Monetary and Fiscal Policy Interactions: National and International Empirical Evidence

Marzieh Assadi

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Supervisors: Professor Joseph Byrne
Professor Ronald Macdonald

Examination Committee: Professor Christian Ewald
Professor Gabriel Talmain
Professor Giorgio Fazio

Abstract

This thesis is comprised of six Chapters on US Conventional and Unconventional Monetary Policy and their interaction with fiscal policy, both domestically and internationally. Chapter 1 introduces the main themes of the thesis. Chapter 2 studies the theoretical background of the thesis. After setting out key themes and the theoretical background in the introductory Chapters, the first core Chapter, i.e. thesis Chapter 3, examines the interaction between fiscal and monetary policy. Price puzzles are a repeated feature of empirical VAR models studying the effect of monetary policy. These price puzzles are often believed to appear due to the lack of information. However, we show that whether monetary and fiscal policy are active or passive influences the appearance of the price puzzle. This is because an active fiscal policy and a passive monetary policy can encourage private expenditure through a positive wealth channel. An active fiscal policy means fiscal authorities set expenditure regardless of tax revenues, while a passive monetary policy refers to a weak response of the policy interest rate to inflation. Finally, we find evidence in this Chapter that fiscal policy stimulates economic activity, i.e. it is non-Ricardian. Chapter 4 examines the effect of monetary and fiscal policy interactions in an international context. In particular, it considers the international spillovers of US monetary policy, whilst account for fiscal policy. This Chapter shows that US government debt influences the duration of the responses to a monetary contraction. Furthermore, it is shown that an increase in US government debt influences both the short and long-term interest rates, inflation, and output in the Euro Area and UK. This is through a positive wealth effect. In addition, the results of Persistence Profiles test, i.e. how fast we converge upon equilibrium following a shock, suggest that accounting for US government debt delays the return to equilibrium following monetary policy shocks. This may be due to the impact of fiscal policy on inflation and its persistence. Chapter 5 studies Unconventional Monetary Policy (UMP). It is shown that UMP increases output and inflation in the US, and generates spillovers to the Euro Area and UK. Furthermore, we present evidence that the portfolio balance is the transmission channel of UMP. That is UMP contributes to lowering the bound yields while it increases the price of assets. Chapter 6 concludes and summarizes the thesis, and provides a discussion of policy implications.

In The Name of Existence and Wisdom Lord
to Nothing Sublime Can Thought Be Applied

(Ferdowsi, 935-1020)

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I am indebted my entire life to my parents whom thought me how to live a charged life and put all my effort and courage to overcome obstacles.

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I must praise the almighty God for the enormous blessings bestowing upon me all the way through my life and studies. I wish to cherish the gift of life by living it gratefully.

Declaration

I declare that this thesis is a record of the original work carried out by myself under the supervision of Professor Joseph Byrne and Professor Ronald MacDonald at the University of Glasgow, United Kingdom. The copyright of this research belongs to the author under the terms of the United Kingdom copyright acts. Due acknowledgement must always be made of the use of any material contained in, or derived from this thesis. The thesis has not been presented elsewhere in consideration for a higher degree. Marzieh Assadi

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Chapter 1

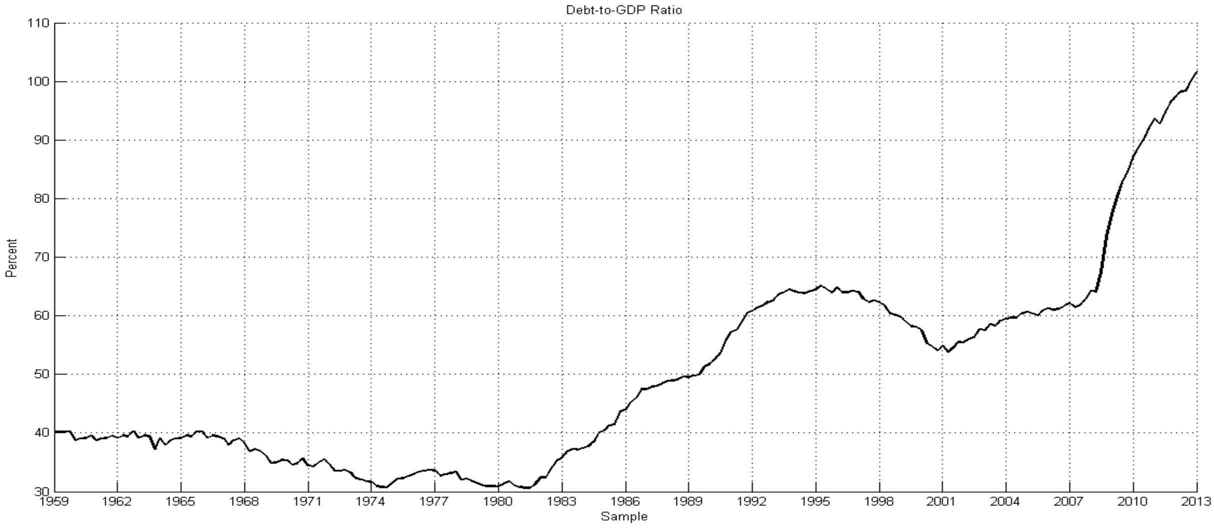
Introduction

1.1 Motivation and Research Questions

An important economic issue facing policymakers over the past decades has been the interaction of monetary and fiscal policy. US fiscal policy can be illustrated by the government debt-to-GDP ratio. This has risen from 35 percent in 1970 to 100 percent in 2013, see Figure 1.1. This occurrence poses a classic question: how does government debt affect the economy? In particular, what are the potential implications of government debt for monetary policy? Macroeconomists are divided on the answer: fiscal policy does not matter for monetary policy, says the Ricardian view, and fiscal policy does matter for monetary policy, says the non-Ricardian view. The crucial importance of taking into account the potential interaction between monetary and fiscal policy for good policy-making is further emphasised in Sims (2011): "there is no excuse for econometric models intended for monetary policy analysis to continue to omit serious treatment of fiscal behaviour".

The standard textbook theories suggest that the key outcome of monetary policy such as inflation and output may be affected by the debt accumulated mainly through the interest rate, see Mishkin (1995). For example, an increase in the real interest rate shall reduce demand, inflation, and output in the short-run. On the other hand, an increase in government debt may also have implications for the level of interest rates. Hence, this thesis examines the empirical evidence on the interactions of monetary and fiscal policy. It deals with various aspects of monetary policy concerning the influence of government debt on the impact of monetary policy shocks.

Figure 1.1. US Government Debt as a Share of GDP



Notes: This Figure presents US Government Debt-to-GDP ratio over the period 1959:Q1-2013:Q2. Data are taken from the St Louis Fed FRED database as detailed in Appendix 3.A.

Moreover, the outcome of monetary policy may change over time depending upon whether fiscal policy is active or passive. Fiscal policy is active if the fiscal authority set its expenditure regardless of the government's intertemporal budget constraint. Fiscal policy is passive if the fiscal authority adjusts tax revenues to satisfy the balanced budget requirements. The study seeks to examine the way that monetary policy interacts with active and passive fiscal policy.

Further to the potential implications of the fiscal stance for monetary policy, another challenge regarding the conduct of monetary policy concerns its effectiveness at the zero lower bound. The zero lower bound on the interest rates has challenged Conventional Monetary Policy first in the early 2000s in Japan, and then after the 2008 financial crisis in the most advanced economies. This necessitates the use of non-standard monetary measures, namely Unconventional Monetary Policy. It accounts for examining the impact of both conventional and unconventional forms of policy in monetary studies. This is another scope that our thesis explores.

Finally, it is also important to consider potential interactions between monetary and fiscal policy in an international context. As nations throughout the world are increasingly globalized, it is often argued that domestic macroeconomic variables such as output, inflation, and interest rates are significantly influenced by the world economy. In a global context, openness particularly alters the sensitivity of the macro variables to domestic and foreign policy shocks. As discussed in Gali (2008), openness influences matters in two ways: (i) increasing the sensitivity of output and inflation to changes in the term structure of interest rates, and (ii) relating the natural interest rates to global output and inflation. Moreover, in a global environment the direct negative effect of an increase in real interest rates on aggregate demand and output can be amplified through the exchange rate channel. Consequently, the interest rate rise will appreciate the domestic currency and switches expenditure towards foreign goods. Openness may also reduce the impact of monetary policy under external shocks. For example, an increase in the commodity prices shall reduce the power of domestic monetary authorities to control inflation.

Hence, globalization raise these two crucial questions, which this thesis attempts to address. First, to what extent have international forces affected the impact of monetary policy? Second, does a change in US interest rates have a smaller domestic impact once we account for international spillovers? To address these questions, this thesis attempts to provide an empirical assessment of the possible changes in the impact of monetary policy due to foreign macro-finance variables.

Overall, our thesis poses the following questions. Does monetary and fiscal policy interactions influence the real economy? If so, what is the transmission mechanism by which these effects occur? Are there any international spillovers associated with the macroeconomic policy interactions? What are the domestic and international impact of unconventional monetary policy? The existing literature mainly focuses on the domestic impact of US monetary and fiscal policy interactions, see for example Bradley (1984), Muscatelli et al. (2004), Chung et al. (2007), Davig and Leeper (2007, 2011), Canzoneri et al. (2011), Ramey (2011), Sims (2011), Leeper and Walker (2012), and Woodford (2012). However, those studies which are conducted in global context, ignore the potential contribution of the fiscal stance to the monetary transmission mechanism, see for example Dees et al. (2007), Pesaran and Smith (2012), and Gambacorta et al. (2014) among others. Furthermore, previous studies about unconventional monetary policy focuses upon the domestic impact of the policy, see for example work by Baumeister and Benati (2010), Gagnon et al. (2011), Kapetanios et al. (2012), Joyce et al. (2011, 2012), Pesaran and Smith (2012), Gambacorta et al. (2014), and Wu and Xia (2014).

We aim to investigate these controversial questions and present new empirical evidence within three core empirical Chapters. The next section explains the structure of our thesis.

1.2 Thesis Structure

This thesis overall comprises six Chapters. The core Chapters intend to explore different aspects of the research questions using a variety of appropriate methodological approaches, motivated by the theoretical literature. Table 1.1 summarises the econometric methods used in the empirical Chapters to investigate our key research questions. This introductory Chapter is followed by a literature review Chapter to provide an insight into the related theories for the work. Given that we study the way that government debt and globalization may influence the interaction between monetary policy, both conventional and unconventional, and fiscal policy, we provide a review of the relevant theories supporting the individual Chapters. Finally, Chapter 6 concludes the thesis together with commenting on the limitation of the study and potential directions for further research. A preview of the main contribution of each Chapter can be seen from Table 1.2. The follow subsections briefly describe our empirical Chapters.

1.2.1 Chapter Three: Scope and Contribution

We pursue two main objectives in Chapter 3. First, we examine the way in which the interactions between monetary and fiscal policy influence inflation and output dynamics in the US. Second, we study the extent to which the fiscal stance may influence the impact of monetary policy shocks at different time periods. For these purposes, the study applies Factor-Augmented VAR (FAVAR) and Time-Varying Parameter FAVAR (TVP-FAVAR) methods to examine US monetary and fiscal policy interactions.

Table 1.1. Summary of Econometric Methods

	Methodology	Economies of Interest	Time Span
Chapter 3	FAVAR and TVP-FAVAR	US Economy	Quarterly time series spans 1959:Q1-2013:Q2
Chapter 4	GVAR	US Economy plus 13 Major Economies	Quarterly time series spans 1979:Q2-2013:Q2
Chapter 5	FAVAR and GVAR	US Economy plus 13 Major Economies	Monthly time series spans 2007:M06-2013: M06

Note: This Table outlines the applied methodologies in the core empirical Chapters. FAVAR stands for Factor-Augmented VAR. TVP-FAVAR stands for Time-Varying Parameter FAVAR. GVAR stands for Global VAR.

The FAVAR modelling approach, pioneered by Bernanke et al. (2005) and Stock and Watson (2005), summarizes a large number of macroeconomic time series into a relatively small number of factors. The key insight of the FAVAR approach is that it is possible to take account of almost all relevant information for policy analysis. For example, price puzzles that is found in the existing empirical literature, counter-intuitively, suggest that inflation may initially rise with a contractionary monetary policy, see Bernanke et al. (2005). We provide empirical evidence from our FAVAR model to interpret the price puzzle. That is prices can increase in response to a monetary contraction in the presence of government debt by generating a positive wealth effect. This positive wealth effect can induce aggregate demand to increase through private consumption leading to a rise in inflation.

We also consider macroeconomic policy performance within a TVP-FAVAR method. We do so because over the past four decades monetary and fiscal policy regimes have changed a number of times. For example, monetary policy responded weakly to inflation before Paul Volcker while the response was stronger post Paul Volcker. Thus, the macroeconomic dynamics over this period cannot solely be described by a linear model. There is increasing use of TVP methods when considering macro outcomes, for example see Primiceri (2005), and Koop and Korobilis (2010). We go beyond these existing studies by accounting for fiscal variables in a TVP-FAVAR model. The impulse response from our fiscal-augmented TVP-FAVAR model also provide evidence that fiscal policy can contribute to producing a price puzzle through generating a positive wealth effect. The price puzzle is more accentuated in the case of an active fiscal policy and a passive monetary policy.

Table 1.2. Contribution to the Literature

	Main Contribution	Methodology
Chapter 3	(i) The price puzzle appeared in response to US monetary contraction tends to be more accentuated when an active fiscal policy coordinated with a passive monetary policy, (ii) US government debt influences the monetary transmission mechanism through generating positive wealth effect, (iii) US fiscal policy appeared to be consistent with the non-Ricardian view.	FAVAR and TVP-FAVAR
Chapter 4	(i) US government debt influences the duration of the responses to a monetary contraction, (ii) US fiscal policy seems to be more consistent with the non-Ricardian view, (iii) US government debt induces a decrease in the convergence rate to equilibrium following the policy shocks.	GVAR
Chapter 5	(i) US-UMP seems to be effective in increasing US inflation and output, (ii) US-UMP can generate international spillovers to the Euro Area and UK, and to stimulate their economies, (iii) US-UMP seems to be transmitted through the portfolio balance channel both domestically and internationally.	FAVAR and GVAR

Note: This Table summarizes the main contribution of the thesis with the related literature. UMP stands for unconventional monetary policy. FAVAR stands for factor-augmented VAR. TVP-FAVAR stands for time-varying parameter factor-augmented VAR. GVAR stands for global VAR.

Chapter 3 seeks to contribute to the empirical literature on monetary and fiscal policy interactions in the following ways. First, we provide empirical evidence to interpret the price puzzle within both the FAVAR and TVP-FAVAR methods. Comparing the estimated impulse responses to a contractionary monetary policy shock, within both the simple and fiscal-augmented FAVAR models, suggest that government debt can produce the price puzzle. It can be explained as government debt influences the monetary transmission mechanism through generating positive wealth effect and increasing consumption, consequently. Further investigation within the TVP-FAVAR model, which accounts for different periods of monetary and fiscal dominance suggest that the price puzzle is more accentuated in the case of an active fiscal policy and a passive monetary policy. This influences the monetary transmission mechanism through generating a positive wealth effect. Thirdly, the estimated impulse responses within both FAVAR and TVP-FAVAR provide empirical evidence for the non-Ricardian view on the US fiscal policy. That is we find evidence of inflation and output both responded to the fiscal shock.

