, non-normality, conditional heteroskedasticity, and stability are performed. Based on the results of these tests, VAR(2) (or, equivalently VECM(1)) is specified. For the cointegration test, it is also necessary to specify the deterministic terms to be included in the model. Since the series have trending behavior, all the most common cases of the deterministic terms are considered. Taking into account that in comparison to the maximum eigenvalue test, the trace test sometimes has more distorted sizes in small samples (Lütkepohl, 2005), the former is implemented as a cointegration test (Johansen, 1995). The results are presented in Table 3.5.

[21] Even if one or couple of the variables were initially stationary, the cointegration relation among the all variables could still hold within the more general definition of cointegration specified by Lütkepohl (2005).

Table 3.3: The Augmented Dickey-Fuller Test for the Levels of the Variables

Variables	Det. Terms	Lags	Test Values	Critical Values 1%	5%	10%	P-Values
GDP83L	c, t	1	-1.67	-4.30	-3.57	-3.22	0.74
GDPDX83L	c	2	-1.98	-3.68	-2.97	-2.62	0.29
FFR	c	2	-1.47	-3.68	-2.97	-2.62	0.53
GINI	c	2	-1.06	-3.68	-2.97	-2.62	0.72

Note: Deterministic terms (c-constant and t-trend) are chosen according to the dynamics of the series. The order of the lagged differences is selected based on Schwarz information criterion.

Table 3.4: The Augmented Dickey-Fuller Test for the First Differences of the Variables

Variables	Det. Terms	Lags	Test Values	Critical Values 1%	5%	10%	P-Values
GDP83L	c	0	-4.20	-3.67	-2.96	-2.62	0.00
GDPDX83L	none	0	-2.47	-2.64	-1.95	-1.61	0.01
FFR	none	1	-4.91	-2.65	-1.95	-1.61	0.00
GINI	none	1	-5.89	-2.65	-1.95	-1.61	0.00

Note: The inclusion of the deterministic term (c-constant) is associated with the dynamics of the series. The order of the lagged differences is selected based on Schwarz information criterion.

Table 3.5: Johansen Cointegration Maximum Eigenvalue Test

Hypothesized No. of CEs	Det. Terms	Lags	Eigen-values	Test Values	5% Critical Values	P-Values
None*	c in CE	1	0.73	38.97	28.59	0.00
At most 1			0.49	20.18	22.30	0.10
At most 2			0.35	12.75	15.89	0.15
At most 3			0.16	4.38	9.16	0.36
None*	c in CE and in VAR	1	0.72	38.41	27.58	0.00
At most 1			0.43	16.94	21.13	0.17
At most 2			0.30	10.73	14.26	0.17
At most 3			0.11	3.57	3.84	0.06
None*	c, t in CE and c in VAR	1	0.73	39.31	32.12	0.01
At most 1			0.49	19.98	25.82	0.24
At most 2			0.35	12.80	19.39	0.34
At most 3			0.11	3.59	12.52	0.80

Note: The following abbreviations are used: CE-cointegrating equation, c-constant, t-linear trend.

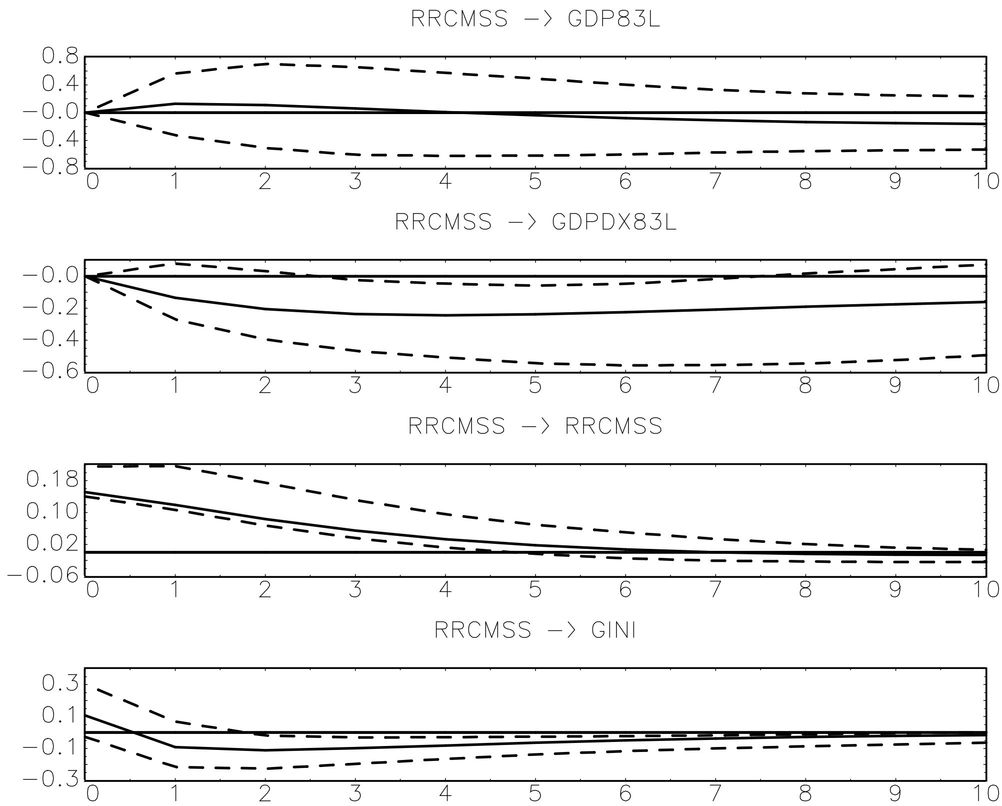
All the results of the cointegration tests with different deterministic terms indicate that the time series are cointegrated, and there is one cointegrating relation among them. Based on the statistical features, a constant is considered in models as a deterministic term. It is included in the cointegration equation of VECM or VAR, which are the benchmark models of the chapter. For modeling the relations among the variables, VECM methodology is employed by applying Johansen´s maximum likelihood (ML) approach (Johansen, 1995). Alternatively, the corresponding VAR model in levels is also used with ordinary least squares (OLS) estimations. As an empirical tool to explore the dynamic interactions among the variables, impulse response functions of the considered models are examined. In the chapter, the provided impulse response functions (IRFs) are for the responses of variables to one standard deviation increase in the shock of the considered variable. In particular, the IRFs of contractionary monetary policy shocks are considered. Hall´s (1992) 95% confidence bands based on 3000 bootstrap replications are provided for the IRFs. For the representation of the IRFs, solid lines are used while, for the demonstration of the confidence bands, dotted lines are drawn.

3.5.2. Contemporaneous Identification

The standard identification approach in the literature is Cholesky identification for VAR models. So, the empirical analysis is initially carried out using this identification procedure. It is necessary to impose contemporaneous restrictions discussed in Section 3.3in order to implement that identification scheme. Taking into account that the yearly data are used in the analysis, the contemporaneous assumption that a monetary policy shock does not affect output and prices within a year is very strong in this case. Therefore, Cholesky identification is used with the exogenous monetary policy shocks proposed by Romer and Romer (2004).The series for these monetary policy shocks have been updated by Coibion et al. (2012) and they are used in the estimation of the IRFs. For the usage in the current analysis, they have been averaged across years. Then, following Coibion et al. (2012), they have been accumulated (RRCMSS) and placed instead of the federal funds rate in the VAR model estimated with a yearly lag.

The IRFs derived using the exogenous monetary policy shocks are provided in Figure 3.6. As can be seen, a contractionary monetary policy shock insignificantly increases income inequality on impact. However, the shock then gradually decreases inequality significantly up to around 0.1 percentage points in a period and it generally stays at that level for several years until the effect fades away. The monetary policy shock also reduces prices while its effect on real output is not significant. Thus, contractionary monetary policy decreases income inequality similar to the estimated IRFs by Villarreal (2014) for Mexico and on the contrary to the results obtained by Coibion et al. (2012) for the USA. As it will be shown in the next chapter, this distributive effect of monetary policy is preserved when the quarterly data are also used as in Coibion et al. (2012). Therefore, the differences in the obtained results lie in the data source and the measure of income inequality used in the empirical analysis. In the current work, the measure of inequality represents the whole distribution of income. Coibion et al. (2012) employ inequality measures that do not cover the top one percent of income distribution, which has substantially influenced the dynamics of income inequality in the USA over the considered period (Congressional Budget Office, 2011).

Figure 3.6: Contemp. Identification with Exogenous Monetary Policy Shocks

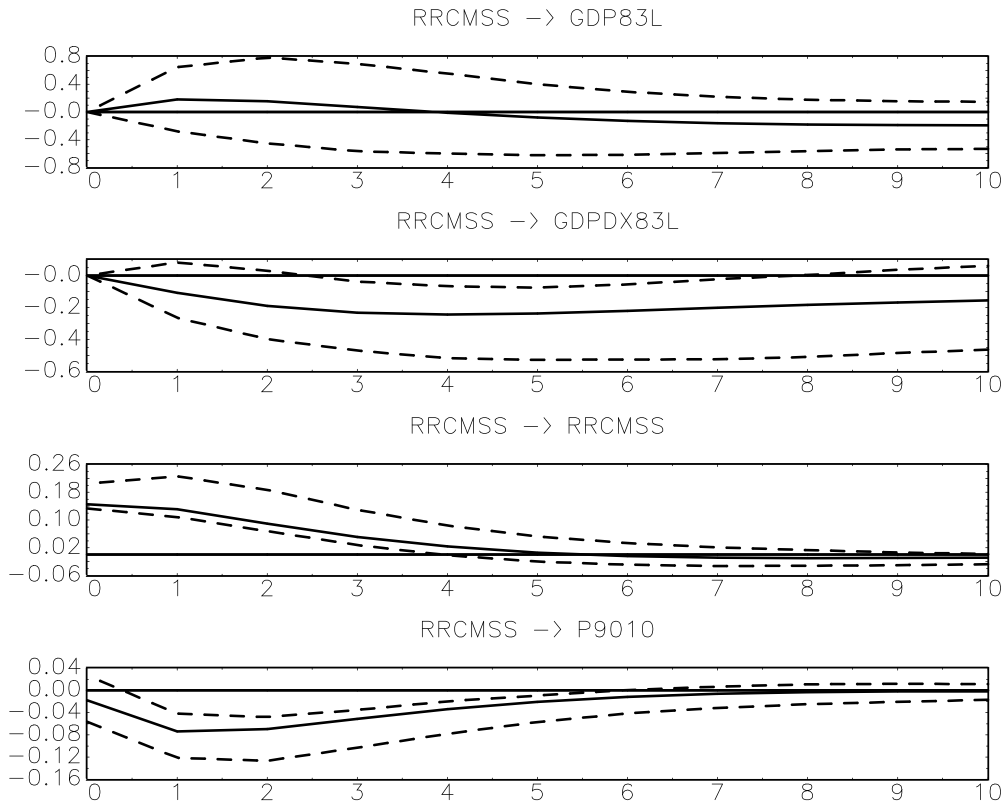


As another measure of income inequality, the ratio between the 90th percentile and the 10th percentile (thereafter, it is referred as the 90-10 ratio) is considered from the report by DeNavas-Walt and Proctor (2015). This percentile ratio is based on the data from the Current Population Survey (CPS) of the U.S. Census Bureau. It is a household survey which includes the resident civilian noninstitutionalized population of the USA. Besides, this inequality measure is based on income before taxes and it does not include noncash benefits (DeNavas-Walt and Proctor, 2015). However, the inequality measure could still be helpful in assessing the distributive effect of monetary policy and in performing a robustness check of the results.

In the considered VAR model for the contemporaneous identification, Gini index has been replaced by the 90-10 ratio (P9010). The resulting IRFs are presented in Figure 3.7. As can be observed from the obtained results, a contractionary monetary policy shock reduces inequality measured by the 90-10 ratio throughout the considered periods. The impact reaches its lowest point of the around 0.08 units decrease in the 90-10 ratio by the first period. The responses of the other variables to the monetary policy shock exhibit very similar behavior with the results provided in the previous case. Thus, the results are robust with regard to the usage of different inequality measures.

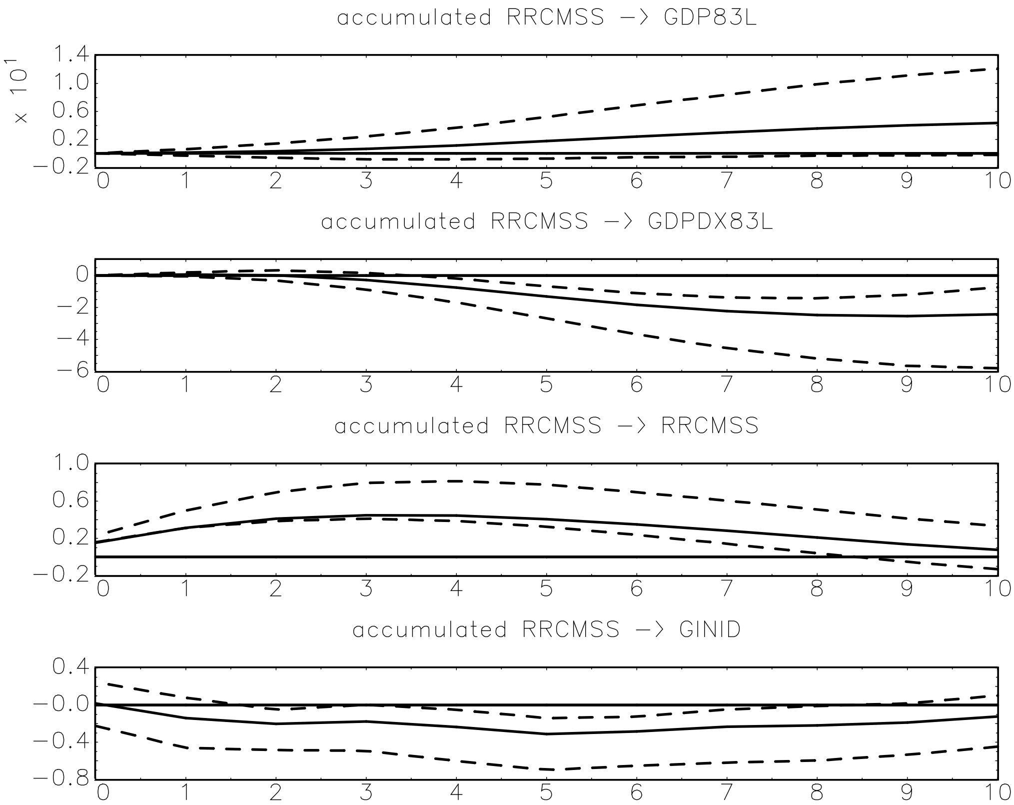
Before continuing the empirical analysis with the long run identification, the existence of the long run distributive effect of monetary policy is examined within the framework of the contemporaneous identification. This examination is implemented by following Born et al. (2015) and by considering the VAR model with Gini index in the first differences (calculated for the whole sample, GINID) and with the other variables in levels. Then, the total effect of monetary policy on inequality is checked for the significance based on the VAR of order two as specified in the previous subsection. This identification approach is line with the method proposed by Blanchard and Quah (1989).

Figure 3.7: Contemporaneous Identification with Exogenous Monetary Policy Shocks (Gini Index is Replaced by the 90-10 Ratio)



The IRFs are accumulated and they are depicted in Figure 3.8. It can be seen that after a contractionary monetary policy shock, the accumulated changes in Gini index decrease up to 0.2 percentage points. Besides, the total distributive effect of monetary policy is generally significant. That is, monetary policy has a long run effect on income inequality and it is thoroughly examined in the next subsection. The responses of the other variables are consistent with the corresponding results of the previous estimations of the IRFs.

Figure 3.8: Contemporaneous Identification with Exogenous Monetary Policy Shocks (Gini Index is in the First Differences)

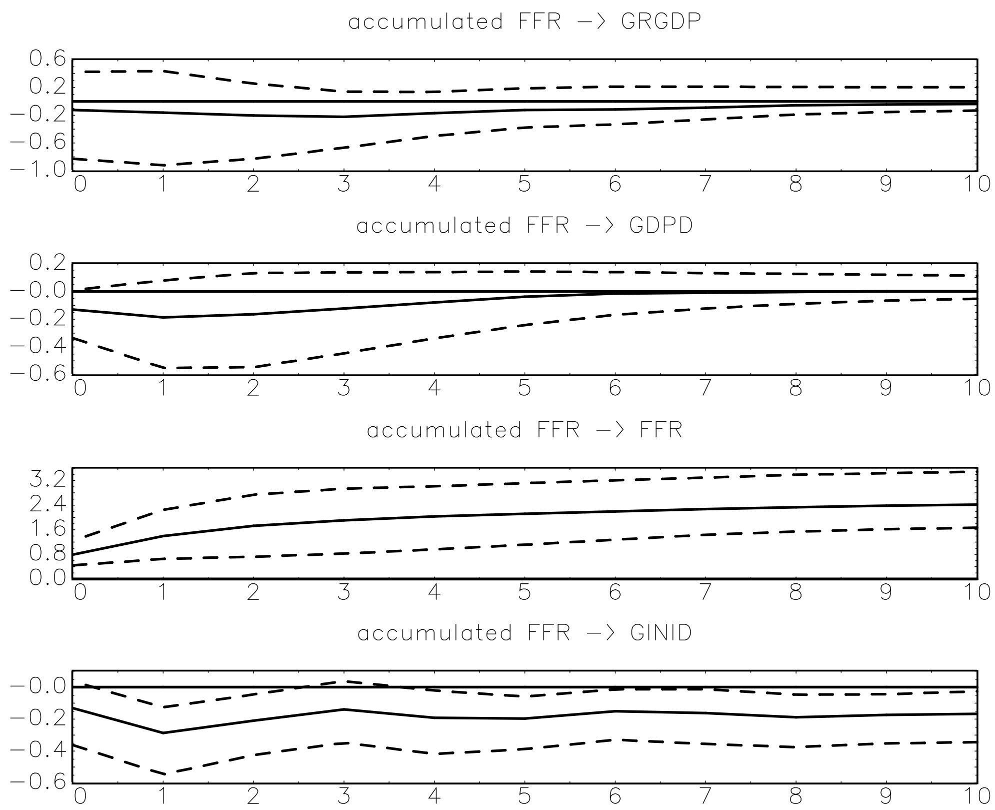


3.5.3. Long Run Identification

After revealing a long run relation between monetary policy and income inequality, the distributive effect of monetary policy is studied by the long run identification methods commonly used in the literature. First, the identification approach proposed by Blanchard and Quah (1989) is directly implemented in order to evaluate the distributive impact of contractionary monetary policy. Analogously with their approach, the VAR model is considered with real GDP growth (GRGDP), GDP deflator inflation (GDPD), the federal funds rate (FFR), and with the first order difference of Gini index (GINID). The VAR model is of the second order as in the benchmark case.

According to the identification method by Blanchard and Quah (1989), long run restrictions are imposed on the total impact matrix as discussed in Section 3.3.The accumulated IRFs are provided in Figure 3.9. As in the case with the usage of exogenous monetary policy shocks, the accumulated changes in Gini index decrease to around 0.2 percentage points after a contractionary monetary policy shock. The accumulated response of real GDP growth is insignificant as the response of real GDP in Figure 3.8. Though GDP deflator decreases following the contractionary monetary policy shock, the impact is not significant as in the case of the response of prices in Figure 3.8. However, compared to the results presented in Figure 3.8, the application of this identification method provides a very similar distributive effect of monetary policy, which is the focus of the current study.

Figure 3.9: Long Run Identification by Blanchard-Quah Method

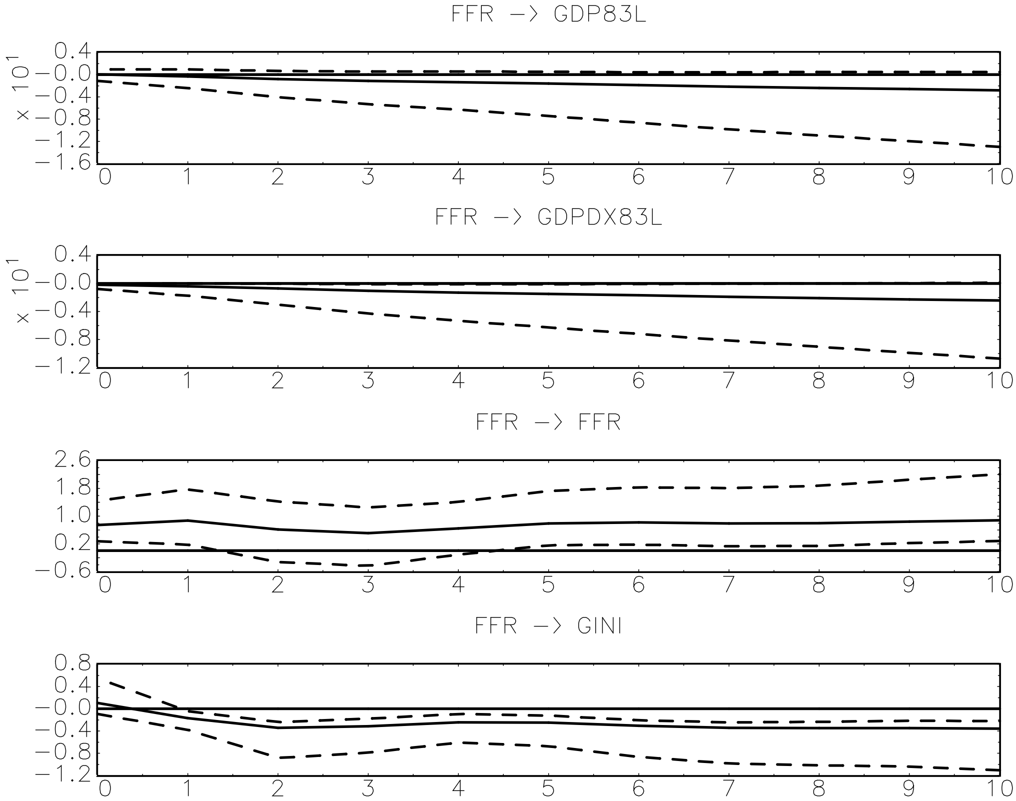


Since there is a cointegration relation among real GDP, prices, the federal funds rate, and Gini index, the IRFs can also be identified through the VECM methodology. As discussed in Section 3.5.1, the VECM of order one is specified with a constant included into the cointegration equation. They are identified by imposing restrictions on the contemporaneous impact matrix and the long run impact matrix as described in (3.8) of Section 3.3. The corresponding IRFs are presented in Figure 3.10. The impact of contractionary monetary policy shock is significant after one period when it reduces inequality by around 0.1 percentage points. Later, tight monetary policy decreases inequality by nearly 0.4 percentage points. Here the distributive impact of monetary policy is stronger than in the previous cases. After a contractionary monetary policy shock, the responses of prices and the federal funds rate are generally similar to the former results whereas real GDP significantly decreases following monetary policy tightening.

As a robustness check for the VECM identification, another set of restrictions is also imposed within this framework. As presented in (3.9) of Section 3.3, no contemporaneous and long run restrictions are imposed on the impact of monetary policy and its channels on income inequality. The resulting IRFs are depicted in Figure 3.11. Comparing them with the results presented in Figure 3.10, it can be observed that the IRFs to a monetary policy shock are actually identical in the both cases. In particular, a contractionary monetary policy shock decreases Gini index of income inequality up to around 0.4 percentage points.

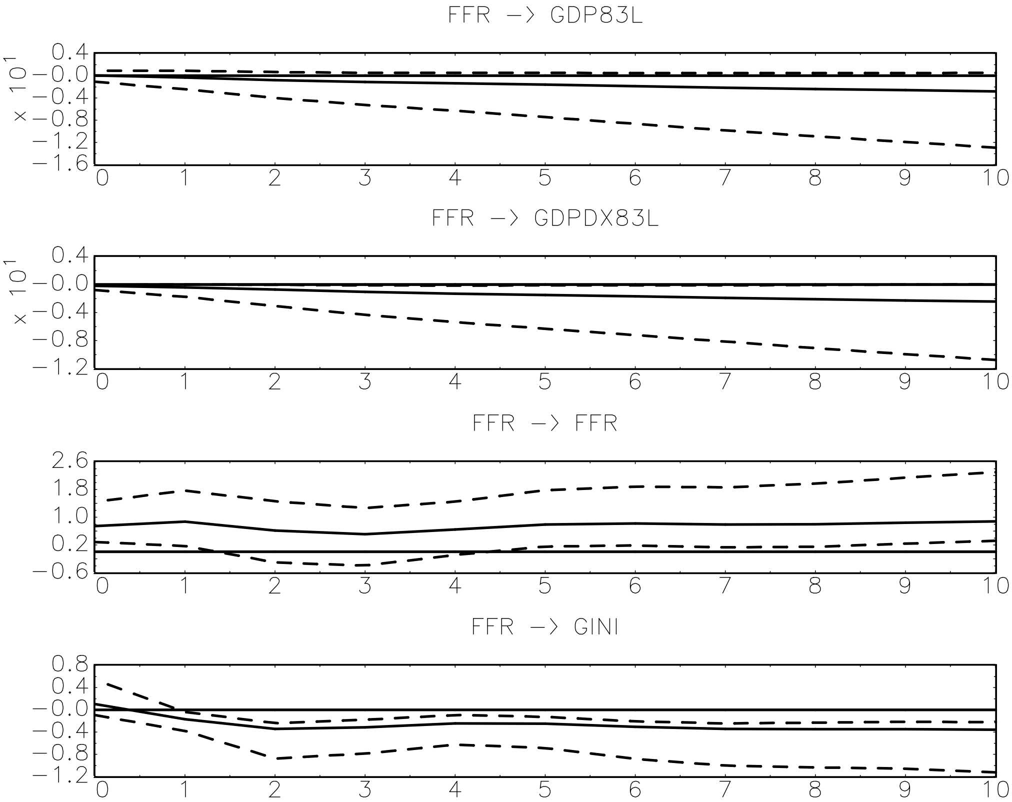
In order to check the robustness of the results with respect to the estimation sample, the recent period when the federal funds rate reaches the zero lower bound is excluded from the sample. The VECM and the corresponding IRFs are re-estimated for this sample period until 2008 as in the case of the contemporaneous identification. The IRFs are identified by using the both sets of the restrictions of (3.8) and (3.9). The resulting IRFs are provided in Figures A3.1 and A3.2 in Appendix 3.1. As can be seen, the obtained results are generally very similar to the IRFs from Figures 3.10 and 3.11. Again, the estimated IRFs from the both identification schemes are almost identical. In this case of the shorter estimation sample, the responses of real output and prices to a monetary policy shock are just less significant. However, a contractionary monetary policy shock still significantly decreases Gini index of income inequality up to around 0.4 percentage points.

Figure 3.10: Long Run Identification by Applying VECM Methodology (Prices are Considered to Have Transitory Effects)



Thus, in the all cases of the identification of a monetary policy shock, income inequality decreases following a tightening of monetary policy. This distributive effect of monetary policy is more pronounced in the case of long run identification with the VECM methodology, which is the benchmark analysis of this study. Gini index decreases up to around 0.4 percentage point after a contractionary monetary policy shock of one standard deviation. In addition, in the case of this identification, the responses of the other variables are better matched with theoretical implications and they are also significant.

Figure 3.11: Long Run Identification by Applying VECM Methodology (Income Inequality is Considered to Have Transitory Effects)



3.6. Conclusion

The empirical analysis is implemented in accordance with the objective of the chapter to evaluate the distributional effect of monetary policy. For the evaluation, the time series analysis for the USA is implemented using annual data. The inequality measure used in the chapter represents the whole distribution of income. The study period covers the time span after the structural break in the relationship between income inequality and the macroeconomics variables that occurred in around 1983.For the period after the structural break, a comprehensive cointegration analysis is carried out. The analysis determines a cointegration relation among real output, prices, the federal funds rate, and Gini index of income inequality. Therefore, the time series are modeled through the VECM and the equivalent VAR representation.

Different approaches are employed to identify a monetary policy shock and to analyze its impact on income inequality through the IRFs. First, exogenous monetary policy shocks (Romer and Romer, 2004; Coibion et al., 2012) are employed within the scheme of contemporaneous identification. Then, a long run identification approach proposed by Blanchard and Quah (1989) is applied in the analysis. The IRFs identified via these schemes show that contractionary monetary policy reduces income inequality, which is measured by Gini index and the 90-10 percentile ratio. Finally, taking advantage of the existence of the cointegration relation among the variables, the identification is implemented through the VECM framework. The obtained results indicate that a contractionary monetary policy shock decreases Gini index of income inequality up to 0.4 percentage points. Thus, the overall income inequality in the country could be reduced by implementing contractionary monetary policy and it might be considered as another effective policy instrument to decrease inequality.

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Appendix 3.1: The IRFs Estimated by the VECM Identification in the Case of the Reduced Sample

Figure A3.1: Long Run Identification by Applying VECM Methodology (Prices are Considered to Have Transitory Effects); Reduced Sample

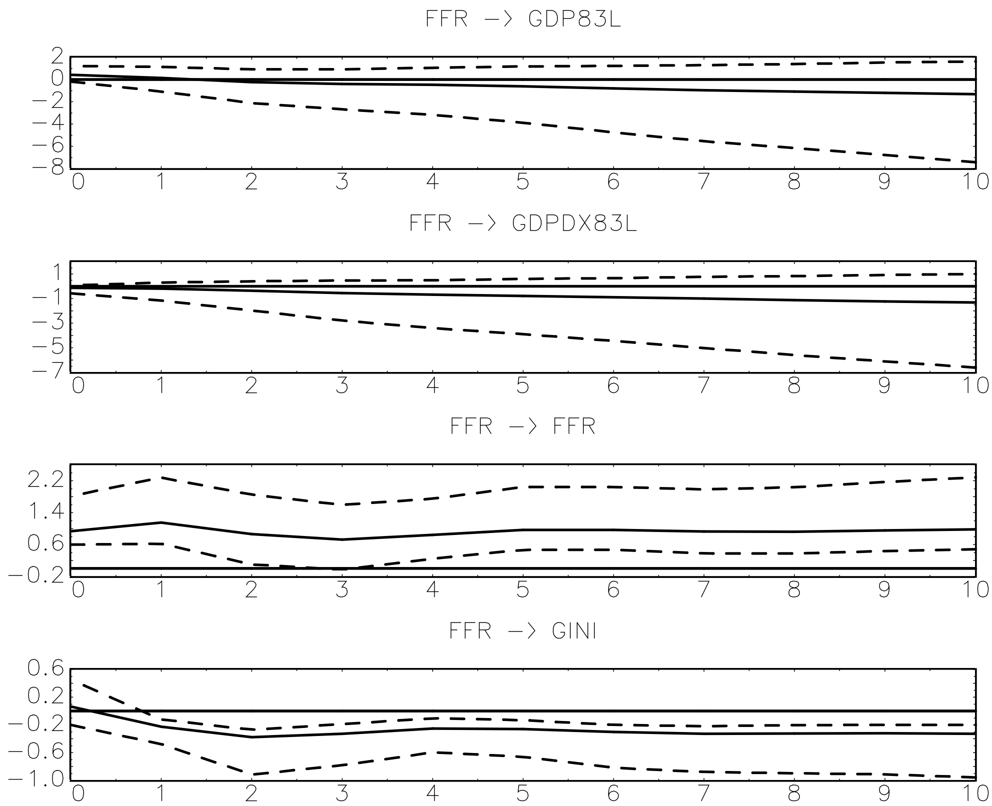
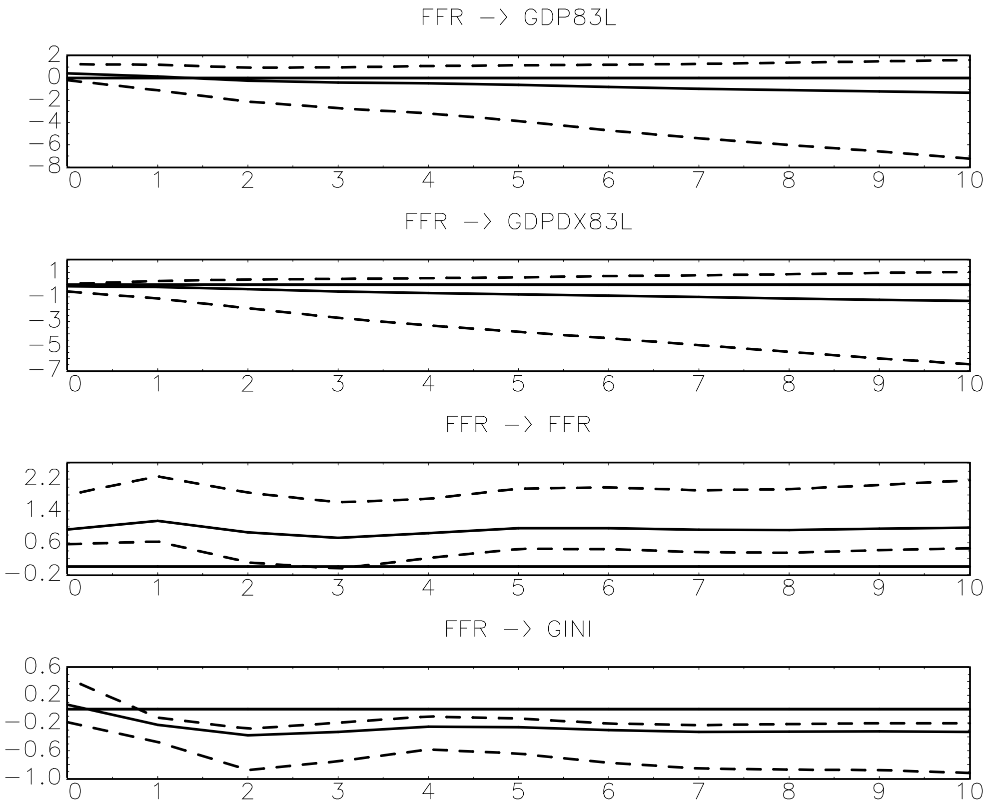


Figure A3.2: Long Run Identification by Applying VECM Methodology (Income Inequality is Considered to Have Transitory Effects); Reduced Sample



Chapter 4: The Distributive Effects of Conventional and Unconventional Monetary Policies

4.1. Introduction

To respond to the global financial crisis, central banks have generally started to conduct unconventional monetary policies in parallel with conventional policy measures. Consequently, unconventional monetary policy measures are currently taken to ease financial conditions by providing external funding. While there are already available studies on the macroeconomic impact of unconventional monetary policy (e.g., Baumeister and Benati, 2013; Chung et al., 2012; Gambacorta et al., 2014; Lenza et al., 2010), its distributive effect has not been essentially explored yet. The objective of the chapter is to fill this gap by evaluating the distributive impact of unconventional monetary policy in comparison with the distributional effect of conventional monetary policy.