1.2.2 Chapter Four: Scope and Contribution

Chapter 4 considers US monetary policy in an international context. It explores the international spillovers of US Conventional Monetary Policy (CMP) in the presence of government debt. We adopt the Global VAR (GVAR) method which is a multi-country model accounting for global shocks through bilateral trade among countries. This approach was developed by Pesaran et al. (2004), and Dees et al. (2007). The GVAR method can be described as a useful method to analyse interactions in the global macroeconomy where both the cross-section and the time-dimensions are large in that some variables are considered as structurally exogenous, see di Mauro and Pesaran (2013), and Chudik and Pesaran (2014). This approach is suitable for policy evaluation in a global environment where the weak exogeneity assumption of foreign variables is required. By weak exogenity we mean that there are no long-run feedback from foreign specific variables to their domestic counterparts, see Pesaran et al. (2004), and Dees et al. (2007).

We argue that US government debt contributes to the persistence of the price puzzle in the global economy. For this purpose, two GVAR models have been constructed, namely a simple and a fiscal-augmented GVAR model. Our fiscal-augmented model includes the potential impact of government debt on the monetary transmission mechanism. We argue that although the short-term interest rate is the key policy transmission channel for both fiscal and monetary policy, under a policy of increasing government debt, however, the interest rate channel can be less powerful. Furthermore, government debt delays the speed of return to equilibrium after a policy shock, compared to a model ignoring monetary and fiscal interactions.

In Chapter 4, we contribute to the empirical literature on the international spillovers of a contractionary monetary policy shock in a number of ways. First, we show that US government debt influences the duration of responses to a monetary contraction, in particular the price puzzle. Second, the impulse responses of an expansionary fiscal policy support the non-Ricardian view on fiscal policy within US economy. This policy shock also appears to generate expansionary effects to the economies of interest. Third, the results of Persistence Profiles (PP) test suggest that government debt induces a decrease in the convergence rate to equilibrium following the policy shocks compared with the otherwise model specifications.

1.2.3 Chapter Five: Scope and Contribution

In Chapter 5, we explore the domestic and international impact of US Unconventional Monetary Policy (UMP). Reflecting on our motivation in this Chapter, the analysis is conducted using the FAVAR and GVAR frameworks while accounting for US government debt. The study pursues two objectives. First, to examine the effectiveness of US-UMP from both a domestic and global perspective. Second, to investigate the transmission mechanism of US-UMP and its potential international spillovers. The study attempts to add further evidence supporting the effectiveness of UMP implemented in the US. Our Chapter 5 also discusses the international spillovers of UMP suggesting US-UMP has influenced the Euro Area and UK economies.

Our contribution in Chapter 5 are in three ways. First, within a FAVAR model we show that US-UMP increased output and inflation. Second, having estimated the impulse responses results within the GVAR model, we find that US-UMP has increased output and inflation both in the US, Euro Area and UK economies. Third, the portfolio balance is validated as the transmission channel of the policy implemented. This means that UMP may cause a reduction in the bond yield spread and a rise in the asset prices leading to a positive wealth effect.

Chapter 2

Literature and Methodological Review

Abstract

The subject matter of this thesis is to explore the conduct of monetary policy, in both conventional and unconventional forms, and the way that it can be influenced by the fiscal stance. The investigation concerns both the domestic impact of monetary and fiscal policy interactions and its international spillovers. To do so, this conceptual Chapter attempts to provide an insight into relevant theories to establish a theoretical background for the empirical chapters. The Chapter consists of two sections. First, we study the theoretical background required for our empirical analysis. That is the macroeconomic impact of monetary and fiscal policy and their interactions. Second, we review the literature on the applied macro econometric methods. Our methodology section focuses on the recent development in the VAR literature and their applications for our study.

Keywords: Conventional Monetary Policy, Unconventional Monetary Policy, Ricardian Equivalence, the Fiscal Theory of the Price Level, Monetary and Fiscal Policy Interactions, Time-Varying Parameter Factor-Augmented VAR, Global VAR.

JEL Classification Codes: C4, E4, E5, E6, F5, H3.

2.1 Introduction

John Maynard Keynes presented in 1936 pioneering work on monetary and fiscal policy, particularly to describe the Great Depression. Up to 1970s, the general consensus was that discretionary fiscal policy mitigated the aftermath of the Great Depression and helped stabilization policy. Indeed, both fiscal and monetary policies were considered as two instruments to achieve macroeconomic goals. However, during the three past decades up to the 2008 financial crisis, theoretical and empirical work raised serious doubts about fiscal policy abilities to accomplish counter-cyclical stabilization, see Blinder (2004).

During the 1970s, there were greater emphasis on monetary economics within macroeconomics. Several reasons contribute to switching from active fiscal policy to focusing on debt sustainability and passive fiscal rules.[1] Particularly, the seminal work of Lucas (1972) provides theoretical foundations for models of economic fluctuations in which money was the fundamental driving factor behind movements in real output in the short-run. Then, the rise of Real Business Cycle (RBC) models during the 1980s and early 1990s, based on the work of Kydland and Prescott (1982), changed the focus to non-monetary factors as the driving forces of the business cycle. Since then, the RBC models have been employed to integrate monetary factors into Dynamic Stochastic General Equilibrium (DSGE) models in order to investigate the aggregate economy. As Walsh (2010) explains, the rigidities of New Keynesian (NK) models have been combined with Rational Expectations (RE) and the RBC methodology to produce DSGE models. It makes the NK models capable to capture the way that peopleˈs expectations and microeconomic behaviour may change in response to policy interventions.

Note that, the NK models assume that all households are forward-looking and optimize their spending decisions. It implies that the Ricardian view on fiscal policy holds within the NK

[1] Blanchard et al. (2010) explain that the key factors in focusing on monetary policy included the ability of monetary policy to maintain a stable output gap, development and integration of financial markets that emphasis the effectiveness of monetary rather than fiscal policy, lags in the design and implementation of fiscal policy compared with monetary policy, and Ricardian Equivalence arguments. Ricardian Equivalance states that a certain type of fiscal policy may not affect the economy, see for example Cochrane (1999), and Christiano and Fitzgerald (2000).

framework. The Ricardian view refers to a situation in which taxes adjust to ensure the government budget constraint, see Elmendorf and Mankiw (1999), Cochrane (1999), and Christiano and Fitzgerald (2000). In contrast, the traditional Keynesian consumption function is upon the assumption that households follow rule-of-thumb with a high and constant marginal propensity to consume, see Cogan et al. (2010). As is explained in Cogan et al. (2010), Keynesian consumers spend all their after tax income whereas the NK forward-looking consumers take into account any expected future earnings and taxes to optimize their spending decisions. Thus Keynesian consumers' expenditure may account for a non-Ricardian view as they consider their lump-sum taxes.

Having noted these developments in macroeconomics and regardless of the Ricardian or non-Ricardian views, price stability still is an important goal for macroeconomic policy. The standard monetarist doctrine, as a popular argument developed in the theoretical and empirical literature, offers a simple answer. That is inflation stabilization should be a concern of the monetary authority with an independent Central Bank. The main justification for analysing monetary policy isolated from fiscal policy lies in the Quantitative Theory of Money that argues inflation is a monetary phenomenon. However, an alternative view argues that the goal of price stability requires both monetary and fiscal policy to coordinate effectively to achieve the policy target, see Christiano and Fitzgerald (2000), and Leeper (2013). As mentioned in Christiano and Fitzgerald (2000), Michael Woodford has called this alternative view on the importance of fiscal policy in the determination of prices as the Fiscal Theory of the Price Level (FTPL).

The FTPL states that fiscal policy affects the price level and that an independent Central Bank is not sufficient to ensure inflation stabilization, see Cochrane (1999, 2001, 2009), Leeper (1991, 2013), Sims (1994, 1997, 2011), and Woodford (1996, 1998). The theory requires the government to run a balanced budget during the business cycles for the price levels to be stable. Note that as Christiano and Fitzgerald (2000) discuss, the difference between the conventional view and the FTPL is related to the way that the government's intertemporal budget equation is viewed. When the Ricardian view considers the government budget as a constraint, the FTPL holds it as a condition for the equilibrium.

Thus, the mainstream argument in macroeconomic policy management holds that monetary policy should be relied upon as the primary policy tool while discretionary fiscal policy can play an important rule under unusual circumstances such as a recession or when short-term interest rates hit the Zero Lower Bound (ZLB), see Blinder (2004). However, some argue that a credible model for analysing policy should be informative of both monetary and fiscal policy, see Curdia and Woodford (2009), Pesaran and Smith (2011), and Sims (2011). In particular, Sims (2011) emphasises that monetary policy has a limited role as a determinant factor of the price level, while fiscal policy has an important implication for prices and the aggregate economy.

Given the objective of this thesis that is to examine the way that US fiscal policy may influence the conduct of monetary policy and its potential international spillovers, this Chapter reviews the related literature. First, we shall review standard theories explaining the impact of monetary policy, both conventional and unconventional, on the real and nominal economy. Then, public finance shall be discussed followed by a brief review of the implication of monetary and fiscal policy interactions for inflation and output. Finally, we consider reviewing the applied methodologies.

2.2 Conventional Monetary Policy

Monetary economics studies the relationship between real variables such as output and employment with nominal variables such as inflation, interest rates, the exchange rates, and money supply.[2] The focus of monetary economics is to provide an insight into how to achieve optimal monetary policy, see Walsh (2010). Monetary policy is mainly concerned with why and by which means the monetary authority controls the supply of money and/or the setting of short-

[2] The classical dichotomy holds that real and nominal variables must be analyzed separately. In particular, this means that real GDP and other real variables can be determined without knowing the level of the nominal supply of money or the rate of inflation. It implies that money is neutral and can only affect the price level and not real variables, see Patinkin (1965). Keynesian and Monetarists reject the classical dichotomy. They argue that prices are sticky implying that in the short-run prices fail to adjust. Thus, any changes in the money supply can alter real macroeconomic variables, as well as nominal variables.

term interest rates. Until recently, monetary policy in advanced economies targets interest rate with the purpose of promoting economic growth, and with the official goal of stable prices and low unemployment, see Bernanke (2013). While it is widely accepted that Central Banks should be responsible for implementing monetary policy, it can also be performed by the Treasury or by a large commercial bank entrusted with the government's tax revenue, see Bordo (2008) for a historical survey of the related literature.[3]

The earlier form of monetary policy was gold standard that the key role of Central Banks was to maintain gold convertibility. Central Banks also utilized their discount rate to adjust external shocks through the balance of payments.[4] After World War I, the gold standard was restored, but emphasis was placed by Central Banks on the domestic objectives of stable prices, output, and employment. After the gold standard, the world has gradually shifted to a fiat money regime.[5] Thus, the focus of monetary policy has shifted from gold convertibility to economic stability. Then, under the 1944 Bretton Woods Agreement, countries maintained a pegged exchange rate allowing Central Banks to intervene in the foreign exchange market with the predominant goal of domestic full employment.[6]

The collapse of Bretton Woods, between 1971 and 1973, ended any connection of the monetary regime to gold.[7] This moved the world to a pure fiat regime in which domestic stability

[3] According to Bordo (2008), the initial motivation for instituting Central Banks has been the fiscal revenues managements. Then it has turned to follow the gold standard rules in order to manage the swings in interest rates induced by the business cycles. Although the early Central Banks had placed the primary weight on their commercial activities, since World War I onwards, they shifted their focus to public objectives in terms of stimulating the economy and to facilitate the Treasury's debt management. Monetary policy in its current state launched by Central Banks in the form of discounting the paper of other financial institutions, both government debt and commercial paper. The interest rate at which Central Banks would lend based on their collateral became known as bank rate or discount rate. By altering this rate, Central Banks could influence credit conditions at both national and international levels, see Bordo (2008).

[4] For example, in the case of a deficit in the balance of payments, gold would tend to flow abroad inducing Central Bank's gold reserve to reduce. Thus, Central Bank would require raising its discount rate. This in turns would lower aggregate demand and offset the deficit. It would also stimulate a capital inflow. The opposite set of policies was to be followed in the case of a surplus.

[5] According to Bernanke (2013), the main reason for ending the gold standard period was that the commitment might have constrained monetary policy in a way that it did not allow highly expansionary policies that was needed.

[6] The Bretton Woods Agreement evolved into a dollar-gold exchange standard in which member currencies were convertible on a current account basis into dollars, and the dollar was convertible into gold, see Bordo (2008), and Bernanke (2013) for further details.

[7] Bordo (2008) explains that the Bretton Woods System collapsed mainly due to the inflationary policy pursed by the US, as the dominant economy, to finance both the Vietnam War and the Great Society project.

joined with the Philips Curve. This led to focus on maintaining full employment at the expense of inflation. The induced Great Inflation of the 1970s was eventually ended in the 1980s by implementing an active monetary policy. Since then the goal of low inflation and sustainable economic growth has been pursued by Central Banks, see Orphanides (2003), Bordo (2008), and Bernanke (2013). According to the literature, between the 1980s to early 2000s, US monetary policy approximately followed a monetary rule, i.e. Taylor Rule, to achieve its goals, see Taylor (1993), and Taylor and William (2010). Then, collapses in output and weak inflation necessitated a fall in nominal interest rates beyond the zero lower bound. Thus, the ability of monetary policy to stabilize the economy through Open Market Operations is sharply diminished and it is no longer possible to reduce the real interest rate further to counteract deflationary pressures.[8]

To understand how Conventional Monetary Policy works, next we explain CMP instruments followed by its transmission channels. Then we study the zero lower bound as the main limitation on the effectiveness of CMP.

2.2.1 Instruments and Objectives

Conventional Monetary Policy can be implemented mainly using discount rate, the minimum reserve requirements imposed on banks, and Open Market Operations.[9,10] The discount rate is the interest rate in which Central Banks charge commercial banks and other depository institutions on loans they receive. Under the minimum reserve system, banks are required to hold compulsory deposits with Central Banks. The amount of the required reserves are determined by

[8] Under extreme conditions, a deflationary cycle can develop leading to a decrease in inflation endogenously and raising the level of the real rates. This in turns would cause demand to weaken and push inflation down raising the real interest rate even further. With the monetary authority powerless to stop this downward spiral through conventional Open Market Operations, the deflationary episode ends only if Central Banks implement some other stimulus to spending, namely the non-standard policy measures such as massive purchases of long-term securities, see Clouse et al. (2000), Goodfriend (2000), and Reifschneider and Williams (2000).

[9] Some argued that the use of discount rate by the Federal Reserve to end the inflation induced by the post-World War I, was the main factor responsible for the Great Recession, see Bindseil (2004), and Bordo (2008). In addition, the Federal Reserve policy of doubling reserve requirements in 1936 had been blamed for the late 1930s recession, see Bordo (2008).

[10] Open Market Operations were first developed in the 1870s by the Bank of England. Then, during the 1930-40 decades, various types of controls and regulations such as margin requirements on stock purchases, selective credit controls on consumer durables, and interest rate ceilings, were utilized in conjunction with the downgrading of monetary policy. The return to traditional monetary policy in the 1950s placed Open Market Operations in a dominant position again, see Bindseil (2004), Bordo (2008), and Bernanke (2013).

the size and composition of the liabilities on the balance sheet of the bank concerned. The minimum reserve system serves two main purposes: (i) to create sufficient structural demand for Central Banks' credit, and (ii) to contribute to the stabilisation of money market interest rates, see Bindseil (2004), and Bordo (2008).

The Federal Reserve moved from the discount rate to Open Market Operation in the early 1920s, and maintained Open Market Operation as its principal tool up to the 2008 financial crisis. Open Market Operation entails influencing either short-term interest rates or the supply of money through purchasing and selling of various financial instruments such as Treasury Bills, Bonds, and Foreign Currencies. Having considered that the demand for money is highly unstable, hence, targeting money supply can lead to a large swings in interest rates. For this reason, monetary officials mainly focus on interest rate stability by targeting interest rates, see Bindseil (2004).

Thus, intervention at the low end of the yield curve has become the general practice for Central Banks. The rationale has been that intervention at the low end would minimizes credit risk, and would assure a smooth transmission of policy actions across the yield curve. Moreover, in normal circumstances, Central Banks have a substantial credibility for maintaining price stability, given that inflation expectations are anchored. Therefore, Central Banks can produce the required real interest rate movements by managing their target for short-term nominal interest rates, see Goodfriend (2000), and Eggertsson and Woodford (2003).

Although monetary policy tools has changed over the time, but the objective of stable prices is still the focus of monetary policy. According to the Federal Reserve Reform Act of 1977, there are three objectives for monetary policy including maximum employment, stable prices, and a moderate long-term interest rates, see Bindseil (2004), Bordo (2008), and Bernanke (2013). While most Central Banks mainly pursue to maintain these objectives, the Great Inflation episode necessitated a changed view on the dual mandate as the monetary authority considers the achievement of price stability as a necessary condition for maximum employment and the growth potential of the economy, see Bernanke (2013).[11]

2.2.2 The Transmission of Conventional Monetary Policy

The process through in which monetary policy interventions influences the real economy in general and the price level in particular is referred to as the monetary transmission mechanism, see Bindseil (2004). As noted, CMP mainly is conducted through Open Market Operations, by purchasing and selling short-term assets, targeting short-term nominal interest rates, and the monetary base, see Bindseil (2004), and Fawley and Neely (2013).

The key channels for the transmission of CMP includes market interest rates, asset prices, credit channel, expectations channels, and the exchange rate channel, see Mishkin (1995). It is expected that any changes in official interest rate will influence market interest rates, i.e. bank deposit rates and mortgage rates. This would also affect expectations about the future course of the economy as well as asset prices and the exchange rate. This in turn would influence private expenditure, aggregate demand, and output. For example, an increase in the official interest rate, under a floating exchange rate regime, would encourage the foreign investment leading to an appreciation of the exchange rate, see Mishkin (1995). This can induce the net exports to fall. Thus, a monetary contraction through the exchange rate channel can lower aggregate demand and output, see Mishkin (1995). In addition, the policy would induce the real interest rate and capital costs to increase. This in turn would encourage saving and reduce private expenditure. The results would be a lower level of prices and output.

A contractionary monetary policy also is expected to cause bank reserves and deposits to fall through the credit channel. This would induce bank loans and consequently output to decline due to a fall in private expenditure that encourages more saving. Credit channel requires asset price changes to work. Thus, the policy would also affect asset prices, as an increase in interest rates would encourage the demand for bonds. It tends to reduce the demand for equities and asset

[11] The dual mandate refers to the first two goals, and the long-term interest rate goal emerged from the achievement of the employment and price stability goals, see Bernanke (2013).

prices. This in turn would lower private expenditure through a negative wealth effect. The result would be a lower aggregate demand, prices, and output, see Mishkin (1995).

Note that these channels may not work at the ZLB because money and bonds become close substitutes. The occurrence of the ZLB prevents the additional money from stimulating economic activity. This situation can motivate Central Banks to focus on specific markets and/or interest rates rather than simply changing the quantity of money, see Fawley and Neely (2013). The next section explores the limitations of CMP at the ZLB.

2.2.3 Limitations of Conventional Monetary Policy at the Zero Lower Bound

Monetary policy has been challenged by the global financial crisis. Prior to the recent financial crisis, the general consensus was that policy interest rates and Open Market Operations are the main monetary policy instruments. However, the effectiveness of this instrument will greatly reduce at the ZLB. The ZLB can cause problem for two reasons. First, negative real interest rates are required for the economy to recover from recessions, particularly in periods of financial market stress. Second, deflation expectations in economic downturns can actually raise expected real interest rates when nominal rates are at the ZLB, with perverse effects on demand and employment induced by a potential deflation spiral, see Clouse et al. (2000), Goodfriend (2000), Bernanke et al. (2004), and Curdia and Woodford (2009).[12]

John Maynard Keynes first raised the question of what can be done to stabilize the economy in a liquidity trap.[13] While the liquidity trap was only a theoretical curiosity at the time, the ZLB has been appeared to be one of the most challenging issue in the conduct of monetary policy, see Eggertsson and Woodford (2003). The ZLB forced Central Banks to consider other forms of monetary policy intervention. Central Banks hold the view that when recovery occurs, CMP and

[12] Clouse et al. (2000) report that the real short-term interest rates were negative in most of the twelve recessions in the US since the early 1930s. The two exceptions occurred in the recessions of the 1930s, and in the post-World War II recession, when deflation actually pushed real rates up as the economy turned down.

[13] A liquidity trap refers to the phenomenon when increased money supply fails to lower interest rates, and, therefore, fails to stimulate the economy, see Krugman (1998). According to the Keynesian view a liquidity trap is caused when people hold cash because they expect an adverse event such as deflation. Thus, Keynesian's formulation of a liquidity trap refers to the existence of a horizontal demand curve for money. However, the liquidity trap invoked since the 2008 financial crisis. It is now referred to the presence of the ZLB as monetary policy has turned to be impotent to reduce the interest rates below zero.

macro-prudential tools will achieve price and financial stability jointly, see Bernanke et al. (2004). However, the challenge is to aid the economy to reach that point.

Four approaches have been proposed to reduce the probability of hitting the ZLB. First, to raise the inflation target.[14] Second, to adopt forward guidance policy.[15] Third, to adopt a history-dependant monetary rule such as price level targeting. Forth, to target nominal GDP, see Krugman, (1998), and Eggertson and Woodford (2003). Krugman (1998) argues that in the actual event of the ZLB, Central Banks should hold the nominal interest rate down and target a moderate rate of inflation for some period to make the real interest rate negative. However, he does not explain how a Central Bank could create inflation at the ZLB. In addition, as Goodfriend (2000) discusses, a Central Bank with the power to create inflation would have the power to stimulate spending directly. This requires changes in CMP, known as the non-standard policy measures, on two fronts: (i) policy intervention on safe sovereign bond markets at much longer maturities than those typically targeted by the policy rate, and (ii) purchase of risky private-sector assets directly, see Bernanke et al. (2004), and Gagnon et al. (2011).

Targeting long-term interest rate is discussed in Woodford (2012). He argues that both the current level of the policy rate and the whole path of expected future interest rates are important for spending decisions. It implies that any Central Bankˈ action that influences interest rate expectations could be a monetary policy tool, even if current short-term rates cannot be reduced any further, see Eggertson and Woodford (2003), Bernanke et al. (2004), and Moessner et al. (2014) among others. These policy actions include forward guidance, asset purchases of private sector debt, and more extensive discount window lending. The idea is that such policies could help to finance credit-constrained firms at the ZLB.[16]

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[14] There are two important issues as regards raising the inflation target: the costs associated with a permanently higher inflation rate, and the difficulty of credibly transitioning to a higher inflation target.

[15] An explicit forward guidance is referred to as an explicit communication of Central Banks regarding the future path of the policy rate, see Joyce et al. (2012).

[16] Monetary policy is effective as long as the real policy rate is below the natural rate of interest. A lower natural rate makes hitting the ZLB more likely, since smaller shocks are sufficient to push the optimal policy rate to negative levels. This makes the ZLB an unlikely immediate issue in emerging markets with their higher inflation and natural rates where monetary policy challenges are mostly related to structural and institutional issues. Advanced economies, however, with their lower natural rates may face the ZLB more frequently. Indeed, the 2008 financial crisis may be

Thus, at the ZLB, Central Banks must switch from short-term interest rate target to non-standard policy measures with the goal of influencing longer-term rates. Longer-term yields are determined mainly by two components: (i) the risk premium, and (ii) the average level of short-term risk-free interest rates expected for the future, see Gagnon et al. (2011). To understand the way that monetary policy can potentially affect long-term interest rates, it is useful to decompose the n-year real yield on a bond as follows.

$$y_{t,t+n} = \bar{y}_{t,t+n} + TP_{t,n} - E_t \pi_n \tag{2.1}$$

Where $y_{t,t+n}$ is the expected real yield at time t on a n year bond, $\bar{y}_{t,t+n}$ is the average expected overnight rate over the next n years at time t, $TP_{t,n}$ is the term premium on an n year bond at time t, and $E_t \pi_n$ is the expected average rate of inflation over the next n years at time t. As Equation (2.1) suggests, the long-term real yields may decline in three ways: (i) an increase in expected inflation, (ii) a fall in the expected policy rate path, and (iii) a fall in the term premium, see Mishkin (1995), and Fawley and Neely (2013).

Central Banks can lower long-term real rates by reducing term premia through asset purchases.[17] When a Central Bank purchases a quantity of a certain type of risk, i.e. duration, it will cause investors to demand less compensation to hold the remaining amount of that type of risk and term premia will fall. This can cause a fall in long-term rates and thereby stimulate the economy through asset price and credit channels, see Mishkin (1995), and Fawley and Neely (2013).[18]

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an indication that large shocks are more likely than previously thought, and the natural rate may be on a secular downward trend, see Laubach and Williams (2003) for a detailed discussion.

[17] When a Central Bank purchases a sizable quantity of long-term bonds at low rates, the value of its bond portfolio would decline if long rates rise. Similarly, the value of long-term loans will decline as long-term rates rise, see Fawley and Neely (2013).

[18] According to the expectations theory of the term structure, altering the maturity of the net supply of assets from government to private investors should have only minimal effects on the term structure of interest rates. This view was supported by the literature studying Operation Twist in the early 1960s, which did not find robustly significant effects for a swap between short-term and long-term Treasury securities, see, Modigliani and Sutch (1967). However, the recent Large Scale Asset Purchases program differs from Operation Twist in that the reduction in long-term bonds is financed by reserve creation rather than sales of short-term Treasury bills. With interest rates on bank reserves and short-term bills roughly equal, the two assets should be viewed as close substitutes and thus the effect on the term spread should be similar. However, as noted by Solow and Tobin (1987), Federal Reserve purchases during Operation Twist were small and were soon offset by increased Treasury issuance of long-term debt. Overall,

Having explained the potential usefulness of targeting long-term rates, however, there are two concerns. First, long-term yields reflect the expected future path of short-term interest rates and a time-varying maturity premium. Wright (2011) links this premium to uncertainty about future inflation and to financial market segmentation driven by differences in preferences over alternative assets. He argues that volatilities in the premium may disorder the transmission of the short-term policy rate to the real economy and generate large international spillovers. More stable long-term rates, however, would come at the cost of greater volatility at the short end. Second, there is the risk of fiscal dominance. It may be perceived by agents that purchasing bonds subordinates monetary policy to ensure financing the Treasury.[19]

Note that a monetary policy intervention that perceived to be long-lived may have expansionary fiscal effects. Indeed, as long as market participants expect a positive short-term interest rate at some point in the future, the existence of government debt implies a current or future tax liability for the public. When the Central Bank expands its balance sheet by open-market purchases, it replaces public holdings of interest-bearing government debt with noninterest-bearing currency or reserves. If the increase in the monetary base is expected to persist, then the expected interest costs of the government debt, and hence, the public's expected tax burden would decline, see Bernanke and Reinhart (2004). As Bernanke and Reinhart (2004) explain, the expectational and fiscal channels of the non-standard policy measures require a credible commitment by the Central Bank that lasts until certain conditions are met.

Having discussed CMP and its limitations, the next section studies UMP instruments and the way that unconventional monetary measures take effect.

there was little movement in the average maturity of Treasury debt held by the public and thus little hope of estimating a statistically significant and robust effect, see Gagnon et al. (2011) for a detailed discussion.

[19] A prolonged public debt may implies that the Central Bank is willing to keep sovereign rates low to reduce the real value of public debt. Thus, targeting short-term rates does not necessarily protect policy from fiscal dominance, as Central Banks could erode the real value of public debt by allowing inflation to rise, although this effect could be mitigated by higher market yields for long-term bonds. This makes the argument of switching to long-term interest rates as monetary policy tool to seem plausible. However, at present, there is insufficient theoretical or empirical work to conclude that the benefits outweigh the costs and that the operational hurdles can be overcome, see Bayoumi et al. (2014).

2.3 Unconventional Monetary Policy

The 2008 financial crisis and its aftermath of the worst global recession since the 1930s pose a number of challenges for Conventional Monetary Policy. The proposed policy alternative namely Unconventional Monetary Policy (UMP) can take several forms. The more common form of UMP involve a massive expansion of Central Banksˈ balance sheets in order to influence interest rates other than the usual short-term official rates.[20] For instance, the Federal Reserve implemented policies known as Credit Easing (CE) when they purchased Mortgage-Backed securities. The purchase of these assets expands Central Banksˈ balance sheet. It can also provide liquidity to market facilitating lower mortgage interest rates directly, see Joyce et al. (2012).[21]

This section studies UMP measures. First, we study the theoretical background for UMP instruments, and the way that they differ from CMP. Then we briefly explain UMP transmission mechanism, followed by addressing some of the limitations of UMP.

2.3.1 The Theory of Unconventional Monetary Measures

UMP can mainly be implemented in three ways. First, to adopt forward guidance policies in order to shape public expectations about the future course of interest rates, namely signaling. Second, to increase the size of the Central Bankˈs balance sheet, namely Credit Easing (CE). Third, to alter the composition of the Central Bankˈs balance sheet through large-scale asset purchases, namely Quantitative Easing (QE), see Bernanke et al. (2004), Gagnon et al. (2011), Joyce et al. (2011, 2012), and Woodford (2012).[22] We now continue to explain these UMP instruments as follows.

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[20] As discussed in Joyce et al. (2012) in some cases, for instance Denmark, UMP involves the use of negative interest rates. Other unconventional measures include suspension or changes to inflation targets.

[21] Some studies compare US-UMP with "Operation Twist", which was implemented in 1961, conclude that there is not much difference between these two. In Operation Twist, the Federal Reserve sold short-term government bonds to buy long-term bonds. Because its sales and purchases were of equal amount, the Central Banksˈ balance sheet stayed unaffected. However, as Joyce et al. (2012) discuss, the purchase of long-term bonds induced the price of bonds to increase and lowered long-term interest rates.

[22] The assets side of the balance sheet of a Central Bank usually consists of domestic government debt, domestic private sector debt, and foreign exchange reserves including gold. The principal category on the liabilities side is base money, i.e. bank notes, and non-cash reserves that banks hold with the Central Bank, see Chadha and Holly (2011), and Chudha et al. (2012) for a detailed description of Central Banksˈ balance sheet.

Forward Guidance

According to standard macroeconomic theory, people's expectations about future policy are a critical aspect of the way in which monetary policy decisions affect the economy.[23] As Equation (2.1) suggests the price and yield of long-term assets depend on expectations about the future path of short-term rates. In particular, risk and liquidity premiums held constant, signaling that short-term rates will be kept low can induce a reduction in long-term bond yields and a fall in the price of equities, see Bernanke et al. (2004).