In response to the global financial crisis, many central banks have substantially lowered their policy rates. To improve deteriorated economic conditions, they have also resorted to unconventional monetary policy instruments when their monetary policy rates have hit the effective zero lower bound. In particular, as unconventional monetary policy measures, the large scale asset purchases have been implemented by the Federal Reserve since the financial crisis (Baumeister and Benati, 2013). These operations have changed the relative supply of short term and long term bonds, and other assets, consequently affecting their prices and the flow of funds in the economy. This can benefit high-income households who hold these bonds and assets. Thus, unconventional monetary policy might also influence the income distribution in the economy.

The main objective of unconventional monetary policy measures is to lower long term interest rates in order to support private borrowing of households and businesses, thereby fostering aggregate demand and real economic activity. This can be beneficial for households who mainly rely on labor income, which might be adversely affected during the crisis. Labor earnings are the primary source of income for the most of households, and these earnings are mostly exposed to recessions (Coibion et al., 2012).

Thus, the implementation of unconventional monetary policy can facilitate to overcome the recent financial crisis. At the same time, it might also affect income distribution. On the one hand, unconventional monetary policy might increase the financial and the businesses income of high-income households. On the other hand, it could also restore labor earnings for low-income households. As a result, unconventional monetary policy might affect income inequality. The overall distributional impact of unconventional monetary policy is studied in the chapter in comparison with the distributive effect of conventional monetary policy.

The chapter evaluates the distributional effects of conventional and unconventional monetary policies for the USA. The distributional effects are evaluated for the general impact on the income distribution, using Gini index. The chapter also assesses the effects of conventional and unconventional monetary policies on the different parts of income distribution, employing corresponding percentile ratios. The obtained results show that contractionary conventional monetary policy reduces income inequality while expansionary unconventional monetary policy raises it. In particular, the results indicate that the distributional impact of conventional monetary policy is stronger. Nevertheless, its impact on the lower part of income distribution is not significant while unconventional monetary policy has a significant effect on it. In addition, the variance decomposition analysis reveals that unconventional monetary policy explains the higher share of the variation in Gini index of income inequality.

The rest of the chapter is organized as follows. Section 4.2 discusses the distributive channels of monetary policy. Section 4.3 presents the empirical methodology while Section 4.4 describes the data. Section 4.5 provides the obtained results and Section 4.6 includes the concluding remarks.

4.2. The Distributive Channels of Monetary Policy

The overall distributive impact of monetary policy depends on the different channels through which monetary policy can affect income inequality. Coibion et al. (2012) classify five such channels, which are also considered by other authors (e.g., Saiki and Frost, 2014). These channels are the following:

1. The *income composition channel* refers to the heterogeneity in primary sources of income across households. Many households depend mainly on wages whereas others acquire their income from business and financial gains. So, if expansionary monetary policy increase profits more than labor earnings, the owners of assets and firms benefit more. Taking into account that they are usually wealthier, expansionary monetary policy shocks might lead to higher income inequality via this channel.

2. The *financial segmentation channel* implies the reallocation of income towards the agents involved in financial markets who can benefit from expansionary monetary policy shocks. Considering the fact that these agents generally earn more income than the agents not engaged in financial markets, expansionary monetary policy would raise inequality through this channel.

3. The redistribution of income based on the structure of owned assets is represented by the *portfolio channel*. Normally, low income households have mainly currency whereas upper income households tend to possess various securities. Therefore, by causing inflation and financial market booms, expansionary monetary policy would harm low income households and benefit upper income households via this channel, leading to the increase in inequality.

4. The impact of unexpected inflation on nominal contracts is expressed by *the savings redistribution channel*. The unexpected increase in inflation would benefit borrowers and would hurt savers. Considering that usually savers are wealthier than borrowers, expansionary monetary policy shocks would reduce inequality through this channel.

5. The *earnings heterogeneity channel* describes the tendency that the labor income of the poorest population is mostly exposed to business cycle fluctuations. At the same time, low income households usually receive a bigger share of their income from government transfers than other households do. Since government transfers are normally countercyclical, expansionary monetary policy might decrease income inequality via this channel.

Thus, through these channels monetary policy could have different distributional effects. Supposedly, through the first three channels, expansionary monetary policy increases income inequality and reduces it via the last two channels. Nevertheless, the channels can operate with different intensity with conventional and unconventional monetary policies. That is, conventional and unconventional monetary policies could have disproportionate effects on these channels. Moreover, the magnitude of their impact through these channels might be different, too, and, consequently, they can have different overall distributive effects. However, the objective of the chapter is not to assess the relative contribution of each channel but to evaluate the overall effect of all the channels.

Talking into account that monetary policy affects as prices as well as real economic activity[22], Nakajima (2015) specifies two general distributive channels of monetary policy: inflation and income channels. They incorporate the channels specified by Coibion et al. (2012). Inflation channel contains the financial segmentation channel, the portfolio composition channel, and the savings redistribution channel. Income channel includes the income composition channel and the earnings heterogeneity channel. Considering these aggregated channels, the chapter uses prices and real GDP as the general distributive channels of monetary policy[23]. It employs the federal funds rate as a conventional monetary policy tool. Federal Reserve assets are used as an unconventional monetary policy instrument. An income inequality measure is also considered in order to assess the overall distributive effects of conventional and unconventional monetary policies.

[22] The mandate of the Federal Reserve includes the promotion of maximum employment.
[23] The considerations of the variables for the empirical analysis are analogous to Chapter 3.

4.3. Empirical Methodology

The chapter considers structural vector autoregression (VAR) models for the analysis of the distributive effects of conventional and unconventional monetary policies. The distributive impact of monetary policy is evaluated through structural VAR models as it is commonly implemented in the related literature (among others, Bernanke and Mihov, 1998; Christiano et al., 1996; Gambacorta et al., 2014; Uhlig, 2005) since the publication of the seminal paper by Sims (1980). The considered baseline VAR model of order p, VAR(p), is the following[24]:

$$y_t = A_0 + A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t, \quad (4.1)$$

Where $y_t = (y_{1t}, \cdots, y_{4t})'$ is the vector of endogenous variables, which are described below; A_0 is (4×1)vector of intercepts terms; $A_j s\ (for\ j = 1, \ldots, p)$ are (4×4) coefficient matrices and $u_t = (u_{1t}, \cdots, u_{4t})'$ is an error term. The error termu_t is assumed to be a zero-mean independent white noise process with positive definite covariance matrix $E(u_t u_t^{'}) = \Sigma_u$. Thus, it is assumed that error terms are independent stochastic vectors with $u_t \sim (0, \Sigma_u)$.

The vector of endogenous variables $y_t$generally consists of real GDP, prices, a monetary policy instrument, and an income inequality measure: $y_t = (Y_t, P_t, S_t, Z_t)'$. In the baseline cases for the evaluations of the distributive effects of conventional and unconventional monetary policies, the chapter commonly uses real GDP, prices, and Gini index of income inequality. The baseline cases only diverge by the usage of different monetary policy instruments. The federal funds rate and Federal Reserve assets are used as monetary policy instruments for the baseline models of conventional and unconventional monetary policies, respectively.

In general, reduced-form disturbances are linear combinations of underlying structural shocks:

$$u_t = B\varepsilon_t, \quad (4.2)$$

[24] The notations of the section are generally in line with the representations used by Lütkepohl (2005).

where B is a (4×4) matrix of parameters andε_t is a (4×1) vector of structural shocks. Consequently, 6 restrictions are necessary for just identification. In the empirical analysis, Cholesky decomposition of the covariance matrix is used for the identification of impulse response functions (IRFs). The ordering of the variables in the VAR model is the same as presented above: $y_t = (Y_t, P_t, S_t, Z_t)'$. Accordingly, the following contemporaneous restrictions are imposed on the matrix B:

$$\begin{pmatrix} u_Y \\ u_P \\ u_S \\ u_Z \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 \\ b_{41} & b_{42} & b_{43} & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_Y \\ \varepsilon_P \\ \varepsilon_S \\ \varepsilon_Z \end{pmatrix} \tag{4.3}$$

In this low-triangular matrix, the zeros provide 6 required restrictions for just identification of the structural shocks to analyze them through the impulse response functions (IRFs). The application of high frequency data in this chapter makes the assumptions behind by the contemporaneous scheme more realistic. Therefore, in the current case, monetary policy shocks are identified directly within the framework of this contemporaneous identification.

Along with the IRFs, the variance decomposition analysis is also implemented for structural VAR models. In the current work, this analysis is also carried out since it is very useful for the objective of the chapter to evaluate the distributive effects of conventional and unconventional monetary policies. The variance decomposition analysis is based on Cholesky decomposition of the covariance matrix as described above. This analysis allows decomposing the total variance of a time series into the percentages attributable to structural shocks, which are orthogonal and have unit variances. The VAR model can be expressed through structural shocks using the vector moving average representation:

$$y_t = A_0 + F(L)\varepsilon_t, \tag{4.4}$$

where $F(l)$ is a polynomial in lag operators. The variance of y_{it} $(for\ i = 1, \dots, 4)$ is given by

$$Var(y_{it}) = \sum_{k=1}^{4}\sum_{j=0}^{\infty} F_{ik}^{j^2}\, Var(\varepsilon_{kt}) = \sum_{k=1}^{4}\sum_{j=0}^{\infty} F_{ik}^{j^2}, \tag{4.5}$$

where $\sum_{j=0}^{\infty} F_{ik}^{j^2}$ is the variance of y_{it} generated by the kth shock. This implies that

$$\frac{\sum_{j=0}^{\infty} F_{ik}^{j^2}}{\sum_{k=1}^{4}\sum_{j=0}^{\infty} F_{ik}^{j^2}} \tag{4.6}$$

is the percentage of the variance of y_{it} explained by the kth shock. It is also possible to study the variance of a variable explained by a structural shock at a given horizon. The percentage of the variance of y_{it} due to the kth shock at horizon h is given by

$$\frac{\sum_{j=0}^{h-1} F_{ik}^{j^2}}{\sum_{k=1}^{4}\sum_{j=0}^{h-1} F_{ik}^{j^2}} \tag{4.7}$$

Thus, the variance decomposition analysis enables decomposing the total variance of a time series into the percentages attributable to each structural shock.

4.4. Data

4.4.1. The Description of the Dataset

The empirical analysis is implemented for the USA. The general estimation sample is from 1983 to 2013. The sample is considered from 1983 because of the structural break occurred in the relationship between income inequality and the macroeconomics variables in around this period (Chapter 3). The sample runs until 2013 because the data on income inequality are only available until that year. Considering that the federal funds rate has reached the zero lower bound since 2009, the estimation sample for the conventional monetary policy models is from 1983 to 2008. The data on the quarterly frequency are used in line with the related literature (e.g., Christiano et al., 1996; Peersman and

Smets, 2001). In the case of the unconventional monetary policy models, the estimation sample is from 2009 to 2013. Following Gambacorta et al (2014), the data on the monthly frequency are used in this case.

In the baseline models, Gini index is used as an income inequality measure. The data source is the OECD, which provides consistently measured series for income inequality. Gini index is measured for total population and it is expressed in percent. It is for disposable income, i.e., after taxes and transfers. Gini index for disposable income is used in order to control for the distributional effects of fiscal policy.

Federal Reserve Economic Database, FRED, is the data source for the other variables of the baseline models: real gross domestic product, GDP, (based on the prices of 2009), GDP deflator (with the base year of 2009), the federal funds rate (expressed in percent), and Federal Reserve total assets. Real GDP, GDP deflator, and Federal Reserve total assets are seasonally adjusted. The federal funds rate is the effective rate, which is the average of daily figures.

To demonstrate the evolution of unconventional monetary policy, as an indicator, the time series for Federal Reserve total assets is presented in Figure 4.1.There is a visible structural shift in Federal Reserve balance sheet in the fourth quarter of 2008. For the comparison with the evolution of the federal funds rate, it is useful to display them together. However, the data for Federal Reserve total assets are available since 2003. Therefore, the monetary base[25] is employed to depict their evolution for the whole considered period. Figure 4.2 shows their evolution from 1983 to 2013. As can be seen, since the end of 2008, the federal funds rate has approached to its zero lower bound while the monetary base has substantially increased. Thus, it is since the end of 2008 when the Federal Reserve has started to implement unconventional monetary policy. To describe the general statistical characteristics of the variables used in the empirical analysis, they are summarized in Table 4.1.

[25] The data source for this total monetary base is also FRED.