For example, in the absence of any change in expectations about short-term interest rates in the future, the level of the overnight rate would not greatly affect spending decisions. It is instead the anticipated path of short-term rates as well as longer-term interest rates, the exchange rate, and other asset prices, that are a more important determinant of expenditure decisions, see Woodford (2012). The crucial role of expectations on the conduct of monetary policy can be found under historical approaches to monetary policy, although it may not involve much Central Bank communication before, see Eggertsson and Woodford (2003). Indeed, as Woodford (2012) explains, CMP through policy rate decisions should attribute mainly to the fact that a change in the current policy rate would have implications for the forward path of interest rates as well, even if the Central Bank did not explicitly comment on this.[24]

It follows from this view that, even when the current policy rate is constrained by the ZLB, a variety of different short-run outcomes for the economy should remain possible, depending on what is expected about future policy. Theory implies that expectations about future policy matters even more at the lower bound as it may continue to constrain policy for several more quarters.

[23] The crucial role of expectations for the conduct of monetary policy in normal times as well as at the ZLB, has been discussed in Eggertsson and Woodford (2003). Within a theoretical model, they obtain solid results suggesting that shaping the interest rate expectations of the public is a key monetary policy tool not only when the ZLB binds, but also under normal circumstances as well.

[24] Communication by the Central Bank may affect expectations of the path of expected interest rates. As discussed in Moessner (2014) communication by the Central Bank is generally relevant for the formation of interest rate expectations. Consequently, even when the policy rate can no longer be reduced, the Central Bank can still influence long-term interest rates through this expectations channel, see Bernanke and Reinhart (2004). Eggertson and Woodford (2003) show that by committing to future monetary accommodation at the ZLB, the Central Bank can circumvent the ZLB to be binding.

The reason is that an expectation of a fixed nominal interest rate for several quarters, makes interest rates insensitive to the aggregate condition over that interval. This creates incentives for a greater expenditure inducing prices to increase, see Woodford (2012). If the situation is expected to persist for some time, the effect should amplified. Hence, when the ZLB is expected to be a binding constraint for some time, the expectations about the conduct of future monetary policy can have a large effect on current economic conditions.

The extent of the influence depends on the way that shift in expectations about future condition would influence current expenditure, see Woodford (2012). As discussed in Woodford (2012), two conditions should be met to achieve the policy objects: (i) having an explicit forward guidance by the Central Bank, and (ii) stating the commitment in an unambiguous way.

Credit Easing and Quantitative Easing

Credit Easing entails an expansion of the Central Bank's balance sheet to reduce specific interest rates and does not alter the composition of the asset side of the balance sheet, see Lenza et al. (2010), and Fawley and Neely (2013). It means that the portfolio of assets held by Central Banks is constant without any changes in the asset types. Thus, the increase in the monetary base induced by the expansion of the balance sheet is reflected in an accumulation of Central Bank reserves, see Lenza et al. (2010), Woodford (2012), and Fawley and Neely (2013).

On the other hand, Quantitative Easing describes any policy that unusually increases the size of Central Bank liabilities, currency and bank reserves, particularly at the ZLB, see Lenza et al. (2010), and Fawley and Neely (2013). Under a pure QE, the focus of policy is the quantity of bank reserves, which are liabilities of a Central Bank, and the composition of loans and securities on the asset side of the Central Bank's balance sheet, see Fawley and Neely (2013).[25]

[25] Both the Bank of Japan in the early 2000s, and the Bank of England in the recent financial crisis explicitly described their objectives as expanding bank reserves that is QE. The Bank of England described its policy in this manner even though its purchases of medium and long-term bonds would tend to reduce the corresponding interest rates. The European Central Bank and Bank of Japan have recently initiated lending programs that could also be considered pure QE in the sense that they targeted reserves and typically accepted a wide range of assets as collateral, see Fawley and Neely (2013).

The comparison of CE and QE is controversial. Some argue that CE can entail QE but it specifically targets interest rates. For example, as explained in Fawley and Neely (2013), Ben Bernanke considers the Federal Reserve's Large Scale Asset Purchases as CE since it targets to improve the functioning of long-term bond markets and to decrease long-term interest rates rather than simply increase the monetary base. Alternatively, Woodford (2012) distinguishes between CE and QE on the basis of an increase in base money associated with policy interventions. He defines an UMP as pure QE if there are substantial changes in liabilities column of Central Bank balance sheet, while any changes in the size of the balance sheet may refer to CE even if it successfully influences long-term interest rates. Finally, according to Lenza et al. (2010), non-conventional policies can be considered as CE until the failure of Lehman. Thereafter, the Central Bank balance sheets expanded strongly even as the composition of the asset side continued to evolve, implying a combination of both QE and CE.

Having noted the difference between CE and QE, however, the most high-profile form of UMP has been QE. Quantitative Easing was urged upon and applied by the Bank of Japan after it had reduced its target for the overnight interest rate essentially to zero, to deal with the bursting of the real estate bubble and the deflationary pressures that followed since the late 1990s, see Borio and Disyatat (2010), Joyce et al. (2012), Woodford (2012), and Bayoumi et al. (2014). With interest rates at the ZLB, the Bank of Japan aimed to purchase government securities from the banking sector and thereby to increase the level of cash reserves, the banks held in the system. The hope was that by targeting a high level of reserves, eventually this would facilitate lending to the broader economy that can induce asset prices to increase and remove deflationary forces. However, it appeared that the policy was ineffective as prices continued to fall, and economic activity remained sluggish, see Woodford (2012). The Central Banks of the US, the Euro Area, and the UK have all followed Japan in adopting UMP that have led to a substantial increases in their balance sheets, see Gagnon et al. (2011), Joyce et al. (2011, 2012), Kapetanios et al. (2012), and Woodford (2012).[26]

The objective of QE is to support aggregate economic activity in periods when the short-term nominal interest rate is constraint at the ZLB. The general idea is that asset purchases operate directly on different segments of the yield curve and reduce interest rates at different maturities while the short-term rate is at zero, see Chen et al. (2012).

The mechanism of affecting the long-term interest rate through QE can be explained as follows. When non-banking private sector sell their long-dated government bonds, their holding of these assets falls. The Central Bank, credits the bank account of the asset sellers rather than printing currency. In fact, the Central Bank finances the purchases through issuing base money in the form of reserves held by commercial banks, which expands its own balance sheet, see Bowdler and Radia (2012). Thus, QE increase both bank deposits and broad money. This expansion in the balance sheet of both the Central Bank and the banking sector can lead to a portfolio rebalancing that induces long-term interest rates to fall.

Furthermore, Central Banks purchases of long-term government securities can lead to an increase in the monetary base. This would influence the market prices of the securities being purchased and the other asset's prices through portfolio-balance channel until the economy starts its expansion through increasing aggregate expenditure. For the policy to take effect, the relative prices of the assets is required to change encouraging private holder of the assets to rebalance their portfolios accordingly, see Joyce et al. (2011, 2012).

In order for such an effect to exist, assets must be imperfect substitutes for one another, see Bernanke et al. (2004), and Woodford (2012). Woodford (2012) argues that when the short-term interest rates are at the ZLB, a Central Bank exchange of very short-maturity Treasury bills for overnight balances at the Central Bank should have little consequence. Thus, the instruments

[26] Note that there are significant differences between the UMP implemented in Japan and those of the above-mentioned Central Banks. For an overview and taxonomy of the various UMP measures taken by these Central Banks during the crisis, see for example, Borio and Disyatat (2010), and Gambacorta et al. (2014).

being exchanged are close to being perfect substitutes. However, this should not be equally true when Central Bank purchases other types of assets with longer-maturity Treasury securities.[27]

In addition, Curdia and Woodford (2009) within a NK framework, argue that the effectiveness of QE is conditional upon the changes in agent's expectation of the future interest rates path. For example, suppose that a Central Bank commits itself to keep the reserves at a level above that needed to ensure a zero short-term interest rate, until certain economic conditions are met. Theoretically, this action is equivalent to a commitment to keep interest rates at zero until the policy targets are achieved, a type of policy we have already discussed. However, as Bernanke and Reinhart (2004) explain, the act of setting and meeting a high reserves target is more visible, and hence may be more credible, than a purely verbal promise about future short-term interest rates.

So far, we explain the conduct of UMP and its effectiveness. From our discussion, we can notice that both CMP and UMP may involve asset purchases through Open Market Operation. The key distinctions between the two, however, is related to the circumstances under which the asset purchases are taking place, the purchases scale, and whether the purchases targets short or longer-term assets, see Bowdler and Radia (2012). Moreover, as Woodford (2012) explains UMP involves a direct injection of a specified quantity of broad money rather than influencing bonds price through variation in the price of base money.

Having discussed UMP instruments, the next section studies the UMP transmission mechanism to identify the way that the policy achieves its target.

2.3.2 The Transmission of Unconventional Monetary Policy

Unconventional monetary measures may affect the economy through several possible channels. These channels include portfolio balance, liquidity, and policy signalling, see Bernanke et al. (2004), Borio and Disyatat (2010), Lenza et al. (2010), Gagnon et al. (2011), Bowdler and Radia

[27] Woodford (2012) explains that according to the Monetarist view, the deliberate expansion of the Central Bank's monetary liabilities matters, regardless of the nature of the assets acquired with the newly created base money to support the desired level of aggregate nominal expenditure.

(2012), and Joyce et al. (2011, 2012).[28] Several studies identify the portfolio balance channel, described by Tobin (1969), as the main transmission channel for UMP through influencing the asset prices, see Gagnon et al. (2011), Joyce et al. (2011), Baumeister and Benati (2012), Kapetanios et al. (2012), and Pesaran and Smith (2012) among others. In particular, if money were an imperfect substitute for other financial assets, then large increases in the money supply will lead investors to seek to rebalance their portfolios raising prices and reducing yields on alternative non-money assets.[29]

When a Central Bank purchases assets, the price of assets, both those assets that have been purchased and their close substitutes, may rise. This would cause assets' expected return to fall. This in turn is expected to stimulate aggregate demand through a positive wealth effect and a reduction in companies' cost of finance. It may also increase market's liquidity, as asset holders perceive that Central Banks will purchase their assets at the time they needed, see Gagnon et al. (2011).

The portfolio balance channel builds upon the assumption that money and other financial assets are imperfect substitutes, see Bernanke et al. (2004), Borio and Disyatat (2010), Gagnon et al. (2011), and Joyce et al. (2011). The portfolio balance channel also influence risk premia within long-term interest rates structure. When Central Banks purchase massive quantities of a certain type of assets then the nominal yield of the assets would fall due to a reduction in the term premia component. As Bernanke et al. (2004) explain this view is associated with both the monetarist expositions, such as Meltzer (2001), and Keynesians, such as Tobin (1969). According to this view, open market purchases of securities would increase the amount of money relative to non-money assets in the public's portfolio. The private asset holders, then, consider to rebalance their portfolios. This would tend to increase the prices and lower the yields of assets

[28] Bernanke et al. (2004) introduce fiscal channel as another potential channel for QE to influence the economy. They explain that fiscal channel relies on the observation that sufficiently large monetary injections would relieve the government's budget constraint, permitting tax reductions or increases in government spending without increasing public holdings of government debt.

[29] The possibility that monetary policy works through portfolio substitution effects, even in normal times, have been advocated by both Keynesians, i.e. Tobin (1969), and Monetarists, i.e. Brunner and Meltzer (1972).

if money and non-money assets are imperfect substitutes. Higher asset values and lower yields, in turn, would stimulate the economy, see Bernanke et al. (2004), Borio and Disyatat (2010), Gagnon et al. (2011), and Joyce et al. (2011).

In contrast, if the private holder of assets were indifferent between holding assets and money, which implies assets are perfect substitutes, asset purchases by Central Banks will not affect yields and despite the policy intervention portfolios would remain unchanged, see Bowdler and Radia (2012), and Joyce et al. (2012). In particular, at the ZLB, money and one-period bonds are both assets bearing zero interest and carrying little credit risk. Thus, the money created through purchases these short-term bonds may be passively absorbed by the private sector, see Bowdler and Radia (2012). Hence, under this circumstance, an expansionary UMP has no impact on the economy.[30] However, if the asset purchases program targets longer-term assets, it would affect the composition of portfolios, as these assets are less close substitutes for money. This implies that the two assets are imperfect substitutes, thus, changes in relative holdings of the two would induce portfolio rebalancing to influence asset prices and yields as recognized by Tobin (1969) and Meltzer (2001), see Bowdler and Radia (2012) for a detailed discussion.[31]

There are at least two theory-motivated explanations for the imperfect substitutions of bonds and bank deposits: (i) preferred habitats, and (ii) the pricing of duration risk, see Joyce et al. (2012). When investors sell their bonds to Central Banks, they exchange a long-dated asset for bank deposits. Many investors with long-dated liabilities, such as pension funds and insurance companies, prefer to match their liabilities with equally long-dated assets. Thus, they are likely to invest the earned money from asset trading to purchase other long-dated assets, such as corporate bonds, to restore the duration of their portfolio. This would lead to a reduction in the stock of long-dated assets hold by the Central Bank. With less duration risk to hold in the

[30]As explained in Bowdler and Radia (2012) QE conducted by the Bank of Japan between 2001-2006 can be taken as an example of nutural asset purchases program as the program targeted to purchase short-dated bonds. The result was only injection of a large sum of money into the economy with no tangible impact on the output.
[31] As explained in Bowdler and Radia (2012), the QE conducted by the Federal Reserve and the Bank of England are reported to be effective to influence output. Their programs focused on purchasing long-dated assets rather than short-dated bonds as practiced by the Bank of Japan.

aggregate, those in the market should require a lower premium. This tends to reduce the term premium for all long-dated assets. As the result, prices of long-dated risky assets, corporate bonds and equities are likely to rise, see Joyce et al. (2012).[32]

As discussed in Gagnon et al. (2011), Central Bank's purchases of long-duration assets, such as medium-to-long-term government bonds, would reduce the average duration of the stock of bonds held by the private sector. This in turn would cause a fall in the premium required to hold duration risk raising their prices.[33] The impact of asset purchases by Central Banks on the yields on risky assets is the sum of any impact on government bond yields plus the impact on the spread between the yields on risky asset and government bonds. Thus, a reduction in bond yields is not necessary for asset purchases by the Central Bank to have an effect on the real economy via the portfolio-balance mechanism. If the spread falls, asset purchases would affect the cost of finance for the private sector and potentially generating capital gains even if bond yields are unchanged, see Gagnon et al. (2011), and Joyce et al. (2012).

The effectiveness of portfolio-balancing channel depends on the extent to which changes in the supply of assets would cause changes in absolute and relative price of assets. Higher asset prices should stimulate an increase in spending through both reducing the cost of capital and increasing wealth. The mechanism in which how a lower cost of capital for households and firms may lead to increase in borrowing can be explained as follows. The interest on funding available

[32] For Treasury securities, the most important component of the risk premium is referred to as the "term premium", and it reflects the reluctance of investors to bear the interest rate risk associated with holding an asset that has a long duration. The term premium is the additional return that investors require, which is above the average of expected future short-term interest rates, for accepting a fixed, long-term yield. As reported in Gagnon et al. (2011), the US-UMP have removed a considerable amount of assets with high duration risk from the markets. With less duration risk to hold in aggregate, the market should require a lower premium to hold that risk. This effect may arise because those investors who willing to bear the risk are the ones left holding it. In addition, even if investors do not differ greatly in their attitudes toward duration risk, they may require lower compensation for holding duration risk when they have smaller amounts of it in their portfolios, see Gagnon et al. (2011).

[33] Note that as discussed in Gagnon et al. (2011) the portfolio-balance effect has nothing to do with the expected path of short-term interest rates. Longer-term yields can be decomposed into two components: the average level of short-term risk-free interest rates expected over the term to maturity of the asset, and the risk premium. The former represents the expected return that investors could earn by rolling over short-term risk-free investments, and the latter is the expected additional return that investors demand for holding the risk associated with the longer-term asset. In theory, the effects of the Large Scale Asset Purchases on longer-term interest rates could arise by influencing either of these two components. Thus, any reduction in longer-term yields has likely come through a narrowing in risk premiums.

for borrowing highly depends on the risk free rates at the maturity that borrowers are willing to take. Thus, any reduction in the yield curve would indicates a reduction in interest rates. This would lower the cost of borrowing and would encourage private spending and investment, see Bowdler and Radia (2012). Increase in asset prices also implies increase in net wealth for the asset holders. This positive wealth effect also is expected to stimulate the economy through private expenditure, see Bowdler and Radia (2012). As explained in Joyce et al. (2012), if households consume part of that increased wealth, or companies invest some of the extra funding raised on capital markets, demand and output will be higher.

Having explained the portfolio balance channel, another channel for transmitting QE is liquidity provision to banks that may influence the level of very short-term interest rates through liquidity effects in the interbank money market, see Joyce et al. (2012). To the extent that such measures would result in excess Central Bank liquidity accumulating in the market, QE can cause a spread between the key policy rate and the overnight market rate. This in turn can reduce market interest rates, thereby stimulating private expenditure. The liquidity channel works as follows. When Central Banks purchases government bonds owned by the non-banks holders, banks' deposits would rise together with reserve balances at Central Banks. To the extent that a bank's reserve holdings would exceed its demand for liquidity, lending would expand. Alternatively, if a bank had already lost some other funding, it might be able to avoid a contraction in its lending or a sale of less liquid assets, see Joyce et al. (2012).[34]

The final channel through which asset purchases may influence longer-term interest rates is signalling. Similar to CMP, the information revealed about likely path of future monetary policy is an integral part of their transmission mechanism. Communication about monetary policy

[34] The bank-funding channel would be weak when the funds generated by the Central Bank asset purchases come to banks as very short-term wholesale deposits, and banks feel the need to increase their liquid asset holdings in the form of reserve balances at the Central Bank to insure against the risk that these deposits might be withdrawn at short notice. However, even then it may be that banks increase their liquid assets by less than the amount of short-term inflows. However, if the money inflow to a bank generated by asset purchases were in the form of longer term funds, then it is more likely that the additional funds could help banks to expand, or at least to avoid contracting, their lending, see Joyce et al. (2012).

operations will influence public expectations about key factors that underpin the asset's market valuation. These factors are expectations regarding the future course of policy, relative scarcities of different assets, and their risk and liquidity profiles, see Bowdler and Radia (2012), and Joyce at al. (2011, 2012). Communication will also manage expectations of the path of future monetary policy decisions and thus affect the slope of the money market yield curve. In addition, the announcement that the Central Bank will engage in operations involving illiquid assets may have a positive effect on investor's confidence in those assets, thereby reducing liquidity premia.

Having discussed UMP instruments and its transmission channels, we conclude the section by explaining the limitations of UMP.

2.3.3 Limitations of Unconventional Monetary Policy

There are conditions under which asset purchases by Central Bank, irrespective of whether they are private sector or government securities, are neutral. We consider exploring UMP limitations as follows.

The first one is in line with the monetarist interpretation of QE. The monetarists hold the view that QE is equivalent to a shock to the supply of money. Thus, its transmission mechanism can be better explained through broad money supply and demand analysis, see Bowdler and Radia (2012). According to the monetarist view, any increase in the deposit holdings of the non-bank private sector, can generate a shock to the supply of money. The non-bank private sector would consider holding this increased supply of money if the determinant factors for the demand of money change. The demand for money depends on three variables: (i) the nominal expenditure, (ii) the overall value of asset portfolios, and (iii) the relative rate of return on money compared to other assets, see Bowdler and Radia (2012). Thus, changes in these variables may cause a change in the demand and supply of money. The sellers of bonds would continue to balance their portfolio until the prices and yields of non-monetary assets change. This would lead the asset holders to hold a higher stock of deposits. Thus, from the monetarist view, for UMP shocks to be effective broad money must change instead of base money, see Bowdler and Radia (2012).

Another critic is related to the plausibility of assumption that holds assets are imperfect substitutable. Eggertson and Woodford (2003) argue that while the imperfect substitutability of assets is a key assumption for QE to work through portfolio balance channel, this condition has not been met in most state-of-the-art macroeconomic models. In addition, even with imperfect substitutability condition, some models have no role for any portfolio balance channel. The essence of their argument is that if the private sector see the assets held by the government and by the Central Bank as indistinguishable from their own assets, then any swap of assets with the Central Bank cannot change anything. This argument is analogous to Ricardian Equivalence proposition, namely the irrelevance proposition on QE.

The irrelevance proposition states that while Central Banks trade private sector assets with money, they cannot eliminate the credit risk associated with the assets. In fact, the risk characteristic of the assets would be shifted from the private sector's balance sheet to the Central Bank's balance sheet, see Bowdler and Radia (2012). Thus, purchases of riskier assets makes the government's net wealth more uncertain which would increase the possibility of additional tax burden for households in the future. Given that households can recognize that the risk component has not been eliminated from their portfolios as a whole, they would anticipate further taxes in the future. Thus, the asset purchases program would not stimulate private expenditure, as households would consider the government's intertemporal budget constraint to anticipate future tax burdens, see Bowdler and Radia (2012), and Woodford (2012).[35]

Furthermore, from a theoretical perspective, QE has been criticised upon the argument of policy neutrality initiated in Wallace (1981).[36] Chen et al. (2012), within a NK model, argue that injecting reserves in exchange for longer-term securities is a neutral operation. They explain that

[35] As explained in Woodford (2012), although the Central Bank purchases of Mortgages Backed Securities (MBS) would take the real estate's risk on its own balance sheet meaning that households would not bear any direct risk in the event of housing market crisis. But this would result in lower earnings for the Treasury and would lower private spending.

[36] According to Wallace neutrality argument, in a complete market environment, the government cannot remove risk. It can simply transfer that risk from the private balance sheet to the public balance sheet. Since the public balance sheet is ultimately backed by the tax liabilities of the private sector, the risk does not disappear, it is simply relabeled. As it can be recognized by the rational agents, the Central Bank balance sheet policy have no influence on realized security prices, see Farmer (2012) for further discussion.

QE may be an effective tool to stimulate the economy if the government purchases securities, which are not equivalent to reserves, either because not all households can invest in those assets or because financial frictions impair investment. Thus, to the extent that market participants take full advantage of arbitrage opportunities, QE should have no effect on real economic outcomes.

Curdia and Woodford (2009) extend this result to a NK model with credit frictions. They explain that if households perceive the assets purchased as equivalent to reserves, again QE has no effect on the economy. Woodford (2012) argues that the effectiveness of QE through portfolio-balance channel is invalid, and, if Central Bank asset purchases are to be effective, their effectiveness must rely on their ability to alter the public's expectations of future Central Bank policies. He proposes that it is better to generate higher inflation expectations for stimulating aggregate demand, instead. He explains that this can be performed by signalling to keep the interest rates low for longer term. However, he does not explain how agents will finance the increase in aggregate demand.

Note that in these models, Open Market Operations are assumed to be neutral on the ground that at the ZLB, money and bonds become perfect substitutes and any swap of one for the other does not change the wealth position of the private sector, see Curdia and Woodford (2009). They argue that QE can be described as a form of commitment strategies that provide forward guidance on the long-term intentions of the Central Bank to hit a given inflation target and to act differently in the future once the economy exits the ZLB, see Breedon et al. (2012), and Woodford (2012).[37]

Another challenge in implementing UMP is related with Central Banks' credibility, see Bowdler and Radia (2012). The Central Bank's credibility is the extent to which that a Central Bank can convince the private sector that the interest rates will be kept lower and inflation higher

[37] As is discussed in Breedon et al. (2012) the NK argument that monetary policy can only work through the management of expectations is not a universal result as it relies on particular assumptions. In these models, financial markets are complete and financial wealth is allocated over an infinite life. Idiosyncratic risk in these economies can be hedged and asset prices depend on state-contingent payoffs. In this case, the price of financial assets is not influenced by changes in their net supply, as demand is perfectly elastic. It seems quite possible, though, that demand curves for assets, particularly those which are issued in large quantities, may become downward sloping, in which case changes in net supply can affect their relative prices. This possibility then means that the relative supply of money or credit can influence market interest rates and so impact directly on expenditure paths without having to rely on pure signaling effects. It is this possibility which gives QE its influence, see Breedon et al. (2012).

in the future. The higher the Central Bank's credibility, the more UMP succeeds to achieve its target.

Finally, the other issues concern the effectiveness of UMP include delaying in balance sheet adjustments, the risk of encouraging a new round of risk taking and leveraging in the financial system, concern that financial markets lose their capacity to discover prices, a too dominant role of Central Banks in market making that may contribute to weakening markets, and complexities concerns the exit, see Bowdler and Radia (2012), and Bayoumi et al. (2014) for a detailed discussion.

Having discussed conventional and unconventional monetary policy, we now turn to another important element of this thesis. That is we discuss fiscal policy in the next section.

2.4 Fiscal Policy

The literature on the macroeconomic impacts of fiscal policy is extensive and controversial, see Bernheim (1987), Elmendorf and Mankiw (1999), Blanchard and Perotti (2002), Canzoneri et al. (2011), and Afonso et al. (2012) among others. Some studies provided evidence that fiscal policy is not as competent as monetary policy to stimulate the economy, see Barro (1974, 1978,1983), Evans (1985,1987), and Plosser (1987). In a seminal paper on monetary and fiscal policy interactions Leeper (1991) explains how the macroeconomic impact of monetary and fiscal policy can differ depending on the assumption that which policy is constrained while the other policy can actively respond to the shocks. Building up on this ground, some recent studies find evidence in favour of the effectiveness of fiscal policy when monetary policy is constrained in the form of a policy commitment, i.e. a Taylor Rule or inflation targeting. For example in recession a constrained monetary policy in conjunction with an expansionary fiscal policy can stimulate the real economy, see Canzoneri et al. (2011), Sims (2011), and Woodford (2011).

While the general agreement holds that macroeconomic stabilization should be controlled mainly by monetary policy in normal times, recent studies about the conduct of monetary policy emphasize that fiscal policy has important implications for the choice of desirable monetary policy, see Davig and Leeper (2007, 2011), Sims (2011), and Woodford (2011). They argue that when there is no concern about the economy and the government shows a strong fiscal discipline, known in the literature as the Ricardian view in the terminology of Woodford (1995), or passive fiscal policy in the terminology of Leeper (1991), then monetary policy can be set without paying any attention to fiscal policy.

However, there are circumstances in which monetary policy would run into constraints that impair its effectiveness. For example, the economy may find itself in a liquidity trap when the interest rates hit the ZLB that prevents further reductions in the interest rate.[38] Under these situations some recommend fiscal policy as an effective tool to stimulate the economy, see Bernanke et al. (2004), Ito et al. (2011), Sims (2011), Farhi and Werning (2012), and Leeper (2013) among others. Nevertheless, there is disagreement and the issue remains deeply controversial as evidenced by vigorous debates on the magnitude of fiscal multipliers, see Farhi and Werning (2012) for a detailed discussion.

Having considered the important implication of fiscal policy for the economy, and its potential impact on the conduct of monetary policy, the follow subsections study the macroeconomic impact of fiscal policy. In doing so, first we briefly explain the way that a fiscal policy shock is transmitted into the economy. Then, different views on the effectiveness of fiscal policy shocks are discussed including the Keynesian approach, the Ricardian and non-Ricardian views on fiscal policy, and fiscal policy at the ZLB. Finally, we explain the Fiscal Theory of the Price Level (FTPL) to study the potential impact of fiscal policy on prices.

2.4.1 The Transmission of Fiscal Policy

Fiscal policy is transmitted mainly through two channels: (i) the exchange rate, and (ii) the interest rate, see Perotti (2007).[39] The policy initially is transmitted through the interest rates

[38] For a detailed theoretical foundation of the discussion, see Smets and Wouters (2007).
[39] The transmission mechanism very much depends on the degree in which the price levels adjust in response to the policy shock, see Wickens (2008).

channel by causing either an upward or a downward pressure on the interest rates dependent upon whether fiscal policy is expansionary or contractionary, respectively.

The outcome of fiscal policy is very much depends upon the exchange rate regime. For example, under a flexible exchange rate regime, an expansionary fiscal policy is expected to raise the demand for money that appreciates the currency. This in turns is expected to cause a reduction in aggregate demand due to an appreciation in the exchange rate that crowd out the net export. The outcome, therefore, would be a lower output counteracting the effect of initial policy. However, under a fixed exchange rate regime a fiscal expansion tends to magnify the effect of policy on output suggesting a relatively larger fiscal multiplier, see Corsetti et al. (2011).

Thus, although the interest rate is the key transmission channel, the extent to which fiscal policy may stimulate the economy is highly dependent upon the way that the exchange rate responds to policy shock. The next sections explain different views on the macroeconomic impact of fiscal policy.

2.4.2 The Keynesian Approach

According to Keynesian view, an expansionary fiscal policy, in the form of eigher an increase in government expenditure or a reduction in tax rates, can stimulate aggregate demand in the short-run by increasing disposable income and generating positive wealth effect, see Branson (1989), Elmendorf and Mankiw (1999), and Wickens (2008). This is especially the case when prices are sticky. Thus, when the economy faced with a recession one potential short-run solution is to run an expansionary fiscal policy and to increase the level of government debt. However, it is generally believed that in the long-run fiscal policy shall increase prices but not output that is refered in the literature as the Neoclassical view, see Wickense (2008), and Romer (2011). This could be due to the potential crowding out of private sctor activity caused by the higher interest rates associated with expansionary fiscal policy.

Thus, in the short-run, an expansionary fiscal policy tends to be Keynesian that influences the real economy, while its effect in the long-run may turn to be Neoclassical. Note that the process of adjustment between Keynesian to Neoclassical depends upon the degree of price flexibility, see Farhi and Werning (2012). In addition, the effectiveness of fiscal policy depends on the way that monetary policy reacts to fiscal policy, in terms of potential changes in the nominal interest rates, money supply, or policy commitments, see Woodford (2011). Furthermore, a debt-financed fiscal expansion can contribute to the accumulation of the government debt that in turns can reduce net national saving and may generate countercyclical macroeconomic effects, see Neck and Sturm (2008).

The profound effect of fiscal sustainability on the effectiveness of fiscal policy is an important issue. When public debt is high, further increases in debt may lead to lowering economic growth, see Reinhart and Rogoff (2010), and Cecchetti et al. (2011).[40] This is the case as reducing a high-level public debt can be obtained by either an increase in taxes, or a reduction in the government expenditure. However, both of these two policy options tend to lower output. Moreover, while an unexpected increase in inflation can reduce the real cost of the debt, the efficiency of the inflation channel to stimulate the economy is highly dependent upon the maturity structure of the debt.[41]

As regards public debt sustainability, literature suggests that public debt can be unsustainable if the nominal interest rate on debt exceeds nominal output growth, see Reinhart and Rogoff (2010). In this case, the debt-to-GDP ratio increases even if the government manages to match its primary expenditure with revenue. This would require the issuance of new debt to cover the interest payments on the outstanding debt, see Neck and Sturm (2008). Furthermore, the relationship between the risk premium and fiscal sustainability is negative implying that any increase in the risk premium may cause interest rates to rise. This in turns leads to a higher public debt and less fiscal sustainability, see Neck and Sturm (2008).