Figure 4.1: Federal Reserve Total Assets (Billions of USD)

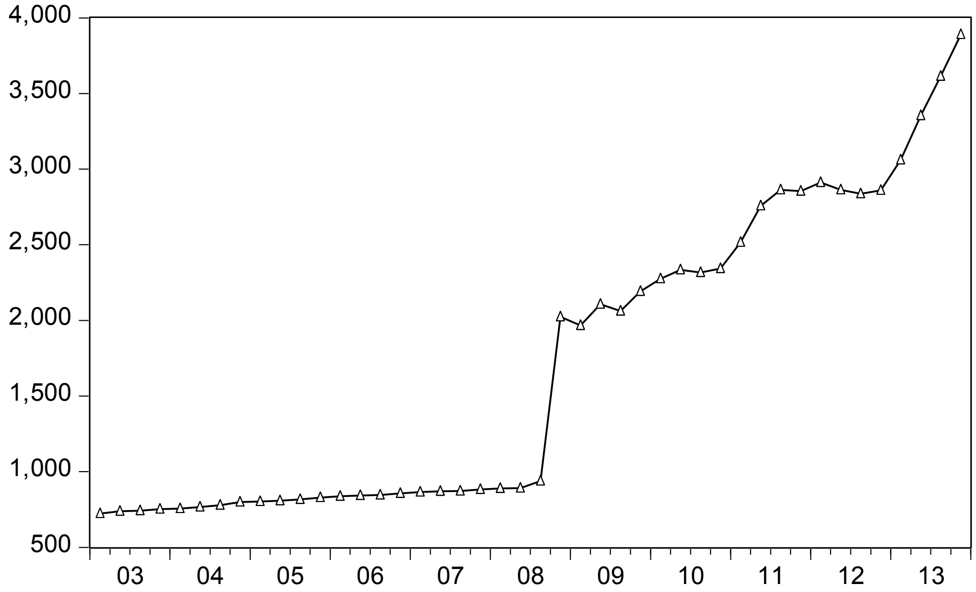


Figure 4.2: The Federal Funds Rate and the Monetary Base

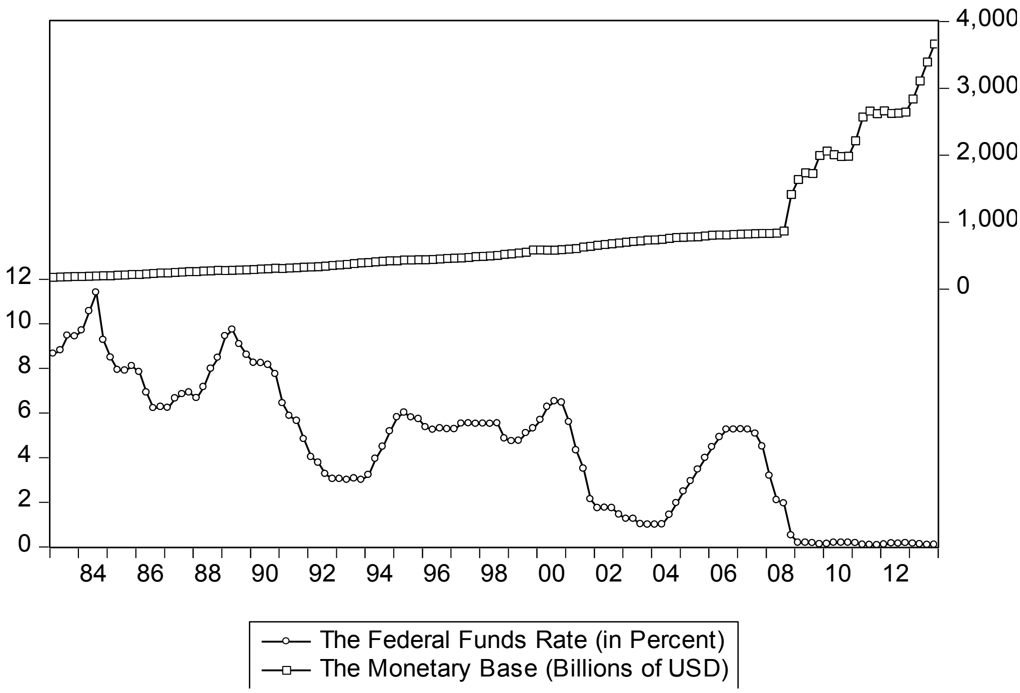


Table 4.1: Descriptive Statistics

The Time Period	1983-2008		2009-2013	
Variables	**Mean**	**SD**	**Mean**	**SD**
Real GDP (billions of USD, based on the prices of 2009)	10793.5	2521.47	15032.22	433.86
GDP Deflator (annual average index, 2009=100)	75.46	13.16	103.33	2.64
The Federal Funds Rate (effective, annual average, in percent)	5.33	2.5	0.14	0.04
Federal Reserve Total Assets (billions of USD)	871.85	251.84	2698.79	520.76
The Total Monetary Base (billions of USD)	482.47	231.37	2439.16	557.47
Gini Coefficient (GINI) (in percent)	35.81	1.45	38.74	0.85

Note: For the period from 1983 to 2008, the mean and the standard deviation, SD, for Federal Reserve Total Assets are calculated using the data available since 2003.

4.4.2. Interpolation

The data for the considered variables of the empirical analysis are generally available in a higher frequency. The exception is the data for income inequality measures. The time series for them are only available on the yearly frequency. Therefore, to apply the contemporaneous identification in the empirical analysis, income inequality measures are interpolated into a higher frequency[26]. The disaggregation of the data for income inequality measures is justifiable since their time series have low variation.

Gini index of income inequality is disaggregated by the index type. That is, the interpolation has been implemented in such a way that, for each reference

[26] All the interpolations used in the chapter have been implemented by the specialized ECOTRIM software created by Eurostat.

period, the average of the disaggregated series equals to the corresponding aggregate value. The disaggregation of the series for Gini index is carried out by the mathematical method proposed by Boot et al. (1967). The disaggregation of the series by this method is implemented using the first difference approach. By applying this disaggregation procedure, the series for Gini index of income inequality is interpolated from the yearly frequency to the quarterly and the monthly series.

As another measures of income inequality, the chapter also employs the percentile ratios. The percentile ratios are calculated using the percentiles provided in the report by DeNavas-Walt and Proctor (2015). In particular, the chapter considers the ratio between the 90^{th} and the 50^{th} percentiles (the 90-50 ratio), and the ratio between the 50^{th} and the 10^{th} percentiles (the 50-10 ratio). The percentiles provided in the report are based on the data from the Current Population Survey (CPS) of the U.S. Census Bureau. The percentiles are based on income before taxes and it does not include noncash benefits (DeNavas-Walt and Proctor, 2015). However, it is still informative to use this available data to calculate the new measures of income inequality for evaluating the distributional effect of monetary policy. For the usage in the empirical analysis, the yearly percentile ratios are interpolated into the quarterly and the monthly series. The interpolation is performed in the same way as it is implemented for the interpolation of the series for Gini index.

The series for real GDP and GDP deflator are also interpolated for evaluating the distributional effect of unconventional monetary policy. The time series for real GDP is disaggregated by the flow type. For each reference period, the sum of the disaggregated series equals to the corresponding aggregate value. The series for GDP deflator is interpolated by the index type as it is described earlier. The interpolation of the series for real GDP and GDP deflator is implemented by the statistical method suggested by Fernandez (1981). For the interpolation by this method, two reference indicators are used for each series. Following Gambacorta et al. (2014), as reference indicators for real GDP, the chapter uses the series for industrial production index, and real retail and food services sales. As reference indicators for GDP deflator, in line with Uhlig (2005), the chapter employs the consumer price index and the producer price index[27]. By implementing these interpolation procedures, the data for real GDP and GDP deflator are disaggregated from the quarterly frequency to the monthly series.

4.5. Empirical Analysis

As it is shown in Chapter 3, there is a cointegration relation among real GDP, GDP deflator, the federal funds rate, and Gini index of income inequality. Therefore, no stationary transformation is performed for the variables and they are used in levels. The same approach is also applied not only in the baseline case of conventional monetary policy but also in the other cases explored in the chapter. In particular, the variables are used in levels when, instead of Gini index of income inequality, another measure of income inequality is employed in the empirical analysis. The measures of income inequality generally have similar dynamic behavior (Congressional Budget Office, 2011). The same approach is also applied when the distributional effect of unconventional monetary policy is examined in the chapter. The implementation of the analysis in levels allows for implicit cointegration relations among the considered variables (Peersman and Smets, 2001; Sims et al., 1990).

The baseline VAR model of conventional monetary policy includes the variables with the following ordering: real GDP (GDP83L)[28], GDP deflator (GDPDX83L), Gini coefficient (GINI), and the federal funds rate (FFR). For the evaluation of the distributive effect of unconventional monetary policy, the corresponding version of the baseline VAR model is considered. It contains the variables with the following ordering: real GDP (GDP09L), GDP deflator (GDPDX09L), Federal Reserve total assets (TAL), and Gini index (GINI).

Following Christiano et al. (1996) and Coibion et al. (2012), the VAR models of conventional monetary policy are considered with a yearly lag (i.e., 4 lags in the case of the quarterly data). Since, in the case of unconventional monetary policy, the estimation sample is relatively short and the objective is to have a

[27] The source for all these reference series is FRED.

[28] In the parentheses, the abbreviations of the variables are stated as they are used in the empirical analysis. The last letter L in the abbreviations indicates the performed natural logarithmic transformation.

parsimonious VAR model, Schwarz criterion is used to determine the lag order of the model (Lütkepohl, 2005). The application of this criterion indicates the order of two for the VAR model. Besides, Gambacorta et al. (2014) use the same order for their VAR model, which is also estimated with monthly data and applied within the framework of unconventional monetary policy.

The VAR models are estimated by ordinary least squares (OLS). Talking into account that the federal funds rate has reached the zero lower bounds since 2009, the estimation sample for the conventional monetary policy models is from 1983 to 2008. In particular, the quarterly data are used in this case. For the evaluation of the distributive effects of unconventional monetary policy, the corresponding VAR models are estimated using the sample from 2009 to 2013 based on the monthly data.

The dynamic interactions among the variables are explored through the IRFs of the VAR models. They are identified by imposing the contemporaneous restrictions discussed in Section 4.3. This identification scheme is common in the literature (among others, Christiano et al. 1996; Sims, 1992) on the evaluation of the impact of conventional monetary policy. For the identification of unconventional monetary policy shocks, this recursive identification method is also applied in the literature (Chen et al., 2015; Jannsen et al., 2015; Meinusch and Tillmann, 2014). In particular, Jannsen et al. (2015) find that their results obtained with the contemporaneous identification are very similar to the IRFs identified through the sign restrictions proposed by Uhlig (2005).

The provided IRFs are for the responses of variables to one standard deviation increase in a monetary policy shock. In the case of conventional monetary policy models, the federal funds rate is included as a policy instrument, and, consequently, monetary policy shocks are contractionary. For the case of unconventional monetary policy models, Federal Reserve assets are used as a monetary policy instrument. Therefore, the interpretation of monetary policy shocks is different in this case. In particular, monetary policy shocks are expansionary in this framework, and their impact on the other variables is interpreted accordingly[29].

For the IRFs, Hall´s (1992) 95% confidence bands based on 1500 bootstrap replications are provided. They are presented in dotted lines while the IRFs are depicted in solid lines. In accordance with Coibion et al. (2012), the IRFs for conventional monetary policy models are presented over 20 periods (i.e., for5 years in this case of the quarterly data).In line with Gambacorta et al. (2014), the IRFs for unconventional monetary policy models are presented for 24 periods (i.e., over 2 years in this case of the monthly data).

4.5.1. The Results for the Baseline Models

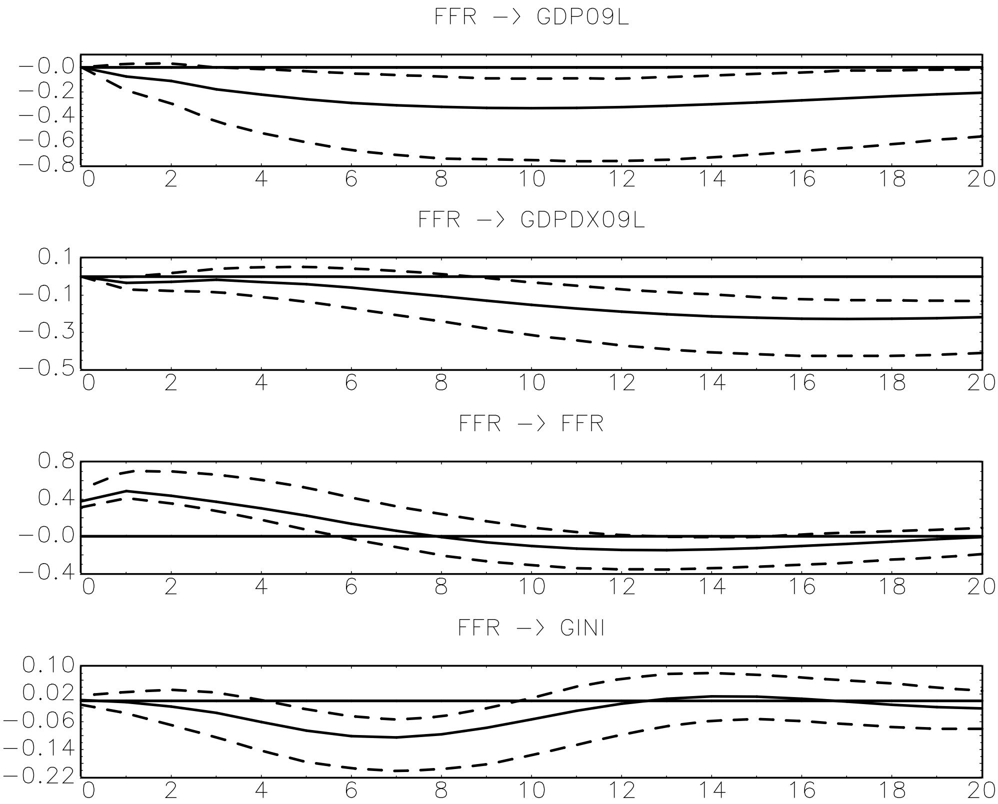
First of all, the empirical analysis is implemented for evaluating the distributive effect of conventional monetary policy in the baseline case with the quarterly data. The usage of the higher frequency data allows the identification of a conventional monetary policy shock directly through the contemporaneous framework. The estimation results can serve as a basis point for the further analysis.

The IRFs of the baseline model of conventional monetary policy are thus identified by the contemporaneous restrictions using quarterly data. The estimated IRFs are provided in Figure 4.3.As can be seen, a contractionary monetary policy shock leads to a peak drop in real GDP by approximately 0.35 percent. This real effect of monetary policy is in line with the related literature (Christiano et al., 1996; Coibion, 2012; Peersman and Smets, 2001). The contractionary monetary policy shock also decreases GDP deflator with the peak effect of around 0.25 percent. It should be noted that the response of GDP deflator to the contractionary monetary policy shock is negative throughout the all considered periods. That is, even without including commodity prices (Christiano et al., 1996; Sims, 1992), the response of GDP deflator does not

[29] It is assumed that there is symmetry in the responses of contractionary and expansionary monetary policy shocks.

feature the "price puzzle."[30] Moreover, the responses of real output and prices to the contractionary monetary policy shock are mostly significant at the 95% confidence level. As can also be observed from Figure 4.3, a contractionary monetary policy shock decreases Gini index of income inequality up to around 0.1 percentage points. The response of income inequality is especially significant between the fourth and the tenth quarters.

Figure 4.3: The IRFs to a Conventional Monetary Policy Shock (The Baseline Model)



30 The commonly used term "price puzzle" refers to the estimation results found in the literature (Balke and Emery, 1994; Bernanke and Blinder, 1992; Sims, 1992) that prices increase in response to a contractionary monetary policy shock.

For the baseline VAR model of unconventional monetary policy, the corresponding IRFs are estimated and they are provided in Figure 4.4. It can be observed from the figure that an expansionary unconventional monetary policy shock raises real GDP with the peak effect of 0.25 percent. The unconventional monetary policy shock also leads to a peak increase in GDP deflator by nearly 0.15 percent. These real and nominal effects of the exogenous expansion of the Federal Reserve balance sheet are generally in line with the analogous results in the related literature (Chen et al., 2015; Gambacorta et al., 2014; Jannsen et al. 2015). Though the magnitudes of these effects are relatively smaller in comparison with the corresponding results in the case of the conventional monetary policy shock, they are still significant at the 95% confidence level.

From Figure 4.4, it can also be seen that the expansionary unconventional monetary policy shock significantly increases Gini index of income inequality up to approximately 0.07 percentage points. The magnitude of this effect is also relatively smaller than the corresponding distributive impact of the conventional monetary policy shock. Nevertheless, in the both cases, the period of the biggest distributive impact of monetary policy is during the second year after the shock.

4.5.2. The Results for the Variations in the Baseline Models

4.5.2.1 Monetary Policy Indicators

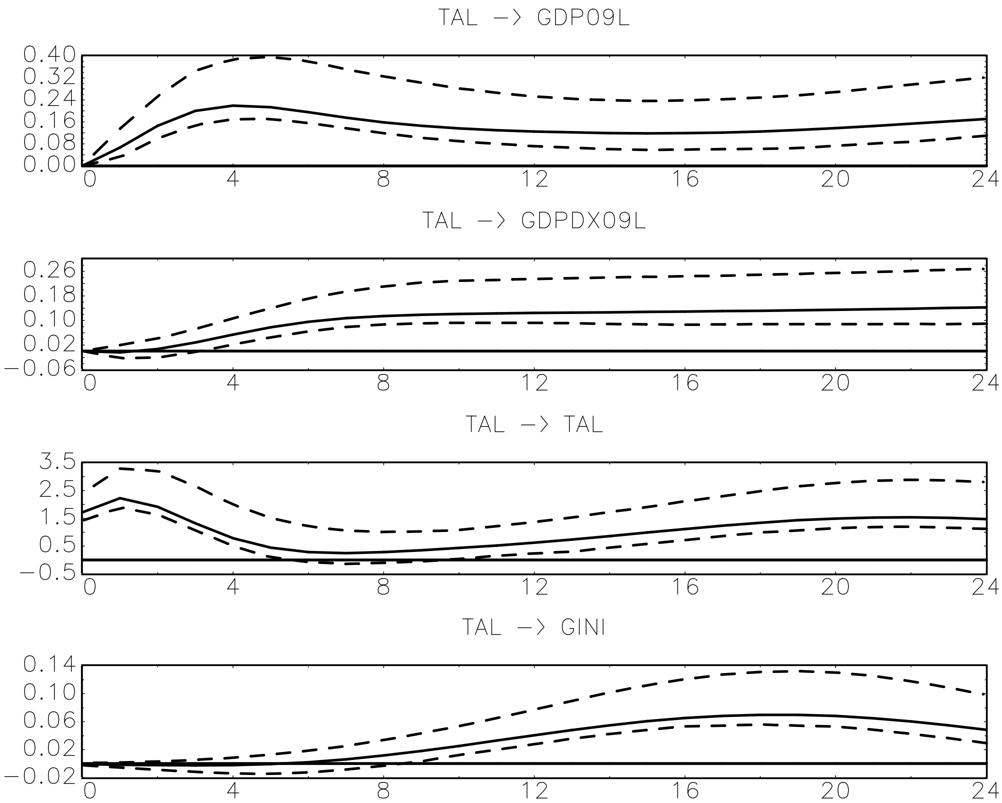
As an alternative variable for monetary policy stance, the yield curve is used instead of the federal funds rate in the baseline model of conventional monetary policy[31]. The slope of the yield curve is defined as a spread between short term and long term Treasury rates[32]. In particular, the yield curve indicator is calculated as a difference between the secondary market three-

[31] As a monetary policy indicator, the yield curve is also used by Chen et al. (2015) and Galbraith et al. (2007).