[40] According to Reinhart and Rogoff (2010) in both advanced and emerging economies, a higher level of debt-to-GDP is associated with markably lower growth outcomes. They propose a threshold of the debt ratio around of 90 percent and above for advanced economies and 60 percent and above for emerging economies.

[41] Reinhart and Rogoff (2010) explain that long-term nominal government debt is highly sensitive to inflation, whereas it is extremely less for the short-term debt.

Given that the debt policy can cause a higher interest rates, monetary authorities may be forced to reduce these rates through implementing an expansionary monetary policy. In the short-run the accommodative expansionary monetary policy may lower the interset rates. But in the long-run the real interest rate would remain unchanged with a higher inflation and nominal rates, see Baldassarri et al. (1993), Elmendorf and Mankiw (1999), and Cochrane (1991, 2001).

Further to the perverse effect of unsustainable government debt, open economy argument poses another challenge for the effectiveness of fiscal policy. In an open economy, the increase in interest rate is associated with a real appreciation of the currency and crowding out of the foreign sector, see Elmendorf and Mankiw (1999), and Wickens (2008). The early work to discuss the outcome of fiscal policy in an open economy context was the Mundel-Fleming model. It was capable of capturing the exchange rate flexibilities under perfect capital mobility and rigid prices and wages. Their model consists of three core equations, namely the *IS-LM* and the Uncovered Interest rates Parities (UIP) condition.[42] Within the model, any increase in government spending will increase domestic output. This will cause an increase in nominal interest rates followed by a domestic currency appreciation inducing a fall in net export. This implies that there would be potential import leakages that can offset the expansionary effect of the policy on output. Thus, the Mundel-Fleming model suggests that fiscal policy is more effective under a fixed exchange rate regime while within a flexible exchange rate regime monetary policy is more potent to influence the real economy, see Baldassarri et al. (1993), and Beetsma et al. (2006).

[42] The Mundel-Fleming model is constructed upon the following equations.

$$IS : y_t = \alpha \ (s_t + p_t^* - p_t) - \beta \ R_t + \gamma \ g_t + \delta \ y_t^*$$

$$LM : m_t = p_t + y_t - \lambda \ R_t^*$$

$$UIP : R_t = R_t^* + E_t(s_{t+1} - s_t)$$

Where y_t and y_t^* are domestic and foreign output, p_t and p_t^* are domestic and foreign price levels, R_t and R_t^* are domestic and the global nominal interest rates, s_t is the nominal exchange rate, and g_t is government expenditure.

2.4.3 The Ricardian and non-Ricardian approaches

Having discussed the Keynesian view on the fiscal policy and the main issue concern its effectiveness, the impact of fiscal policy on the economy can be categorized under two different views: (i) the Ricardian view, and (ii) the non-Ricardian view. The idea of Ricardian Equivalence on fiscal policy is popularized by Barro (1974, 1979, 1983) in the 1970s. The Ricardian view refers to a situation in which either taxes and/or seigniorage adjust to ensure that the government's budget constraint is satisfied. In contrast, when the fiscal authority set its budget independently without considering the government's intertemporal budget equation, fiscal policy is described as the non-Ricardian, see Sims (1994), Woodford (1995), Cochrane (1999), and Christiano and Fitzgerald (2000).[43]

As explained, the Keynesian analysis holds that a fiscal expansion, say a tax reduction without any cut in expenditure, can stimulate the economy by increasing private expenditure through the waelth effect channel. However, the Ricardian view states that this policy is ineffective as the situation with tax cut is equivalent to the non-policy situation, see Elmendorf and Mankiw (1999), and Wickense (2008).[44]

The Ricardian argument is based upon the perception that a tax cut which generates debt, implies a higher taxes in the future to finance the incurred debt. Thus, this policy only postpones the tax burden and does not reduce it. Given that forward-looking housholds would expect that future taxes shall rise, they would respond to this policy by increasing saving rather than consumption. Thus, the fall in public saving would be matched with an equal increase in private saving implying national saving is unchanged, see Elmendorf and Mankiw (1999), and Wickense (2008). This is also the case with additional interest-bearing government bonds to finance debt. The Ricardian view holds that further tax is required in the future to ensure the debt repayment.

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[43] The mathematical presentation of the government's intertemporal budget is provided in Appendix 2.A.

[44] As discussed in Elmendorf and Mankiw (1999) some argues that while government bonds represent an asset for the bond holders, simultaneously they represent a liability for tax payers. Thus, the positive wealth effect created by a debt-financed tax cut would be balance out by taxpayers' liabilities implying that there generated no wealth effect in the economy as a whole.

Thus, any government debt will also contribute to an increase in private saving rather than consumption with no impact upon prices.

In essense, the Ricardian argument has been constitued upon two ideas: (i) the government budget constraint, and (ii) the permenant income hypothesis, see Elmendorf and Mankiw (1999), and Walsh (2010). According to the government budget constraint lower taxes today will imply a higher taxes in the future if government purchases remain unchanged as the present value of the tax burden would be invariant to the path of tax burden.[45] As regards the permenant income hypothesis, it states that households make their spending decisions based on their permenant income which is a function of the present value of their after-tax income. Given that the Ricardian argument asserts that a debt-financed tax cut will change the path of the tax burden but not its present value, therefore, it will not change permenant income and consumption either, see Elmendorf and Mankiw (1999).[46]

Furthermore, under the Ricardian view a tax cut policy would not affect households' net wealth as they believe that the present value of their tax liabilities has not changed. This would lead to an increase in private saving as households expects that they will be taxed in the future to pay the government debt arises from tax cuts, see Canzoneri et al. (2011). Thus, the policy cannot change aggregate expenditure and prices.

Whilst the Ricardian view holds that only monetary policy can shift the aggregate demand and influences prices and output, the non-Ricardian view holds the opposite. It holds that a tax reduction policy can generate a positive wealth effect as agents expect that government will issue new bonds to finance the deficit. This would affect the price levels. When the monetary authority follows an interest rate rule, say Taylor Rule, if fiscal policy requires the issuance of new debt,

[45] See Appendix 2.A for a mathematical presentation of the argument.

[46] It is worth noting that the Ricardian argument does not imply that all fiscal policy as irrelevant. For example, if households expect that government tax cut policy would be finnaced with a cut in government purchases in the future, then permenant income does rise stimulating private expneses and output. Note that it is the expected cut in government purchases that stimulate the economy rather than the tax cut, see Elmendorf and Mankiw (1999).

then the Central Bank will accommodate the price of bonds at a level implied by its interest rate target. This would affect the aggregate economy, see Canzoneri et al. (2011).

In contrast, the Ricardian view of fiscal policy, that is monetary dominance, holds that changes in the money stock or its growth rate will require either taxes, expenditures, or borrowing in the budget constraint to adjust. Thus, the Ricardian view presumes that the price levels primarily determined by the money supply in the long-run. In contrast, under the non-Ricardian view, that is fiscal dominance, changes in government debt require changes in inflation even if monetary policy is exogenous. Therefore, a complete analysis of price level determinacy requires taking monetary and fiscal policy interactions into account, see Canzoneri et al. (2011). It argues that government debt would eventually be paid by seignorage through issuing base money. Thus, the increase of the government's debt indicates issuing more base money in the future.[47]

Having said that the non-Ricardian view on fiscal policy says that fiscal policy is important for the determination of the price level, the Fiscal Theory of the Price Level (FTPL) explains the consequences of the non-Ricardian view for inflation. We continue to discuss this theory in the follow section.

2.4.4 The Fiscal Theory of the Price Level

There are two independent views on the price level determination: (i) the Quantity Theory of Money, and (ii) the Fiscal Theory of the Price Level (FTPL).[48, 49] According to the FTPL, Central Banks purchases of government bonds would affect the price levels, See Leeper (1991, 2013), Sims (1994, 1997, 2013), and Woodford (1995, 1998). Note that the key defining characteristic of the FTPL is the non-Ricardian assumption on fiscal policy.[50] As Woodford (1998) explains, the FTPL is in particular useful to examine the outcome of macroeconomic policy interactions.

[47]Woodford (1995), and Cochrane (2001) explain that the demand for assets and changes in base money is an increasing function of the agent's anticipations of fiscal policy.

[48] Among the classic works on the Quantity Theory of Money are Friedman (1956), and Patinkin (1965). The FTPL is initiated first by Sargent and Wallace (1981), and further developed by Cochrane (1999, 2001), Leeper (1991), Sims (1994, 1997), and Woodford (1994, 1995, 1998).

[49] See Buiter (2000), and McCallum (1998) for a critical review of the FTPL.

[50] As is noted in Christiano and Fitzgerald (2000), Michel Woodford argues that under a non-Ricardian fiscal policy, fiscal shocks should produce the same results as shocks to prices, regardless of monetary policy. They call this event as "Woodford's really unpleasant arithmetic".

For example, the period of the 1960s and 1970s is a time when the government budget constraint was not considered in macroeconomic policy making. Therefore, it might be reasonable to consider that the non-Ricardian assumption held for this period, see Christiano and Fitzgerald (2000).

Having said that fiscal policy might matter for the price level, it can impact prices in two ways, see Walsh (2010). First, equilibrium requires that the real quantity of money to be equal with the real demand for money. Given that fiscal variables influence the real demand for money, the equilibrium price level will also depend on fiscal policy. Second, the FTPL emphasises that the government's budget represents an equilibrium condition rather than a constraint.[51] As explained in Walsh (2010), the standard monetary models, which are built upon forward-looking expectations of the prices levels, show that there may be multiple price levels consistent with a given nominal quantity of money, and equality between the supply and demand of money. Thus, an additional equilibrium condition may be required to obtain the unique price level. Woodford (1995) argues that the government's intertemporal budget constraint can provide this additional condition for determining the equilibrium price level in which the fiscal stance replaces the money supply as the key determination of the price level, see Cochrane (1999), Leeper (1991), Sims (1994), Woodford (1995), and Christiano and Fitzgerald (2000).[52] It is also possible that the fiscal autuority forces the monetary authority to finance the government debt with seigniorage. This can cuase a higher inflation under the FTPL, see Walsh (2010).

The FTPL is an extension of Sargent and Wallace's unpleasant monetarist arithmetic.[53,54] According to Sargent and Wallace (1981), an economy is referred to as the monetarist economy

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[51] Over the periods that government performs balanced budget, the monetary authority conducts routine Open Market Operations, see Walsh (2010).

[52] In some cases, the equilibrium price level can even be determined by fiscal policy independent of the nominal supply of money, see Walsh (2010) for a detailed discussion.

[53] Sargeant and Wallace (1981) develop a framework in which fiscal policy drives inflation. In their example, limitations on tax receipts can result in a fiscal responsibility for the monetary authority. This explanation places responsibility for both the monetary and fiscal authorities to control inflation.

[54] Sargent and Wallace (1981) discussion is based on the assumption that the government's debt is financed by seigniorage which means issuing currency rather than bonds. However, this source for financing the government's debt is small compared with the other sources. The key difference between the FTPL and unpleasant monetarist arithmetic is that the former considers the nominal government debts while the latter relies on real debt, see Leeper

if it satisfies these two requirements: (i) the monetary base is closely connected to the price level, and (ii) the monetary authority can raise seignorage by generating revenue through money creation. On the other hand, within a monetarist economy, the public's demand for government bonds would constraint the government budget mainly in two ways: (i) by setting an upper limit on the real stock of government bonds relative to the size of the economy, and (ii) by affecting the interest rate that the government must pay on the bonds.

The extent to which these constraints enable the monetary authorities to control inflation depends on the way that fiscal and monetary policy interacts. In the case of an active monetary policy, the monetary authority independently set monetary policy by announcing the growth rate of the base money. An active monetary policy is one that pursues its inflation target independent of fiscal policy, see Leeper (1991).[55] This would determine the amount of government's seignorage revenues. Thus, the fiscal authority would face the constraints imposed by the demand for bonds. Then, the government must set its budget to ensure that any deficit is financed through a combination of the seignorage determined by the monetary authority, and bond sales to the public. In this case, the monetary authority is able to control inflation.

In contrast, in the case of an active fiscal policy, the fiscal authority independently plans its budget and announces all current and future deficits and surpluses in terms of the amount of revenue that must be raised through bond sales and seignorage. An active fiscal policy is one in which the tax and government expenditures are determined independent of intertemporal budget constraint, see Leeper (1991).[56] Under this circumstance, the monetary authority would face the constraints imposed by the demand for government bonds. Thus, the monetary authority would finance any discrepancy between the revenue demanded by the fiscal authority and the amount

and Walker (2012). For example, consider a rise in the price level. Under the FTPL, it implies more cash flows but no changes in the real surplus or seigniorage. However, unpleasant monetarist arithmetic interpretation suggests that the higher the price level, the lower would be the real cash flows and seigniorage revenues.

[55] As explained in Leeper (1991) under an active monetary policy, the nominal interest rate responses aggressively to inflation, that is more than one-to-one. In contrast, a passive monetary policy is one that the monetary authority sets interest rates to accommodate fiscal policy.

[56] Leeper (1991) explains that under active fiscal policy taxes do not respond sufficiently to government debt. In contrast, a passive fiscal policy is one in which the fiscal authority raises or reduces taxes to balance the budget intertemporally.

of bonds that can be sold to the public. If the fiscal deficits cannot be solely financed by the new bonds sales, the monetary authority is forced to create money and endure additional inflation. Therefore, it seems that the monetary authority has less power to control inflation when fiscal policy dominates. This will be more pronounced if the demand for government bonds required an interest rate on bonds greater than the growth rate of the economy that limits the monetary authority's power to control either the growth rate of the monetary base or inflation, see Sargent and Wallace (1981).[57]

Note that the FTPL and the conventional view on inflation differs based on two different views on the government's intertemporal budget equation. This equation can be expressed in a simple form as follows.

$$\frac{B}{P} = \text{Present Value of Future Surpluses} \tag{2.2}$$

In Equation (2.2), B represents the outstanding nominal government debt and P is the price level. The conventional view holds that this equation is a constraint on the government's budget policy regardless of the value of P. Thus, if for any reason Equation (2.2) is disturbed, the government must alter either its expenditure or taxes to restore the equality, see Christiano and Fitzgerald (2000). In contrast, the FTPL argues that the intertemporal budget equation is an equilibrium condition in a way that under any situation that disturbs Equation (2.2), the value of P, the price level, would adjust to restore equality. Thus, if the real value of government debt were to increase, no adjustment to fiscal and monetary policy would be made to satisfy Equation (2.2). This indicates a non-Ricardian fiscal policy, see Christiano and Fitzgerald (2000).[58]

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[57] When the fiscal authority plans to finance the government debt by issuing new bonds, this would increase the real stock of bonds held by the public. As discussed in Sargent and Wallace (1981) if the principal and interest due on these additional bonds are raised by issuing more bonds to maintain the limitation on the growth rate of the base money, the real stock of bonds will grow faster than the size of the economy. This circumstance cannot stay in the long-run since there is an upper limit on the stock of bonds relative to the size of the economy. Thus, once the limit is reached, the principal and interest on the bonds must be financed by seignorage. This makes the creation of additional base money inevitable. Therefore, in a monetarist economy the result of government debt would be inflation, eventually.

[58] While Sims (1994), Woodford (1995), and Cochrane (1999) argue that Equation (2.2) is an equilibrium condition, Buiter (2002) strongly argues that the intertemporal balanced budget condition represents a constraint on government budget. Note that interpreting the intertemporal government's budget as a constraint on government budget

As Woodford (1995) discusses if households believe that there would be no future tax consequences for government debt policy, this would create a positive wealth effect and increase private spending. If aggregate supply remains unchanged, both good-market equilibrium and the government's budget constraint require that the price level increase enough to reduce real debt to its initial value.[59]

In addition, the FTPL holds that government bonds are imperfect substitutes for money that provides liquidity. It means that banks can use both money and bonds in managing the liquidity to meet their demand deposits. In this framework, fiscal policy plays a substantial role in determining the total supply of liquidity, while the Central Bank through the Open Market Operation determines the composition of liquidity see Christiano and Fitzgerald (2000), and Canzoneri et al. (2011).

Having discussed the impact of fiscal policy on prices, the next section consider explaining the conduct of fiscal policy at the zero lower bound.

2.4.5 Fiscal Policy at the Zero Lower Bound

Up to this point, we discuss different views on the macroeconomic impact of fiscal policy. Another challenge for macroeconomic policy management is the Zero Lower Bound (ZLB) on the interest rates. The ZLB changes the implication of fiscal and monetary policy as clearly monetary policy is constrained. Under Keynesian view at the ZLB, monetary policy is less effective to influence the economy, see Bodenstein et al. (2009), Devereux (2010), Eggertsson (2010), Romer and Romer (2013), and Coresetti and Muller (2012) among others. While the nominal interest rates are close to zero, the main question here is the potential ways to influence aggregate demand and to raise the level of current inflation and hence to decrease the real interest rate, see Ramey (2011), Romer and Romer (2013), and Woodford (2011). Given that the main

represents a Ricardian view, while the non-Ricardian view considers it as an equilibrium condition, see Christiano and Fitzgerald (2000).

[59] In contrast to Sargent-Wallace analysis, Woodford proposition does not depend on any particular response by the monetary authority to changes fiscal policy.

problem at the ZLB is insufficient spending, macroeconomic policies are required to increase expenditure to stimulate the economy, see Eggertsson (2012).

Further to our discussion regarding the use of UMP at the ZLB, the literature also emphasizes the effectiveness of fiscal policy to stimulate the economic activity given that there is no crowding-out effect through higher interest rates, see Correia et al. (2013).[60] For example, Eggertsson (2010), Christiano et al. (2011), and Woodford (2011) have shown that government spending multipliers can be very large at the ZLB, and that increasing government spending can be welfare improving.[61]

The special circumstance of the interest rates at the ZLB can support the use of active fiscal policy. As discussed in Cogan et al. (2010) at the ZLB fiscal multipliers can be much larger compared with the normal times given that interest rates are constant. It implies that any increase in government expenditure cannot crowd-out investment, but also it can crowd-in private consumption.

So far, we discuss that monetary and fiscal policy are interrelated and their interactions have important implications for prices and the aggregate economy. Now we proceed to explaining the way that monetary and fiscal policy interacts.

2.5 Monetary and Fiscal Policy Interactions

As noted, in textbook treatments of monetary policy it operates mainly through the interest rate channel, which influences investment decisions while prices are fixed in the short run, and clearly interacts with fiscal policy. In addition, an expansionary fiscal policy is expected to increase

[60] Krugman (1998), Eggertsson and Woodford (2003), and Farhi and Werning (2012) within a NK model, show that at the ZLB it is optimal to commit to keeping the interest rate at zero for longer. This policy would increase output and inflation both in the present and in the future and optimally would trade off the mitigation of a recession in the present and the creation of a boom in the future.

[61] As Eggertsson (2012) discussed it is possible that at the ZLB the government spending multiplier turns to be negative if the rise in government spending is expected to be permanent. This can be better explained using a monetary policy role as the below equation:

$$i_t = \max\{0, r_t^e + \pi^* + \phi_\pi(\pi_t - \pi^*) + \phi_y(\hat{Y}_t - \hat{Y}^*)\}$$

Here π^* indicates the implicit inflation target, r_t^e is equilibrium interest rate, and $(y_t - y_t^*)$ is output gap, indicating the long-run output target. As can be seen, the effect of a fiscal expansion on multipliers would disappear if $\phi_\pi \to \infty$ or $\phi_y \to 0$. Thus, at the ZLB a temporary fiscal expansion is required to stimulate the economy.

demand and output.[62] However, an expansionary fiscal policy may be undermined by a Central Bank using contractionary monetary policy to offset the potential positive demand effect. Likewise a Treasury authority seeking to implement fiscal austerity to ensure, say, debt is sustainable, may undermine an expansionary monetary policy, see Branson (1989) and Wickens (2008).

Despite the existence of a vast literature on the impact of monetary policy on the economy, monetary studies often neglect to consider potential role for fiscal policy in their analysis.[63] However, as discussed in Sims (2011) the fluctuations in the price levels cannot be solely explained by monetary policy since fiscal policy may play an important role.[64] The underlying mechanism can be explained as follows. Consider a standard NK model with government budget constraint. A contractionary monetary policy may require additional debt to be issued to pay higher interest rates on the public debt. This policy shock can generate inflation if rational-forward looking agents believe that the debt will not be fully backed by future taxes. Thus, a monetary contraction can lead to an increase in nominal government debt through higher interest rates. As Sims (2011) explains, this monetary policy-generated increase in the interest rate can increase inflation through a positive wealth effect. An increase in the interest rates can affect bondholders' disposable income. The impact would intensify when interest expenses are a major part of the government budget due to a fiscal-induced increase in the interest expenditure share of government debt. If agents perceive that the rise in government's debt would be financed by issuing further bonds or seigniorage rather than taxes, it would increase the aggregate demand by encouraging private expenditure. This can cause a higher inflation rate and output, see Davig and Leeper (2007, 2011), Sims (2011), Leeper and Walker (2012), and Leeper (2013).

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[62]The short-run aggregate supply curve may be either vertical, i.e. with anticipated shifts in monetary or fiscal policy, or have a positive slope when the shift in the policy is unanticipated. Thus, a shift in demand curve can change either only prices, with a vertical supply curve, or both output and prices with a positively slopped supply curve, see Branson (1989).

[63] For exceptions, see Sargent and Wallace (1981), Cochrane (1998, 2001, 2009), Leeper (1991, 2013), Sims (1994, 1997, 2011), and Woodford (1996, 1998). Nordhaus (1994) provides a theoretical model in which monetary and fiscal policy can undermine one another.

[64] This does not imply that monetary policy shocks as a substantial factor in determining the price level can be ruled-out. It indicates that monetary shocks may not be the dominant factor, see Sims (2011).

Sims (2011) argues that a debt-financed fiscal expansion, may account for volatility in US inflation over the 1960-1980. He discusses that an expansionary fiscal policy shock under an active fiscal policy and a passive monetary policy coordination may contribute to increasing the price level. Accordingly, he strongly suggests that the econometric models intended to analyse monetary policy outcome entirely should explicitly account for the fiscal stance given that fiscal policy can be a primary source for changes in the inflation rate.

The literature on the interaction between monetary and fiscal policies explains that alternative macroeconomic policy coordination may yield different policy outcomes.[65,66] An active monetary policy and a passive fiscal policy can be described in the form of aggressive response of monetary policy to current inflation while fiscal policy adjusts taxes sufficiently in response to government debt. This combination produces the conventional outcome that inflation is always a monetary phenomenon while tax policy ensures sustainability of government debt.

In the case of an active fiscal policy and a passive monetary policy, both prices and money growth will increase while the monetary authority is forced to accommodate this shock, see Canzoneri et al. (2011), Davig and Leeper (2007, 2011), and Leeper and Walker (2012). Under this policy management, the fiscal authority sets its expenditure without taking into account the balanced budget requirements, which is tax revenues are not sufficient to finance the expenditures, and seigniorage must adjust to ensure that the government's budget constraint is satisfied. It implies that monetary policy must adjust to deliver the level of seigniorage required to balance the government's budget. Thus, as Walsh (2010) explains fiscal policy can alter the money supply and influences price levels.

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[65] There are three possible combinations of macroeconomic policy: (i) conventional combination in the form of an active monetary policy and a passive fiscal policy, (ii) a combination of a passive monetary policy and an active fiscal policy which mostly is described as the FTPL, and (iii) an unified monetary and fiscal policy in the form of either passive or active that generate unstable equilibrium, see Leeper (1991), and Canzoneri et al. (2011).

[66] Monetary and fiscal policy interactions can be either complementary or substitutive. They interact as substitutes when a monetary expansion is matched with a fiscal contraction and vice versa. For example, if the fiscal authority raises tax rates or cuts spending, then the monetary authority reacts to it by lowering the policy rates and vice versa. If they act as complements, both monetary and fiscal policy are either expansionary or contractionay, see Muscatelli et al. (2004).

Note that monetary policy has been switched to passive mainly when the concern of monetary policy moves away from inflation stabilization toward other issues such as output stabilization or financial crisis mitigation. In these circumstances monetary policy weakly adjusts the nominal interest rates in response to inflation, see Leeper and Walker (2012). However, the motivation for implementing an active fiscal policy mainly has been to prevent the deflationary spiral, see Davig and Leeper (2011), and Eusepi and Preston (2011).[67]

Woodford (1998), Favero and Monacelli (2003), Chung et al. (2007), and Davig and Leeper (2007, 2011) argue that active fiscal policy and passive monetary policy during 1960s and 1970s may explain US inflation dynamics better than monetary factors. As discussed in Chung et al. (2007), and the references therein there is evidence that over this period the Federal Reserve weakly responded to inflation and failed to satisfy the Taylor principle. Then, from the mid-1980s, it appears that the Taylor principle has been satisfied again.[68]

Chung et al. (2007) argue that under a passive monetary policy and an active fiscal policy regime, the price puzzle can be explained as a normal response of prices rather than a puzzle. As explained earlier, if agents anticipate this macroeconomic policy coordination would have government debt implication, it would generate a positive wealth effect. The consequence would be an increase in private expenditure leading to a rise in prices and output. Thus, inflation can sharply increase in short-run in response to a monetary contraction.[69] However, an active monetary policy with a passive fiscal policy would yield a Ricardian equilibrium, implying that debt-management policy has no monetary consequences, see Davig and Leeper (2007, 2011), and Eusepi and Preston (2011).

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[67] The Federal Reserve's bond-price pegging policy after World War II, or the Quantitative Easing policy after the recent financial crisis that shift the focus from targeting inflation, stand out as examples for passive monetary policy, see Leeper and Walker (2012). Another example is the case with Japanese economy since the mid-1990s, as their economy experienced a prolonged period of low interest rates combined with massive fiscal packages. In both these two circumstances interest rate reaches the zero lower bound.

[68] Taylor Rule, as a monetary rule, shows that how much a Central Bank should change the nominal interest rates in response to changes in inflation and output gap. In particular, Taylor Rule recommends that for each one percent increase in inflation, the Central Bank should raise the nominal interest rate by more than one percent. This is called the Taylor principle, see Taylor (1993).

[69] Chung et al. (2007) present results, within a Markov-Switching VAR model using Choleski identification, suggesting that there is a positive correlation between interest rate and inflation under the non-Ricardian case.

Having studied the literature on monetary and fiscal policy and their interactions, the next section provides a brief review of our applied econometric methods.

2.6 Review of Econometric Methodology

In this section, we set out key methodological issues important for our empirical work. In Macro-Econometric modelling, the choice of model depends on the purpose of study, and whether the study is theory-motivated or a statistical description of data is required.[70] In general, dependent upon the modelling objectives, four main econometric approaches can be adopted as follows.

First, there are large-scale macro-econometric models such as the Federal Reserve Board's model of the US economy. Secondly, following the methodology developed by Doan, Litterman and Sims (1984), and Blanchard and Quah (1989), there are unrestricted, Bayesian, and Structural VAR specifications that are used extensively in the literature. VAR and Bayesian VAR (BVAR) models are primarily used for forecasting. The Structural VAR (SVAR) approach aims to provide the VAR framework with structural content by imposing restrictions on the covariance structure of different types of shocks. The basis of the SVAR analysis is the distinction made between shocks with temporary effects from those with permanent effects, which are then related to economic theory. The third approach is closely associated with the Dynamic Stochastic General Equilibrium (DSGE) methodology originally employed in the Real Business Cycle (RBC) framework and developed following the seminal work of Kydland and Prescott (1982) and Long and Plosser (1983). The DSGE method can provide an explicit intertemporal general equilibrium model of the economy based on optimizing decisions made by households and firms. The fourth approach is the Structural Co-integrating VAR approach aims to develop a macro econometric model with a transparent theoretical foundation providing insights on the behavioural relationships. In practice, this approach is based on a log-linear VARX model, that is VAR model

[70] As Pesaran and Smith (2011) discuss, theory is required to recognize the prior knowledge about a problem in a coherent and consistent way. However, the formal theory must be confronted with the data if it is to enhance our understanding and has relevant to the macroeconomic policy. They argue that macroeconomic modelling can benefit from a more flexible approach when does not rely on a narrow adherence to a specific theoretical framework.

augmented with weakly exogenous variables such as foreign variables. This approach has also the flexibility to use the co-integrating VARX models to build the national and global macro econometric models.

Having mentioned the main econometric modelling methods, on the other hand, an adequate model for analysing policy must account for a number of key elements as follows, see Pesaran and Smith (2011). First, the use of long-run co-integrating relations where they exists. Second, the use of flexible short-run dynamics to make it possible the estimation of the long-run relations within the context of co-integrating VAR structure. Third, the recognition of the wide range of inter-connections to allow heterogeneity that exist within and across countries. In a macroeconomic context, this requires a multi-country system involving trade and financial variables that provide the main channels of transmission of shocks across economies, such as that is used in the Global VAR (GVAR) of Dees et al. (2007). Fourth, the wide range of inter-connections in the economic system poses issues of dimensionality, as there will be a large number of variables involved. This would require the structure of the data to overcome the "curse of dimensionality".

The curse of dimensionality is as the dimension of the system increase the number of parameters to be estimated grows and exhausts the available degree of freedom for large datasets, see Sims (1980).One practical approach for high dimensional inter-connected systems is Factor-Augmented VAR (FAVAR) modelling framework as in Bernanke et al. (2005). Fifth, the wide range of inter-connections raises questions about the treatment of shocks. Multi-country *VARX* models, such as those that are the foundation of the GVAR model, which account for the international transmission of shocks, adopts the Generalized Impulse Response Functions (GIRF). The GIRF method which is useful to analyse the dynamic responses of the system to shocks, is a useful alternative for Orthogonalized Impulse Responses (OIR) that is invariant to the ordering of the variables and different shocks.