[32] The slope of the yield curve is usually defined as a spread between long term and short term rates (Estrella and Trubin, 2006). It is defined in an opposite way in order to obtain a contractionary monetary policy shock consistently with the baseline case. That is, the computation of the yield curve indicator in this way provides the comparability of the IRFs with the results of the baseline case.

month Treasury bill rate and the ten-year Treasury constant maturity rate[33]. According to Estrella and Trubin (2006), the spread between these short term and long term rates serves as the best yield curve indicator. Then, in the baseline VAR model, the federal funds rate is replaced by this yield curve indicator (YCTBR) and the corresponding IRFs are re-estimated in the empirical analysis.

Figure 4.4: The IRFs to an Unconventional Monetary Policy Shock (The Baseline Model)

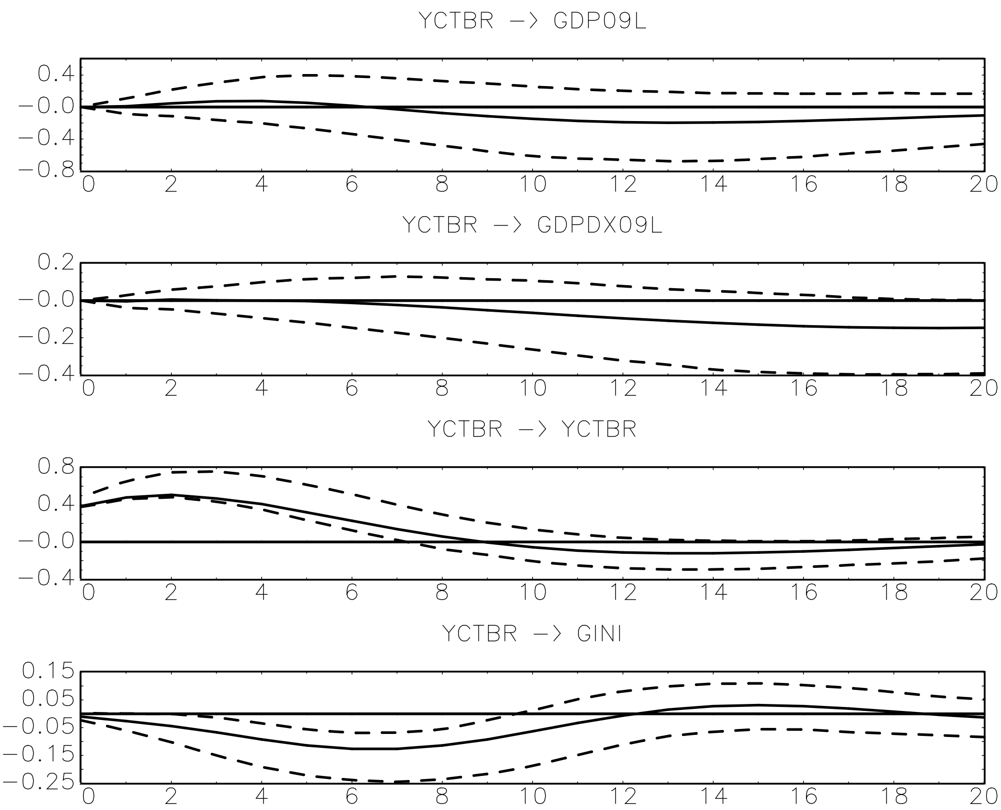


[33] These short term and long term Treasury rates are taken from FRED.

Figure 4.5 shows the obtained IRFs when the yield curve is used as a monetary policy indicator. As can be seen, the responses of real output and prices to a conventional monetary policy shock are not as significant as in the baseline case. Nevertheless, the response of GDP deflator does not still feature the "price puzzle." The response of Gini index to the shock is actually the same as in the baseline case.

Figure 4.5: The IRFs to a Conventional Monetary Policy Shock

(The Model with the Yield Curve)



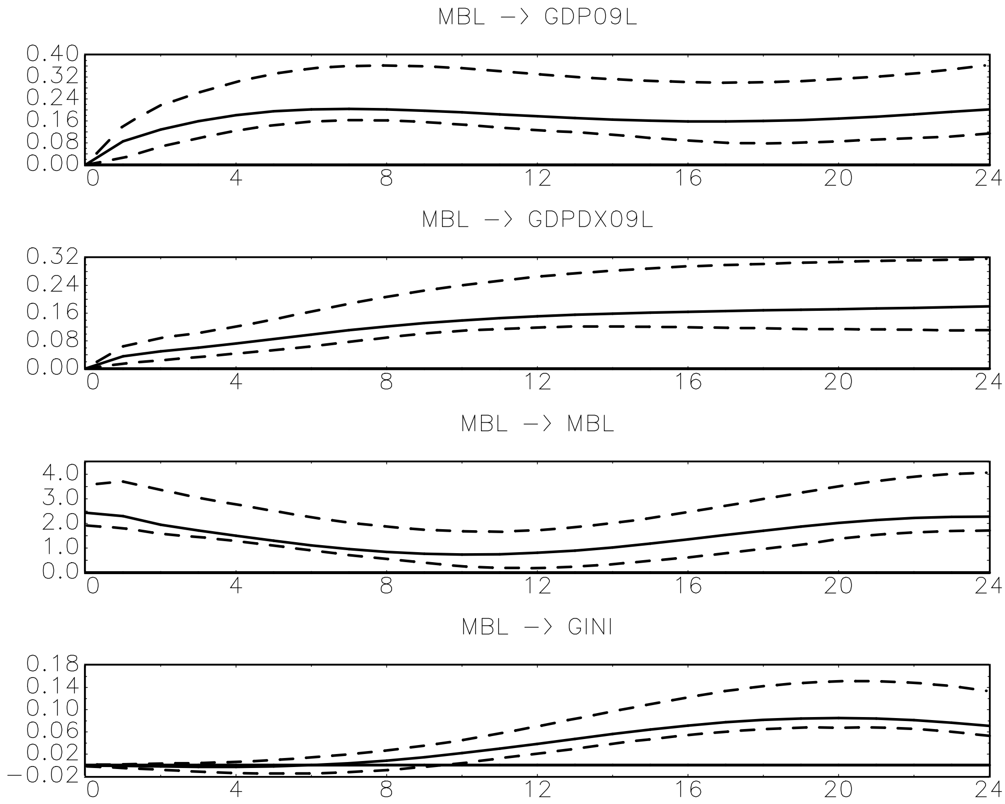
In the baseline model of unconventional monetary policy, another monetary policy instrument is used, too. Federal Reserve total assets are replaced by the monetary base[34]. As another quantitative policy instrument, the monetary base (MBL) is employed in the literature (Gambacorta et al., 2014; Saiki and Frost, 2014) for the evaluation of the effect of unconventional monetary policy. The corresponding IRFs are depicted in Figure 4.6. As can be observed from the figure, all the obtained results are very similar to the respective IRFs from the case when Federal Reserve balance sheet is considered as a monetary policy instrument. In particular, an unconventional monetary policy shock also significantly raises Gini index of income inequality, and its biggest impact is around 0.08 percentage points. Analogously, Saiki and Frost (2014) find that unconventional monetary policy increases income inequality in Japan.

The federal funds rate has been at its effective lower bound in the sample period considered for the case of unconventional monetary policy. However, there have still been some rate cuts during this period. Consequently, there is a risk that unconventional monetary policy shocks might be associated with these cuts in the federal funds rate. To check whether monetary policy shocks are affected by these changes in the federal funds rate, the appropriate robustness analysis of the obtained results is implemented. Following Gambacorta et al. (2014), the benchmark VAR model of unconventional monetary policy is extended by including the federal funds rate. Within the ordering of the variables, it is included just before Federal Reserve assets. That is, it is assumed that an unconventional monetary policy shock does not affect the federal funds rate on impact. The corresponding IRFs of the extended VAR model are provided in Figure A4.1 in Appendix 4.1. As can be seen, the magnitudes of the responses of the variables to unconventional monetary policy are relatively smaller than they are in the baseline case. However, the responses of real output, prices, and Gini index are still significant and they have the same dynamics as in the baseline case. All these results do not essentially change when, instead of Federal Reserve assets, the monetary base is used as a policy instrument (Figure A4.2 in Appendix).

[34] This total monetary base is from FRED, and it is seasonally adjusted.

Figure 4.6: The IRFs to an Unconventional Monetary Policy Shock

(The Model with the Monetary Base)



4.5.2.2. The Indicators of Future Inflation and Financial Uncertainty

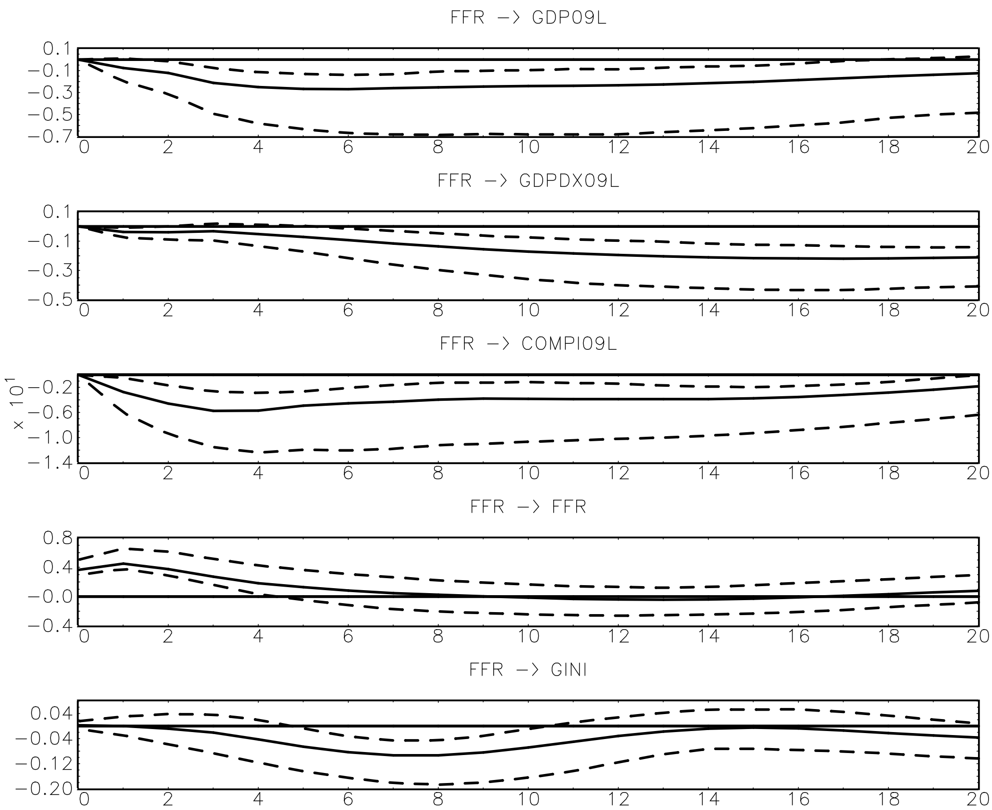
In the baseline model of conventional monetary policy, the response of GDP deflator to the monetary policy shock does not feature the "price puzzle." Nevertheless, a commodity price index[35] (COMPI09L) is still added to the model. It is an indicator of future inflation, which is included into the VAR models of conventional monetary policy in the related literature (Christiano et al., 1996; Sims, 1992). The corresponding IRFs are re-estimated in this extended version of the model. The obtained results are presented in Figure 4.7. As can be seen from the figure, a contractionary monetary policy shock significantly reduces commodity prices. The responses of the other variables are similar to the corresponding IRFs in the case of the baseline model.

The commodity price index is also added to the model when the yield curve is used as a monetary policy indicator. In that case as well, though, the "price puzzle" is not present in the response of GDP deflator. The estimation results for the corresponding IRFs are provided in Figure A4.3 in Appendix 4.2. In this case, the extension of the model makes the responses of real output and prices to a conventional monetary policy shock more significant. By contrast, the magnitudes and dynamics of the responses of Gini index to the shocks are very similar across the both cases. Moreover, the responses of Gini index are actually the same as in the baseline case.

[35] The commodity price index is proxied by crude oil (petroleum) price index, which is the average of three spot prices: Dated Brent, West Texas Intermediate, and the Dubai Fateh. The both indices are very closely related and, in contrast to the former, the latter is fully available in the IMF database for the considered sample. The quarterly averages of the available monthly indices are used in the empirical analysis.

Figure 4.7: The IRFs to a Conventional Monetary Policy Shock

(The Extension of the Baseline Model by Commodity Prices)

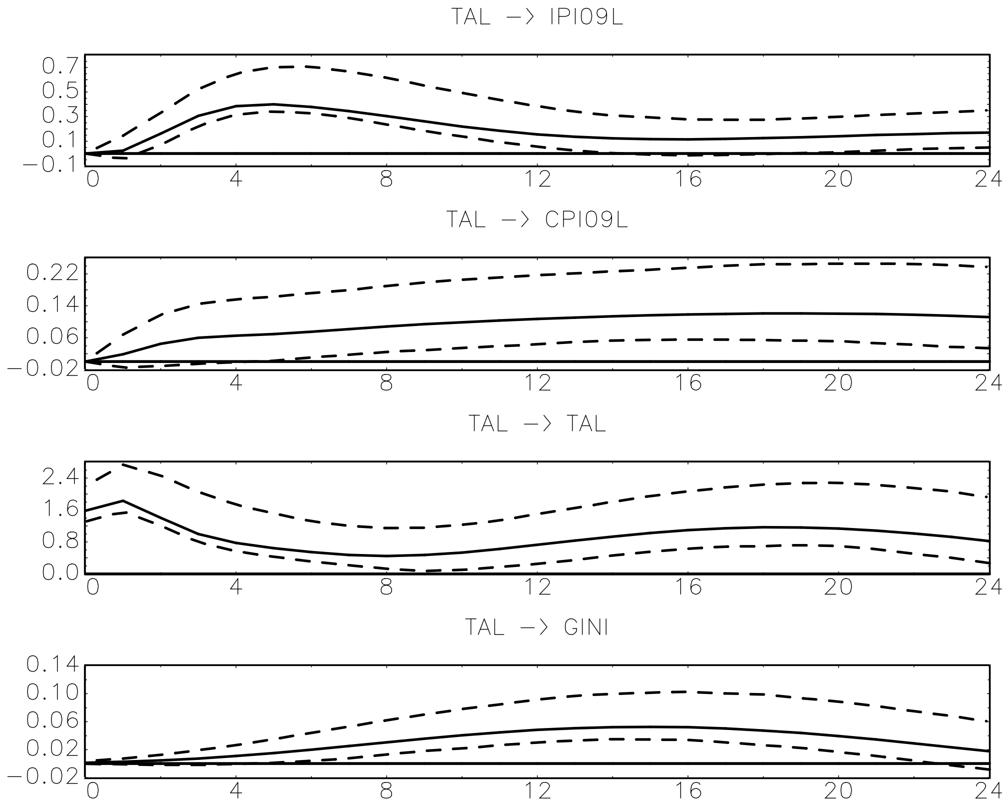


Before the extension of the baseline model of unconventional monetary policy by an indicator of financial uncertainty, another modification of the model is implemented. As mentioned earlier, the interpolated data on real GDP and GDP deflator are used for the estimation of the baseline model to assess the distributive effect of unconventional monetary policy. Nevertheless, the data on the monthly frequency are available for industrial production index, IPI, and consumer price index[36], CPI, which are closely related to real GDP and GDP deflator, respectively. To check the robustness of the previously obtained results, the baseline model is modified by replacing real GDP and GDP

[36] IPI and CPI are seasonally adjusted and they are taken from FRED. The base years of the indices are rescaled to 2009 to be in line with this base year of the other series.

deflator with the IPI (IPI09L) and the CPI (CPI09L), respectively. The resulting IRFs are presented in Figure 4.8. It can be observed that the IRFs are very similar to the corresponding results of the baseline case. They only differ by the larger response of real output in this case. In comparison with real GDP, the higher responsiveness of the IPI to an unconventional monetary policy shock is also found by Gambacorta et al. (2014).

Figure 4.8: The IRFs to an Unconventional Monetary Policy Shock (The Model with the IPI and the CPI)



For the identification of the unconventional monetary policy shocks, implied stock market volatility index[37] (VIX) is included into VAR models by some of the related literature (Gambacorta et al. 2014; Jannsen et al., 2015; Meinusch and Tillmann, 2014). It serves as a proxy for financial risk and uncertainty. According to Gambacorta et al. (2014), the inclusion of the VIX into the VAR model facilitates to disentangle exogenous unconventional monetary policy shocks from endogenous responses to financial market uncertainty. In this sense, it is analogous to the inclusion of commodity prices into the VAR models of conventional monetary policy. In that case, the commodity price index serves as an indicator for future inflation, and it is included into the VAR models for the identification of conventional monetary policy shocks (Christiano et al., 1996; Sims, 1992).

As robustness check for all the aforementioned results in the case of the consideration of unconventional monetary policy, the VIX is included in the corresponding VAR models. In the ordering of the variables, it is included just before Federal Reserve assets[38], assuming that innovations to the VIX have instantaneous impact on the balance sheet[39]. The estimated IRFs are provided in Figure 4.9 below (for the extension of the baseline case) and in Figures A4.3 to A4.7 in Appendix 4.3 (for the other results). The obtained results show that the response of the VIX to an unconventional monetary policy shock is not generally significant. The magnitudes of the responses of the other variables are relatively smaller in this case. However, these responses are still significant and they display the same dynamics as they have in the baseline case.

[37] The data source for the VIX is Chicago Board Options Exchange, CBOE.

[38] Jannsen et al. (2015), and Meinusch and Tillmann (2014) include the VIX into the VAR models after the monetary policy instrument in the orderings of their considered variables. Accordingly, the VIX is included into the VAR model also just after Federal Reserve assets. The results are not essentially affected by this change of the ordering of the VIX. Therefore, the results are provided in the chapter for only one scheme when the VIX is ordered just before Federal Reserve assets.

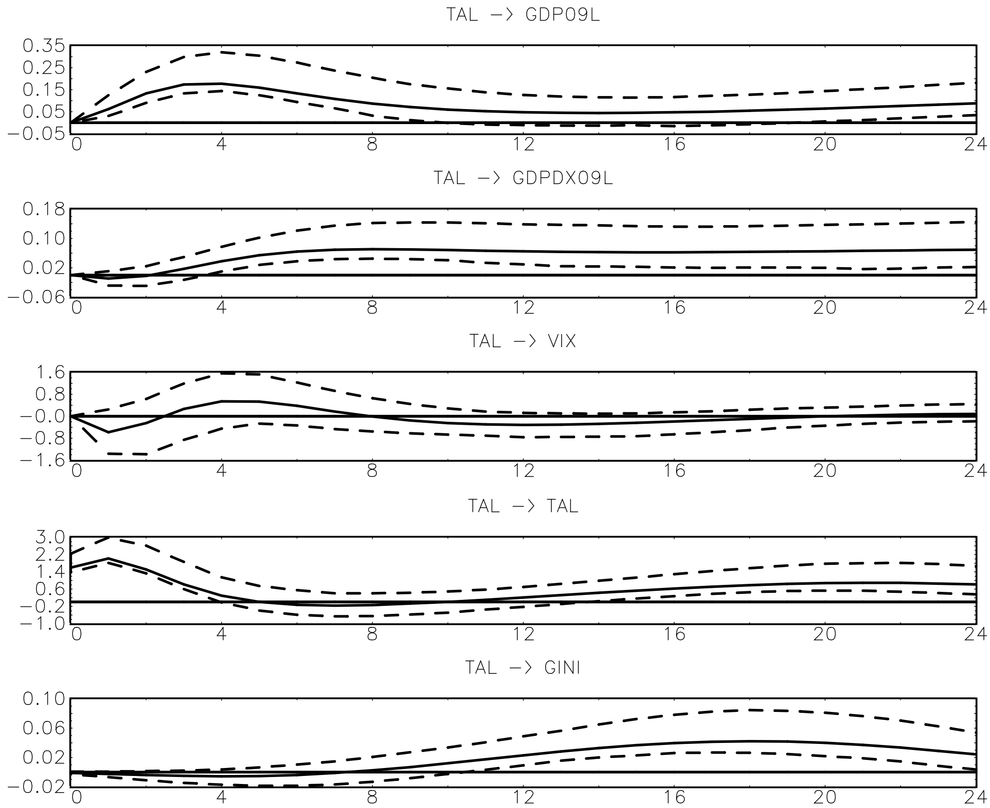
[39] Gambacorta et al. (2014) assume that unconventional monetary policy has also immediate effect on financial market uncertainty, and they identify unconventional monetary policy shocks by zero and sign restrictions. This identification approach for unconventional monetary policy shocks is within the agenda for future research and it will be used in the upcoming research work.

4.5.2.3. Income Inequality Measures

In order to assess the impact of conventional monetary policy on the different parts of income distribution, other income inequality measures are employed in the empirical analysis. In particular, the chapter considers the 90-50 and the 50-10 percentile ratios. The baseline VAR model is modified by consecutively including the 90-50 (P9050) ratio and then the 50-10 (P5010) ratio instead of Gini index. The VAR models are then re-estimated, and the corresponding IRFs are identified by the contemporaneous restrictions. The resulting IRFs are provided in Figures A4.8 and A4.9 in Appendix 4.4.

Figure 4.9: The IRFs to an Unconventional Monetary Policy Shock

(The Extension of the Baseline Model by the VIX)



As can be seen from Figures A4.8 and A4.9, the responses of real output and prices to contractionary monetary policy shocks are very similar to the corresponding results of the baseline case when Gini index is used. From Figures A4.8, it could be observed that a contractionary monetary policy shock leads to a decline in the 90-50 ratio. The peak drop of the percentile ratio is around 0.008 units. In line with the baseline case with Gini index, this decrease of income inequality is significant between the fourth and the tenth quarters. From Figures A4.9, it can be seen that the impact of the conventional monetary policy shock on the 50-10 ratio is not significant. That is, contractionary monetary policy does not affect the lower part of income distribution.

Analogously to the previous case with conventional monetary policy, the chapter also considers the effects of unconventional monetary policy on the different parts of income distribution. To evaluate these effects, the same 90-50 and 50-10 percentile ratios are used in the analysis. The corresponding IRFs are provided in Figures A4.10 and A4.11 in Appendix 4.5.As can be seen from the figures, all the responses of real output and prices to an unconventional monetary policy shock are similar to the corresponding results in the case of the usage of Gini index. The responses of the 90-50 and the 50-10 ratios are also similar to the IRF for Gini index. In particular, the unconventional monetary policy shock significantly increases the 90-50 and the 50-10 ratios by approximately 0.003 and 0.002 units, respectively. Nevertheless, the result for Gini index is more significant. This is especially the case with the response of the 50-10 ratio. However, this response of the 50-10 ratio is still significant compared with the corresponding result in the case of the conventional monetary policy shock. On the contrary, the response the 90-50 to the conventional monetary policy shock is relatively stronger than it is in this case. Anyway, in the both cases, the results for the 90-50 ratio are significant and they are in line with each other.

4.5.3 Variance Decomposition

In order to assess the relative importance of conventional and unconventional monetary policy shocks, the variance decomposition analysis is also implemented in the current chapter. It allows decomposing the total variance of Gini index of income inequality into the percentages attributable to a monetary policy shock identified by the same contemporaneous restrictions. It is very informative to observe these percentages over the considered periods for both conventional and unconventional monetary policy shocks. In particular, the results are presented for the first two years after the shocks according to the considered period for the IRFs of the unconventional monetary policy models.

The chapter provides the results for the variation of Gini index due to a conventional monetary policy shock in Table 4.2. As can be observed from the table, the conventional monetary policy shock explains up to 11.48 percent of the variation in Gini index of income inequality.

The variation of Gini index attributable to an unconventional monetary policy shock is presented in Table 4.2, too. The results provided in the table indicate that the unconventional monetary policy shock significantly influences the variation in Gini index with the highest impact of 40.71 percent. Thus, the impact of the unconventional monetary policy shock on the variation in Gini index of income inequality is stronger than it is in the case of the conventional monetary policy shock.

Table 4.2: The Variance of Gini index due to Conventional (CMP) and Unconventional (UCM) Monetary Policy Shocks

Periods (in Quarters)	CMP Shock	SE	Periods (in Months)	UMP Shock	SE
1	0.13%	1.44	1	0.92%	2.93
			2	1.03%	3.26
			3	1.07%	3.83
2	0.05%	1.5	4	0.99%	4.37
			5	0.78%	4.8
			6	0.53%	5.1
3	0.35%	2.22	7	0.46%	5.39
			8	0.93%	5.86
			9	2.26%	6.68
4	1.02%	3.28	10	4.66%	7.82
			11	8.1%	9.08
			12	12.26%	10.28
5	2.62%	4.86	13	16.72%	11.32
			14	21.06%	12.18
			15	25%	12.9
6	5.32%	6.74	16	28.4%	13.51
			17	31.26%	14.05
			18	33.6%	14.54
7	8.63%	8.44	19	35.5%	14.98
			20	37.03%	15.37
			21	38.27%	15.71
8	11.48%	9.52	22	39.27%	16.02
			23	40.07%	16.28
			24	40.71%	16.5

Note: The variations of Gini index are in percent. Standard errors (SE) are provided based on 1500 bootstrap replications.

4.6. Conclusion

The empirical analysis in the chapter is implemented in line with its objective to assess the distributional effects of conventional and unconventional monetary policies in comparison with each other. The evaluation of these distributional effects is performed for the USA. For the estimation of the distributive impact of conventional monetary policy, the sample period is from 1983 to 2008 based on the quarterly data. The estimation sample for assessing the distributive effect of unconventional monetary policy covers the period from 2009 to 2013 and it is based on the monthly data. The distributive impact of conventional and unconventional monetary policies is evaluated through structural VAR models. Based on them, the chapter estimates the IRFs and the variance decomposition, which are identified by imposing the contemporaneous restrictions. In particular, conventional monetary policy shocks are contractionary whereas unconventional monetary policy shocks are expansionary.

In the baseline case of the conventional monetary policy model, the estimation results of the IRFs indicate that a contractionary monetary policy shock reduces Gini index of income inequality up to approximately 0.1 percentage points. In the baseline case of the unconventional monetary policy model, the obtained results show that an expansionary monetary policy shock raises Gini index of income inequality up to around 0.07 percentage points. In the both cases, the distributional effects of monetary policy are significant at the 95% confidence level. The obtained results are robust for the different variations and extensions of the baseline models. In addition, the estimated IRFs show that conventional and unconventional monetary policies generally increase the percentile ratios, which measures inequality within the different parts of income distribution. In particular, they have the analogous significant effects on the 90-50 percentile ratios. The obtained IRFs also indicate that the contractionary impact of conventional monetary policy is not significant on the 50-10 percentile ratio while the expansionary effect of unconventional monetary policy on this ratio is still significant.

The chapter also provides the results for the variance decomposition of Gini index attributable to conventional and unconventional monetary policy shocks. The results are presented for the first two years after the shocks. They indicate that the unconventional monetary policy shock explains the higher share of the variation in Gini index of income inequality than the conventional monetary policy shock.

In summary, the distributive effect of conventional monetary policy is stronger but its impact on the lower part on income distribution is not significant. That is, contractionary monetary policy does not affect the lower part of the distribution. Nevertheless, unconventional monetary policy significantly increases inequality in the lower part of income distribution. Additionally, the higher share of the variation in Gini index is attributable to unconventional monetary policy. Thus, this distributive impact of unconventional monetary policy should also be considered along with the other macroeconomic policies for the planned measures to reduce income inequality.

4.7. References

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Appendix 4.1: Robustness Checks for the Extensions of the VAR Models by the FFR

Figure A4.1: The IRFs to an Unconventional Monetary Policy Shock (The Extension of the Baseline Model by the FFR)

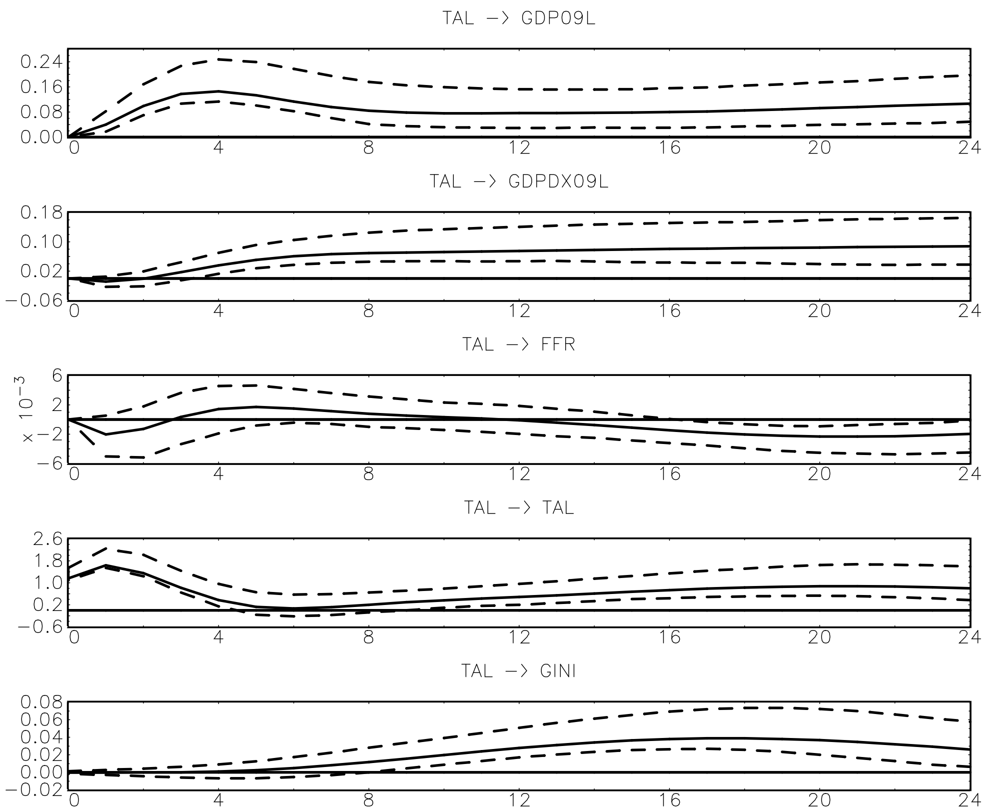
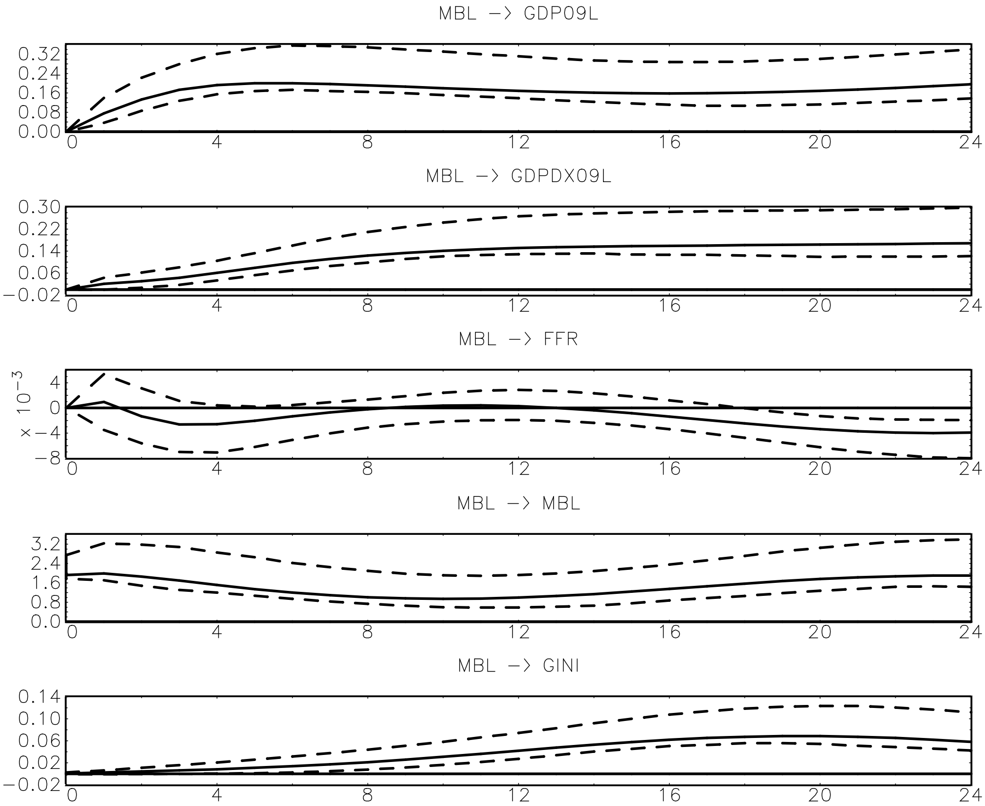
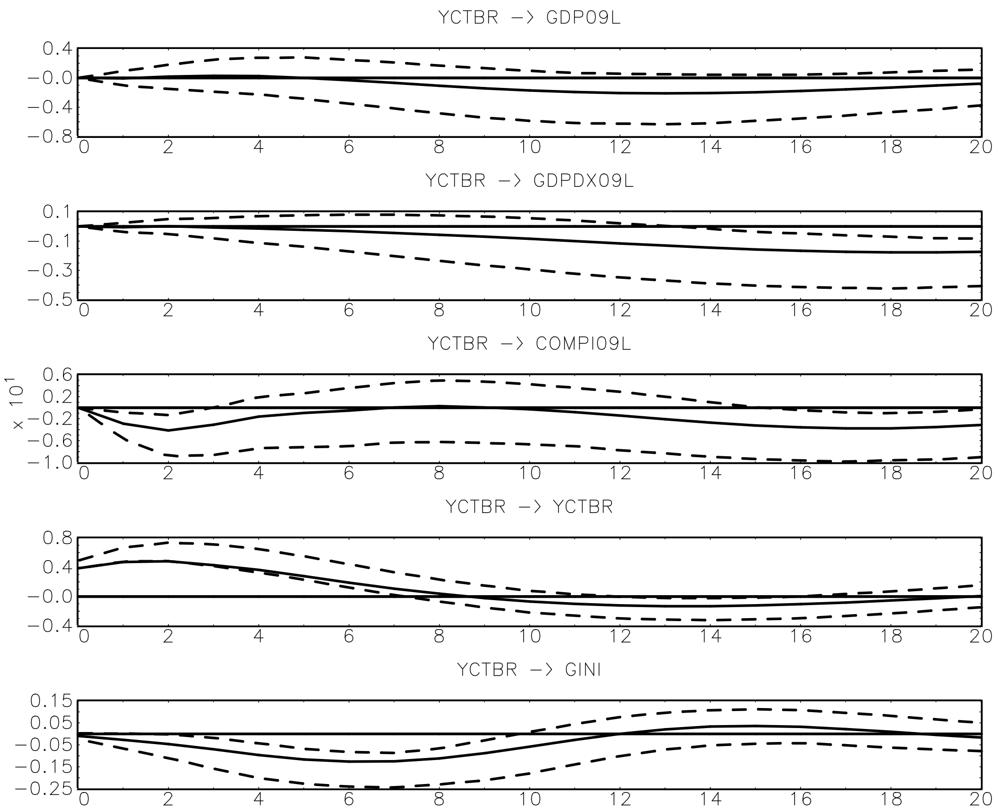


Figure A4.2: The IRFs to an Unconventional Monetary Policy Shock (The Model with the Monetary Base Extended by the FFR)



Appendix 4.2: Robustness Check of the VAR Model with the Yield Curve

Figure A4.3: The IRFs to a Conventional Monetary Policy Shock (The Model with the Yield Curve Extended by Commodity Prices)



Appendix 4.3: Robustness Checks for the Extensions of the VAR Models by the VIX

Figure A4.4: The IRFs to an Unconventional Monetary Policy Shock (The Model with the Monetary Base Extended by the VIX)

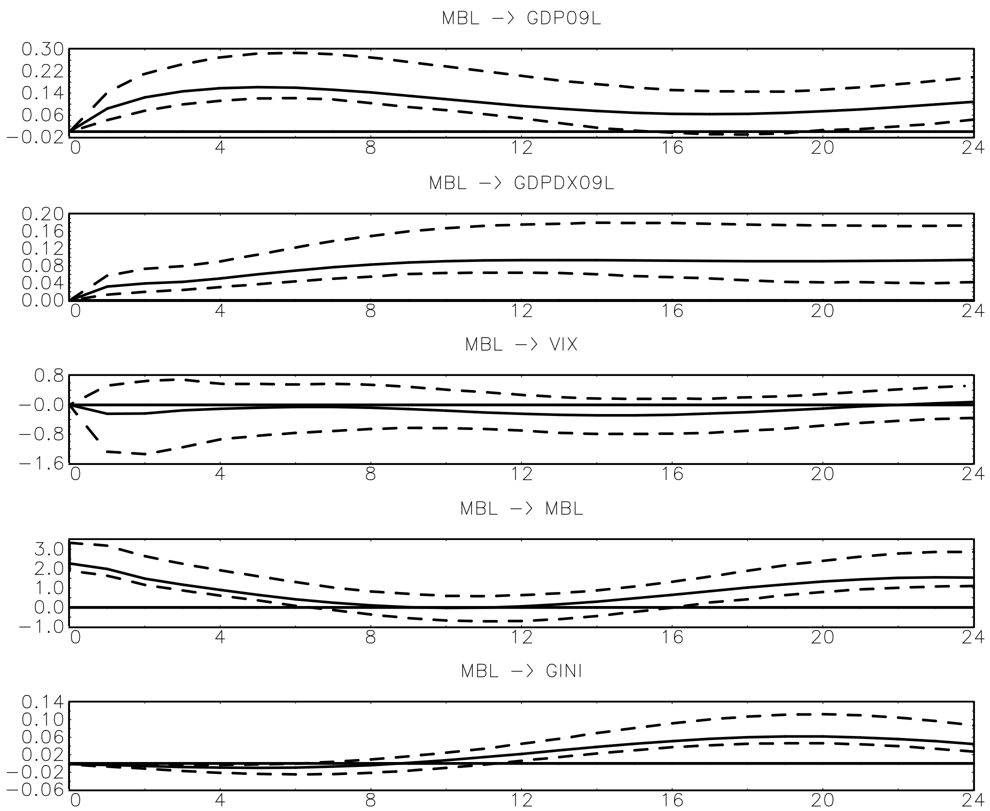


Figure A4.5: The IRFs to an Unconventional Monetary Policy Shock (The Model with the IPI and the CPI Extended by the VIX)

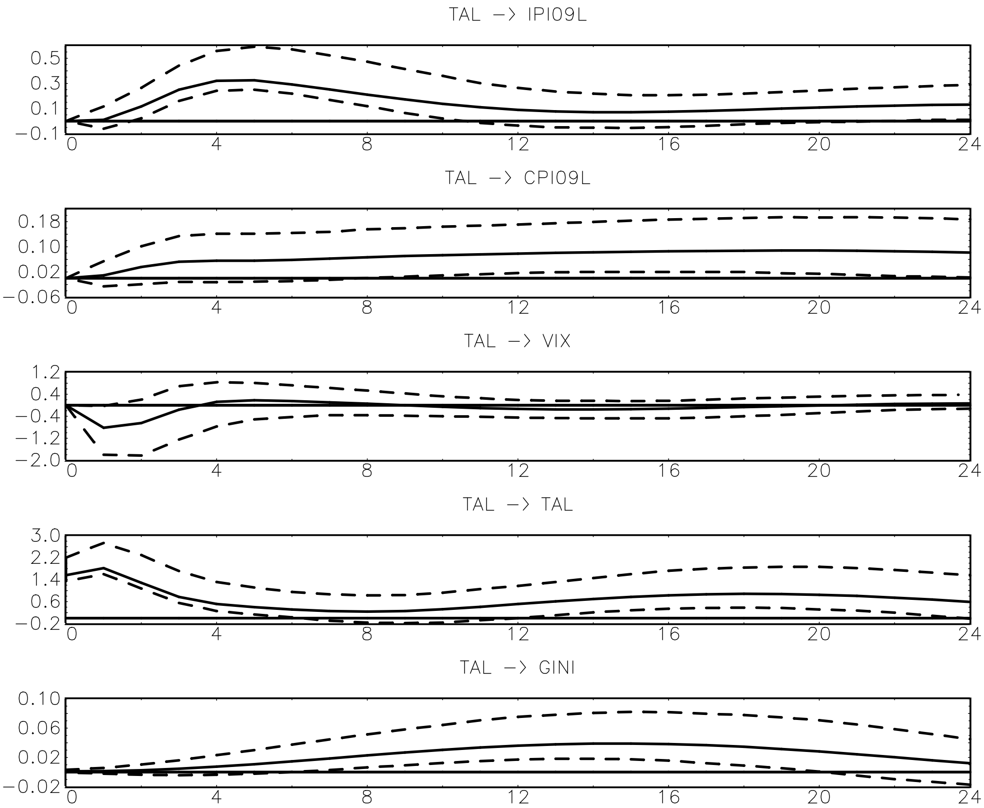


Figure A4.6: The IRFs to an Unconventional Monetary Policy Shock (The Extension of the Baseline Model by the FFR and the VIX)

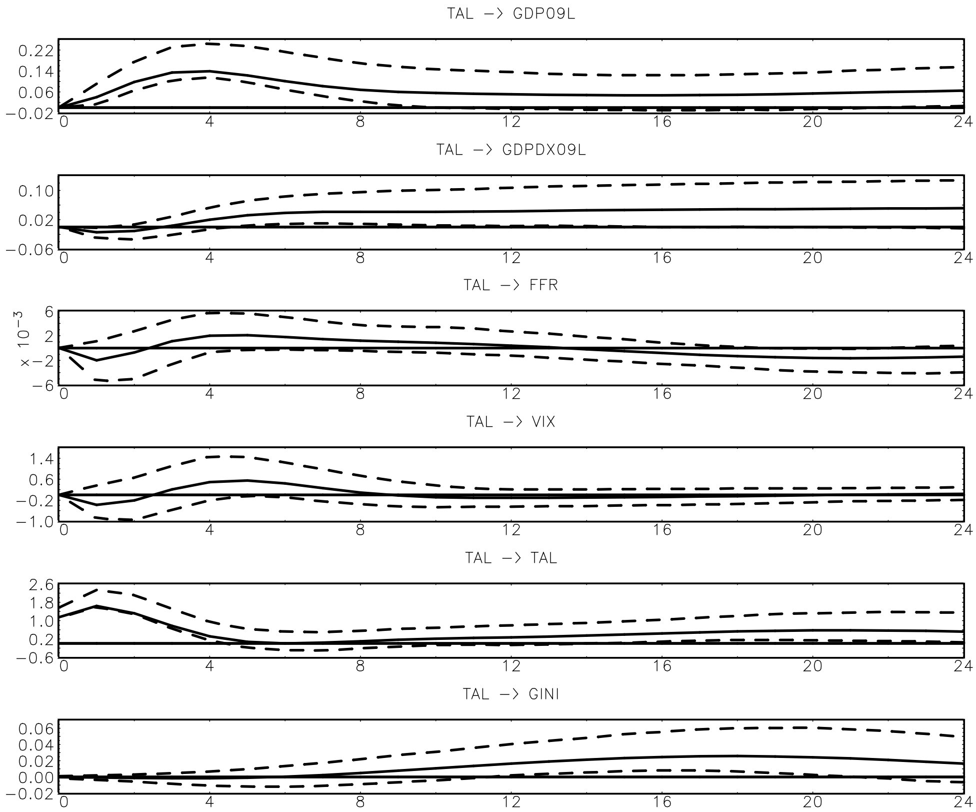
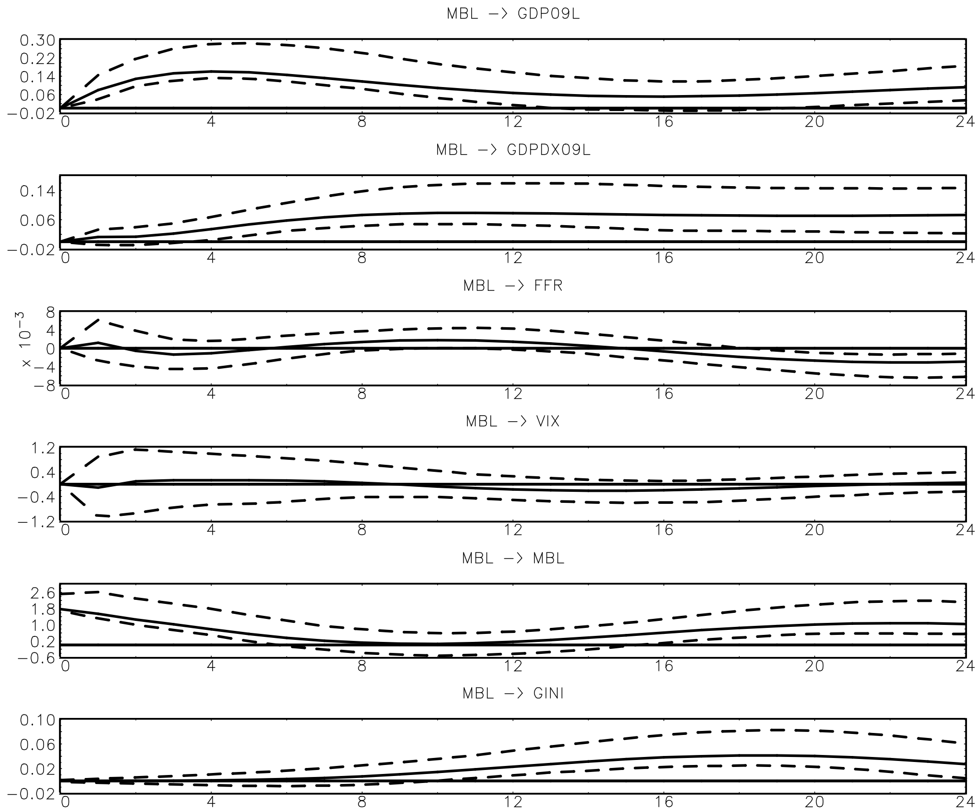


Figure A4.7: The IRFs to an Unconventional Monetary Policy Shock (The Model with the Monetary Base Extended by the FFR and the VIX)



Appendix 4.4: The Impact of Conventional Monetary Policy on the Different Parts of Income Distribution

Figure A4.8: The IRFs to a Conventional Monetary Policy Shock (The Model with the 90-50 Ratio)

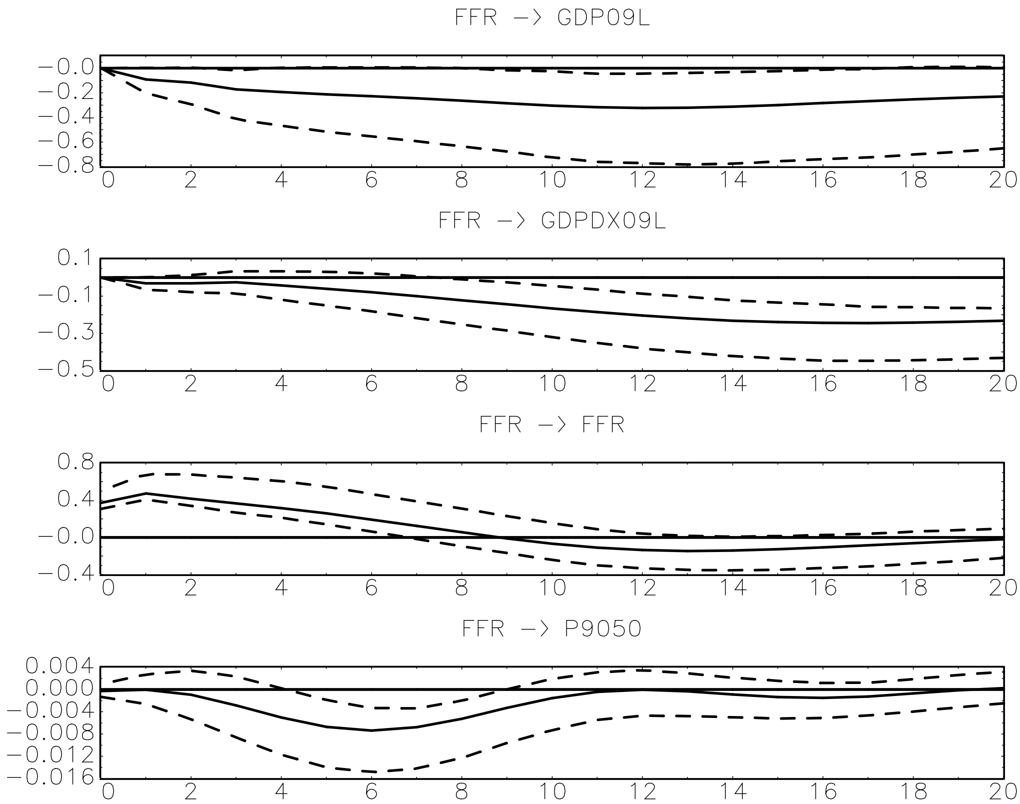
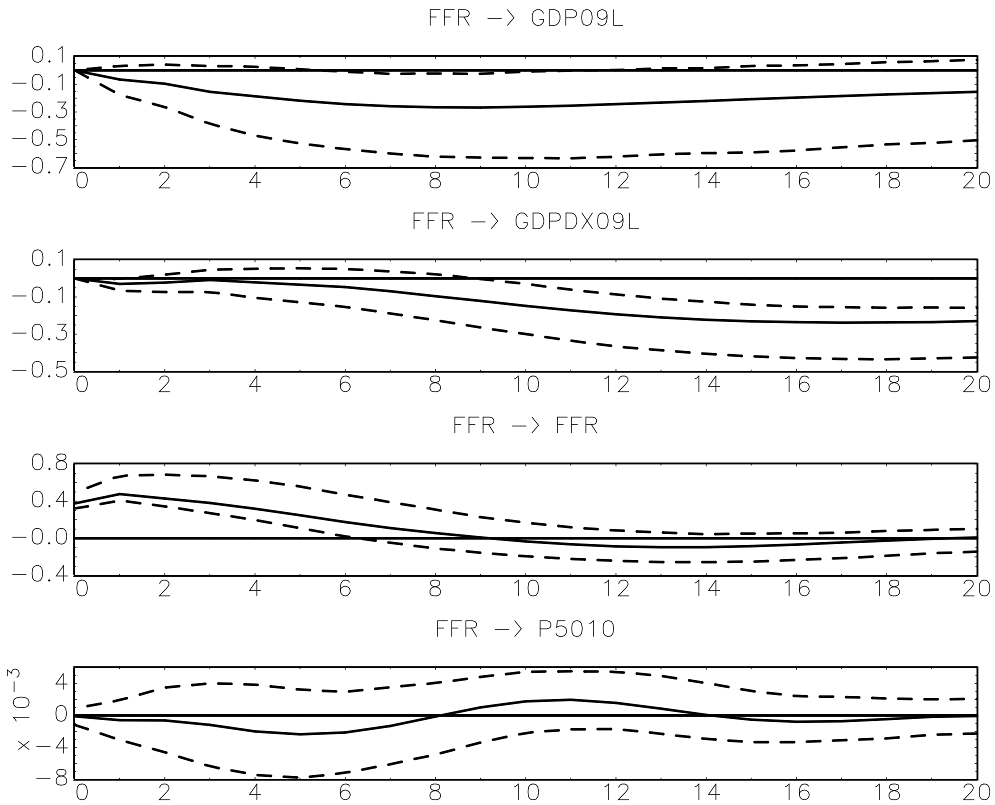


Figure A4.9: The IRFs to a Conventional Monetary Policy Shock (The Model with the 50-10 Ratio)



Appendix 4.5: The Impact of Unconventional Monetary Policy on the Different Parts of Income Distribution

Figure A4.10: The IRFs to an Unconventional Monetary Policy Shock (The Model with the 90-50 Ratio)

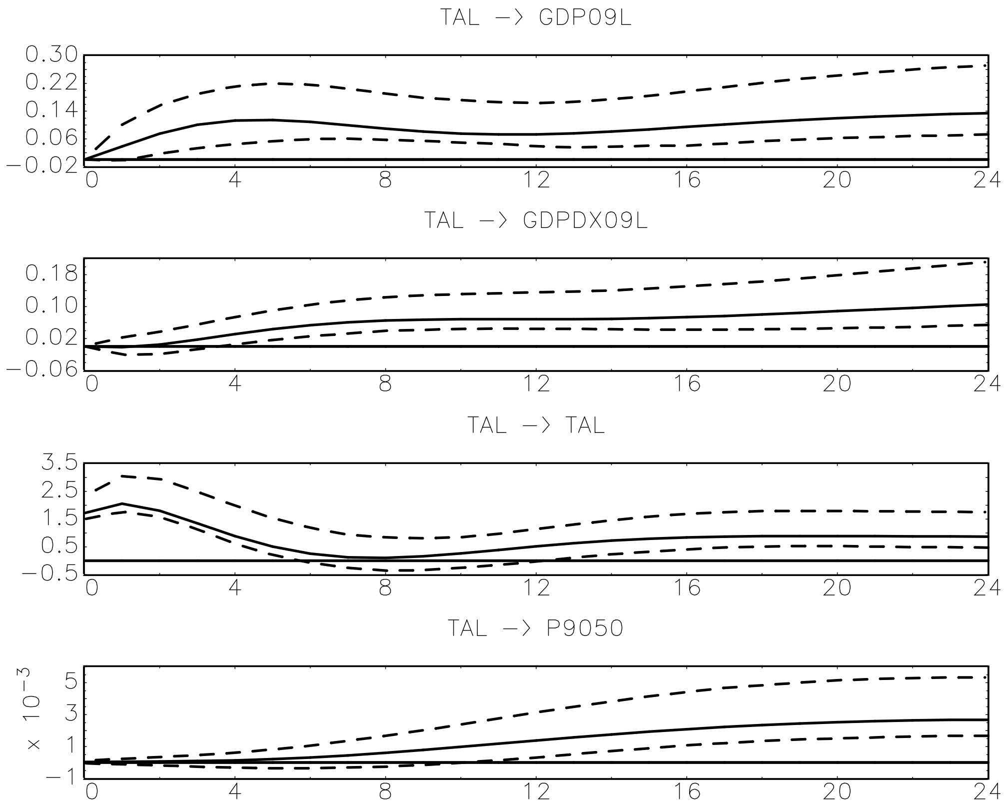
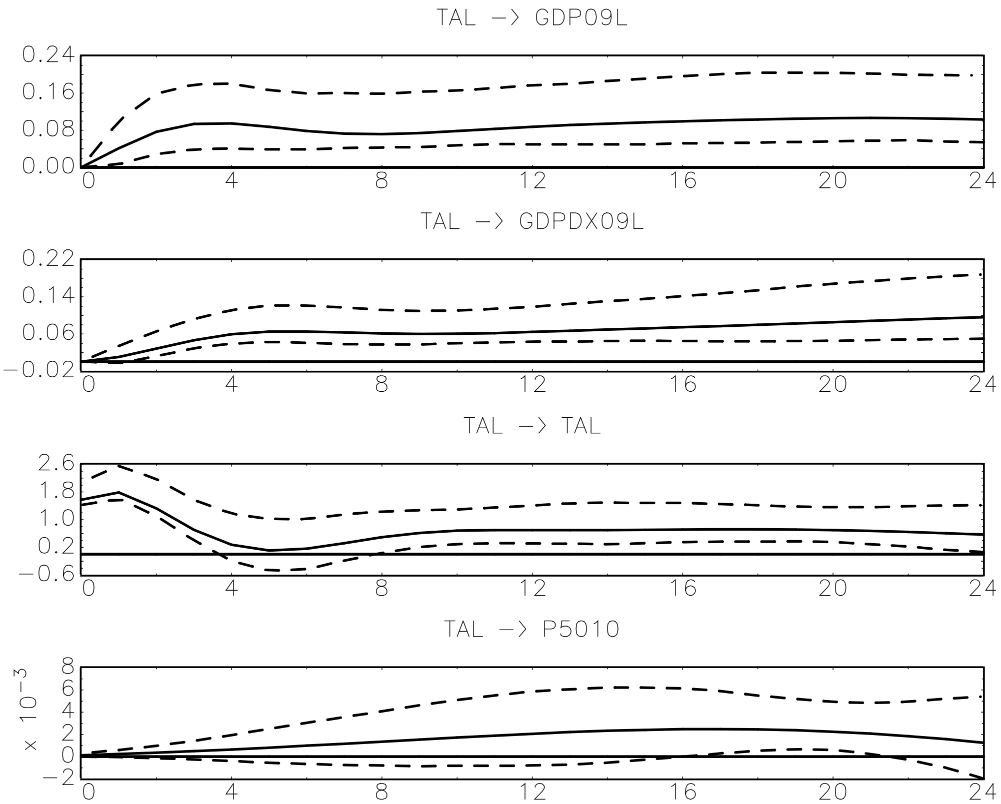


Figure A4.11: The IRFs to an Unconventional Monetary Policy Shock (The Model with the 50-10 Ratio)



Chapter 5: Concluding Remarks and Future Research

5.1. Conclusion and Future Research

In line with its general objective, the doctoral thesis has explored the distributive effects of macroeconomic policies. First, it has examined the distributional effect of fiscal policy through studying the interrelations among economic growth, income inequality, and fiscal performance. Next, the distributive effect of conventional monetary policy has been evaluated via the long run relationship among the income inequality measure and macroeconomic variables. Finally, the distributional impact of unconventional monetary policy measures in comparison with the distributive effect of conventional monetary policy has been analyzed. All these findings are summarized below with the corresponding lines of future research.

Chapter 2 examines the interrelations among economic growth, income inequality, and fiscal performance for the UK, the USA, and Canada. These interrelations as well as channels among them are studied through structural VAR models. As channels among those variables, government spending, investment, and taxes are considered. The longest possible consistently measured data on income inequality are employed for the estimations, providing new evidence on the interrelations among growth, inequality, and fiscal performance.

The conducted empirical analysis reveals that there are generally some differences in the obtained results for the UK, and the USA and Canada. This might be explained by the differences between the UK and the Anglo-American economic models. The UK probably shares some common features with European continental economic models since it has comparatively higher level of taxation and spending on the welfare state. In particular, Income inequality negatively affects economic growth in the case of the UK. The corresponding effect is positive in the cases of the USA and Canada. At the same time, income inequality generally reduces government net lending/borrowing for all the countries.

The obtained results also reveal that economic growth leads to the increase of income inequality in the case of the UK and to the decline of inequality in the cases of the USA and Canada. On the other hand, economic growth improves government net lending/borrowing for all the countries. Due to the direct positive effect of investment on economic growth, its impact on the other variables is mostly similar.

The results also show that government spending reduces income inequality in the UK but it raises inequality in the USA and Canada. At the same time, government spending decreases economic growth through crowding out and worsens fiscal performance for all the countries. Thus, the general government spending in the USA and Canada is not an efficient fiscal policy measure for the reduction of income inequality. The distributional impact of government spending might depend on its composition.

According to the obtained results, tax revenues generally raise income inequality in all the considered countries. That is, the effect of indirect taxation outweighs since it generally increases income inequality, in contrast to direct taxation. Thus, this effect should be taken into account, especially during the consideration of taxation as a financial source for government spending.

Based on the obtained results of Chapter 2, new research lines arise. To find out the actual effects of direct and indirect taxes on income inequality, the taxes can be disaggregated. Instead of total government spending, a more specific fiscal policy measure, designed for the reduction of inequality, could be considered. For instance, social benefits and social transfers in kind might be employed. Then, the empirical analysis can be redone with these new fiscal policy measures. In addition, Solt´s database for the imputed inequality measures (Solt, 2009) could be used to consider the panel of countries for an analogous analysis.

The empirical analysis of **Chapter 3** is implemented according to its objective to evaluate the distributional effect of monetary policy. The empirical analysis is carried out for the USA, using the data in an annual frequency. The chapter employs an inequality measure that represents the whole distribution of income. The time series of the considered variables are observed and confirmed the statement in the literature (e.g., Cutler and Katz, 1991; Galli and von der Hoeven, 2001) that there was a structural break in the relationship between income inequality and macroeconomic variables in the USA in around 1983. Therefore, the estimation sample covers the time period after this year.

Monetary policy affects prices and real economic activity, at the same time, having redistributive impact (Nakajima, 2015). To control for these main effects of monetary policy, the chapter incorporates GDP deflator and real GDP into the considered models. As a monetary policy tool, the federal funds rate is used. In order to evaluate the distributional effect of monetary policy, Gini index of disposable income is generally used in the empirical analysis. The consideration of Gini index based on after tax net income allows controlling for the distributional effects of fiscal policy.

A comprehensive cointegration analysis is implemented over the examined time period. The chapter finds a cointegration relation among real GDP, the federal funds rate, GDP deflator, and Gini index. Consequently, the VECM and the equivalent VAR representation are used in the empirical analysis to model the time series. As an empirical tool to evaluate the distributive effect of monetary policy, the IRFs of the considered models are explored. In particular, the chapter examines the responses of the variables to contractionary monetary policy shocks. In line with the objective of the chapter, a special emphasis is placed on the examination of the responses of income inequality.

Monetary policy shocks are identified by different approaches. Within the scheme of contemporaneous identification, the chapter applies exogenous monetary policy shocks proposed by Romer and Romer (2004) and updated Coibion et al. (2012). In the framework of long run identification, the chapter uses the method suggested by Blanchard and Quah (1989). The results obtained by these identification approaches indicate that contractionary monetary policy reduces income inequality measured by Gini index and the 90-10 percentile ratio. Taking advantage of the existence of the cointegration relation among the considered variables, the chapter identifies the IRFs through the VECM framework. The corresponding IRFs show that a contractionary monetary policy shock decreases Gini index of income inequality up to 0.4 percentage points. Thus, the implementation of contractionary monetary policy could reduce the overall income inequality in the country. It might be another effective policy tool to decrease inequality. Therefore, combined policy measures should be implemented by taking into account the interactions between fiscal and monetary policies, and the potential various outcomes when these different policy instruments are applied.

The natural line of future research for Chapter 3 is the exploration of the long run relation among the considered variables for other countries. It would be even more interesting to check the existence of the cointegration among the variables for the panel of countries. Further research could also be implemented on a country level. For instance, there are available data on income inequality at a state level for the USA (Frank, 2014). Using these data, the convergence of income inequality levels among the states can be explored.

In accordance with its objective, **Chapter 4** evaluates the distributive effects of conventional and unconventional monetary policies in comparison with each other. The empirical analysis in the chapter is conducted for the USA. The distributive effects of conventional and unconventional monetary policies are assessed through the IRFs and the variance decomposition identified by the contemporaneous restrictions. Specifically, conventional monetary policy shocks are contractionary while unconventional monetary policy shocks are expansionary.

In the baseline case of the conventional monetary policy model, the obtained results show that a contractionary monetary policy shock reduces Gini index of income inequality. In the baseline case of the unconventional monetary policy model, the estimated IRFs indicate that an expansionary monetary policy shock raises Gini index. In particular, the results show that the distributive effect of conventional monetary policy is stronger. Nevertheless, in the both cases, the distributional effects of monetary policy are significant. Moreover, they are also robust for the different variations and extensions of the baseline models.

The chapter also assesses the impact of conventional and unconventional monetary policies on the different parts of income distribution. The obtained IRFs demonstrate that conventional and unconventional monetary policies significantly increase inequality in the upper part of income distribution measured by the 90-50 percentile ratio. The results also indicate that the contractionary effect of conventional monetary policy on the lower part of income distribution (measured by 50-10 percentile ratio) is not significant. However, the expansionary impact of unconventional monetary policy on the lower part of income distribution is significant.

The empirical analysis of the chapter also includes the variance decomposition of Gini index due to conventional and unconventional monetary policy shocks. The obtained results show that the unconventional monetary policy shock explains the higher share of the variation in Gini index of income inequality than the conventional monetary policy shock. Thus, the distributive impact of unconventional monetary policy should be taken into account during the design of the macroeconomic policies aimed to reduce income inequality.

The analysis in Chapter 4 opens the door for further research in this area. First of all, the distributive effects of conventional and unconventional monetary policies could be assessed through different channels, and their relative contribution might be evaluated within each policy. Next, different economic inequality measures can be employed for assessing the distributive impact of conventional and unconventional monetary policies. In particular, inequality measures of wages could be used based on high frequency data on labor earnings from Center for Economic and Policy Research (2015). In addition, conventional and unconventional monetary policy shocks can be identified by alternative methods. For instance, it will be interesting to identify an unconventional monetary policy shock using zero and sign restrictions and compare the results with the ones presented in this thesis.

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