Given the motivation of our research, this section provides an insight into our applied macro econometric framework, which is based upon the VAR modelling approach. The VAR technique has been found very useful in macroeconomic policy analysis. As addressed in Chapter 1, we extend two recently developed VAR models to incorporate fiscal policy. First, following Bernanke et al. (2005) the FAVAR methodology has been applied to examine monetary and fiscal policy interactions and its implication for the US economy. Having considered the potential impact of fiscal policy on the economy, as discussed earlier, there is a potential omitted variable bias in the existent empirical literature on the FAVAR models. Our study attempts to fill the gap by providing new empirical evidence on the implication of US fiscal policy for the conduct of monetary policy and the monetary transmission mechanism. The curse of dimensionality that concerns the VAR models has been dealt with by employing the FAVAR model. We also apply the Time-Varing Parameter (TVP) FAVAR method, that accounts for the potential non-linearity of the parameters, to examine US monetary and fiscal policy interactions under different macroeconomic policy regimes. This non-linearity may occurred due to structural breaks, hence, is needed to be accounted for upon Lucus critiques.

Second, following Dees et al. (2007) the GVAR methodology has been employed by augmenting fiscal policy to investigate the short-run dynamic responses of the model to monetary and fiscal policy shocks together with their international spillovers, while ensuring that the effects of the shocks on the long-run relations eventually vanish. This provides an important insight into the dynamics of co-integrating models where shocks have permanent effects on the levels of individual variables in the model.

The GVAR methods employed enable us to undertake realistic policy evaluation exercises following one of two routes. The first route imposes no restrictions on the short-run dynamics of the model and investigates the model properties using GIRF analysis. This route addresses Sims' critique and provides insights on the macro economy's dynamic responses, which unlike the OIR is invariant to the order of the variables in the underlying VAR. The second route incorporates long-run relationships restrictions based on the economic theory in the otherwise unrestricted country-specific models. This approach allows us to investigate the impact of policy innovations within a restricted model.

These econometric methods enable us to study monetary and fiscal policy interactions within both national and international framework. Prior to proceeding to our empirical chapters, the follow subsections briefly review these recent developments in the VAR models.

2.6.1 Basic VAR

The VAR models, pioneered by Sims (1980) have acquired an important place as a useful econometric tool in applied macroeconomics. The popularity of these models is due to their ability to both summarize the information contained in the data and to conduct certain types of policy experiments, see Canova (2007). By construction, the VAR models focus on modelling a relatively small set of core macroeconomic variables to preserve parsimony. Thus, care is needed for the choice of variables to be included in the VAR analysis. Although VAR models are considered as a standard tool for policy analysing because of their ability which allows dynamic simulations and forecasting, they often produce counter-intuitive results due to lack of sufficient information, see Eichenbaum (1992).[71]

In general, VAR models are commonly low dimensional to maintain the degree of freedom. This makes the choice of macroeconomic variables difficult.[72] The literature on the VAR models argues that low dimensional VARs is likely to contribute to the appearance of various macroeconomic puzzles generated within the VAR models. A recurring puzzle is a rise in the

[71] The most well-known example is the price puzzle case when prices increase in response to a monetary contraction. Some argue that the appearance of the price puzzle can be either due to the information set or as a result of the choice of the wrong identifying assumption, see Hanson (2004).

[72] The majority of VARs in the literature employ between three to eight variables due to the curse of dimensionality. The limitation of VAR models to include sufficient information is related to the degree of freedom required to estimate parameters. Increasing the dimension of VAR model may reduce the available degree of freedom, even for large datasets. Eichenbaum (1992), and Bernanke et al. (2005) provide a detailed discussion on the subject.

price levels in response to a monetary contraction, which is referred in the literature as the price puzzle.[73,74]

In order to mitigate the curse of dimensionality, a number of approaches are proposed. These approaches mainly includes either calculating monetary policy shocks as innovations to short-term interest rates instead of monetary aggregate, extending the standard VARs by involving more variables to capture inflationary pressure, e.g. the commodity price index, or by variables representing the foreign sector of the economy, see Sims (1992), and Hanson (2004). However, according to Bernanke et al. (2005) there are two potential problems emerge by employing extra information in the VAR analysis. First, as both the dimension and the span of information in the employed VAR models are different among studies, the measurement of policy innovations is likely to be affected. Second, the Impulse Response Functions (IRF) can only be obtained for the variables included in the model and not all the required variables.

In addition to the problem arising from the low-dimensional VARs, another issue that may affect the results is the potential changes in the conduct of macroeconomic policy and the nature of structural exogenous shocks over the time. This can cause parameter instability over the time.[75] Accordingly, the VAR models with Time-Varying components can assess the policy outcome more precisely.

Finally, identification of policy interventions is another issue concerns VAR models that may also contribute to producing the price puzzle. One proposed approach is that policy shocks to be identified by restricting the shape of the dynamic response of macroeconomic variables to them, see Uhlig (2005). According to this method, the variables included in a VAR model to

[73] As mentioned earlier the practice for understanding the nature of the price puzzle sheds light on the low-dimensionality problem of the VAR models. In fact, the majority of the VAR models employ a limited number of variables between three to eight variables to maintain the parsimony property of the estimation. However, it is hard to justify that the economic activity be measured by a few number of macroeconomic variables, see Bernanke et al. (2005) for a detailed explanation.

[74] It is a common practice in the VAR literature to interpret that the price puzzle appears because of the lack of sufficient information. However, there are two other alternative explanations for the price puzzle, namely the cost channel, and as a normal reaction of prices when the model accounts for the fiscal stance, see Barth and Ramey (2002), and Chung et al. (2007) for a detailed discussion, respectively.

[75] The potential structural changes in the economy mainly are induced by changes in the degree of integration in financial markets and a decline in the volatility of output and inflation that attribute to the Time-Varying Parameters (TVP) of the macroeconomic variables, see Korobilis (2013) for a detailed explanation.

study the monetary transmission mechanism are grouped into two subsets. Then sign restrictions are imposed on the impulse responses of the first subset of variables to monetary policy shocks, while no restrictions are imposed on the response of the second subset of variables. The response of the second subset of variables to monetary policy shocks is then used to answer the relevant empirical question on the monetary transmission mechanism, see, for example, Faust (1998) and Uhlig (2005). Thus, as monetary policy shocks are exclusively identified by imposing sign restrictions on the response of prices to the shocks, the price puzzle would never have been observed. Although the sign restriction approach has been found as an effective method to deal with the price puzzles produced in VAR models, there are potential role for misspecification in the explanation of the puzzle, see Favero et al. (2005).

Having explained the main issues concerning the basic VAR models, the follow sections attempt to address the way that VAR models can be modified to include as many variables as required for policy analysing and to account for the potential changes in the transmission mechanism over the time.

2.6.2 Factor-Augmented VAR

The appearance of the price puzzle in the VAR models can be dealt with by the enlargement of the information set. There are a number of theory-motivated variables that must be included in the VAR model, but due to the curse of dimensionality they cannot all be modelled within a VAR. The practical solution is to employ the Principal Component (PC) approach to summarize key trends in a large dataset, see Favero et al. (2005).

Stock and Watson (2005) develop a Dynamic Factor Models (DFM) to capture the dynamic of all macroeconomic information associated with economic activity. DFM seeks to go beyond PC by summarizing key information in a large dataset and accounting for data dynamics. The most important advantage of factor models is that a small number of factors extracted from the dataset can represent the main driving forces in a large set of cross-sectional data. As discussed in Del Negro and Schorfheide (2010), their constructed factor model outperforms the forecasting accuracy compared with the standard VAR approach.

Building on the DFM in Stock and Watson (2005), the idea to combine the standard VAR model with the Factor Modelling namely the FAVAR approach is proposed in Bernanke and Boivin (2003), and further advanced in Bernanke et al. (2005). Within the FAVAR framework, it is possible to summarize the information of a large number of time series into a small number of estimated factors and to take advantage of the simplicity of the standard VAR approach. In this way, all the available and the theoretical motivated information can be used to extract a few numbers of factors that improve the analysis of policy shocks.

The presented results in the above-cited studies confirm that the idea of constructing a FAVAR model in a data-rich environment can mitigate the price puzzle to some extent, see the results presented in Bernanke et al. (2005) as an example. Moreover, the information extracted from the large data sets using the PC method proved to be quite useful for the empirical analysis of monetary policy. It decreases the uncertainty about parameter estimates and is capable of eliminating the main puzzle in the transmission mechanism of monetary policy, see Bernanke et al. (2005), Favero et al. (2005), Koop and Korobilis (2010), and Korobilis (2013). Chapter 3 provides a detailed technical description of the FAVAR modelling procedure.

2.6.3 Time-Varying Parameter Factor-Augmented VAR

As noted, another issue with the VAR models is the problem concerns time-invariant parameters estimated. Cogley and Sargent (2001) develop a VAR model with Time-Varying coefficients. They estimate a nonlinear VAR model with drifting coefficients but constant variance.[76] In another approach, Sims and Zha (2006) estimate a Markov-Switching VAR model that explicitly allows for changes in monetary policy regimes. They find evidence suggesting that only the covariance matrix of their estimated VAR is time-dependant while the model coefficients remain time-invariant, indicating that there is regime change in the variance of structural disturbances.

[76] Their estimated TV-VAR model has a dimension of three variables including inflation, unemployment, and short-term interest rates.

Primiceri (2005) advances this approach by proposing a Time-Varying Parameter (TVP) VAR method which allows all parameters to vary over the time. He presents evidence for time variation of the responses to monetary shocks in 1960s and 1970s implying that the transmission mechanism of the policy shocks evolve over the time in both systematic and non-systematic US monetary policy.[77] Furthermore, the results presented in Primiceri (2005) suggest that non-systematic monetary policy becomes less important during the Greenspan administration while the systematic policy turns to become more aggressive against inflation and unemployment.[78] This finding implies that a Taylor-type Rule is less representative of US monetary policy over the 1960s and 1970s than in the last two decades. See Table 3.2 for a statistical description of changes in the macroeconomic policy indicators. Nevertheless, little evidence is found to support the link between systematic monetary policy and the high inflation and unemployment episodes.

Note that the trivariate TVP-VAR model estimated in Primiceri (2005) potentially faces the problem of the low-dimensional VAR. Building on the FAVAR and TVP-VAR modelling approaches as the two important innovations prominent in the VAR literature, Koop and Korobilis (2010), and Korobilis (2013) propose the TVP-FAVAR to account for both the curse of dimensionality and potential changes in the parameters. The TVP-FAVAR model is constructed using a two-step approach. First, the factors are estimated using the PC approach obtained from the data matrix and treated as observed. Second, the Time-Varying Parameters are assumed to follow a random walk procedure computed using standard state-space method. Thus, employing the TVP-FAVAR modelling method make it possible to involve all the theoretical and empirical motivated information to trace the way in which policy shocks can affect the economy. The results obtained from a TVP-FAVAR model presented in Korobilis (2013) appear

[77] Non-systematic monetary policy is referred to both policy errors and interest rate movements that are the responses to variables other than inflation and unemployment, which are exogenous. As opposed to the non-systematic policy, the response of interest rate to inflation and unemployment represents the systematic monetary policy, see Primiceri (2005).

[78] Primiceri (2005) discusses that the peaks in inflation and unemployment in the Burns period can be better explained by non-systematic policy shocks as a less aggressive monetary policy was conducted in the 1970s.

to succeed in mitigating the price puzzle to a great extent.[79] Chapter 3 discusses technical elements of the TVP-FAVAR approach in greater detail.

2.6.4 Global VAR

Further to extending the VAR models to incorporate as much as theory-motivated information to build up econometric models, it is also useful to consider the interactions of the VAR models across countries. The Global VAR (GVAR) approach allows us to do that. The GVAR framework introduced by Pesaran, Schuermann and Weiner (2004), and further advanced in Dees, di Mauro, Pesaran, and Smith (2007) is a powerful econometrics tool for global modelling. This method combines time series, panel data, and factor analysis techniques to address a wide range of economic and financial issues. Despite the fact that the GVAR model has been initially developed as a tool for credit risk analysis, many other applications of this approach proved it as a suitable policy analysis technique, particularly very useful for the analysis of the transmission of shocks among the world's economies.

The GVAR model is constructed of a large number of country-specific models. The interactions across these individual models take place by relating the domestic variables to their foreign counterparts and global observed variables such as oil price. We construct foreign variables as a weighted averages of foreign variables that correspond to the domestic variables to match the international linkages, such as bilateral trade, and serve as a proxy for common unobserved factors. As explained in di Mauro and Pesaran (2013), the curse of dimensionality associated with the VAR models is addressed by estimating the individual country-specific Vector Error Correcting models conditional on the foreign variables. The assumption of weak exogenity of the foreign variables satisfies that there are no long-run feedback from foreign specific variables to their domestic counterparts, see Pesaran et al. (2004), and Dees et al. (2007). It also concerns the size of economies compared to the global economy.

[79] As is reported in Korobilis (2013), those IRF results which are estimated based on the Bernanke et al. (2005) identification approach, show that there is a price puzzle in 1975 while the price puzzle is disappeared in 1981 and 1996.

The idea of pooling a large number of country-specific VAR models within a global model to study their interactions, emerged in response to the world increasing interdependencies. Given the limitation of the VAR models to capture the potential international linkages, the GVAR methodology has been demonstrated a practical and parsimonious procedure that can deal with the identification of common global factors in a theoretically coherent and statistically consistent approach, see Dees et al. (2007), and di Mauro and Pesaran (2013). The method can also provide a global framework for the quantitative analysis of policy shocks and their transmission channels. A detailed discussion of the GVAR modelling procedure is provided in Chapter 4.

2.7 Concluding Remarks

For decades the common theoretical understanding has been that monetary policy is sufficient to achieve low inflation and stable economic growth. However, the 2008 financial crisis and the zero lower bound event caused most of the major Central Banks to adopt unconventional monetary measures. Further to the ongoing discussion on the impact of UMP, fiscal policy also received attention as an effective way to stimulate the economy. As discussed in Davig and Leeper (2011), the ultimate impacts on the economy depends on the way that monetary and fiscal policy interacts. This is one of our key research question.

Given the motivation of our thesis, we study the macroeconomic impact of monetary and fiscal policy both in normal and unusual times. We explain that although CMP achieved a low and stable prices, but when the interest rates reach the ZLB, CMP is less effective. This accounts for adopting UMP. Having considered the literature on the effectiveness of UMP, fiscal policy may also have an important impact on the conduct of monetary policy and the economy.

For this reason, we discuss the effectiveness of fiscal policy under different views. We explain that regardless of the Ricardian or non-Ricardian view on fiscal policy, at the ZLB monetary policy tools turn to be less competent to stimulate the economy. This accounts for the use of fiscal policy. In addition, we discuss that within the FTPL, fiscal policy has an important role to determine the price levels. Having discussed the literature on monetary and fiscal policy interactions, we conclude that the outcome of monetary and fiscal policy intervention depends on which policy dominates. This argument can provide an alternative explanation for the price puzzle. That is an active fiscal policy and a passive monetary policy can contribute to the appearance of the price puzzle.

Finally, we review the literature on our applied econometric methods that are TVP-FAVAR and the GVAR methods. These methods have been proved useful in dealing with the curse of dimensionality, and the non-linearity of the parameters that concern the VAR models. Our applied methodology also accounts for the potentail international spillovers of the policy shocks.

Appendix 2.A- Government Intertemporal Budget

The government-Treasury budget constraint can be identified as presented in Equation (2.A.1).

$$G_t + i_{t-1}\ B^T_{t-1} = T_t + (B^T_t - B^T_{t-1}) + RCB_t \qquad (2.A.1)$$

Where G_t denotes government expenditure including transfer payments, $i_{t-1}\ B^T_{t-1}$ denotes interest payments on the outstanding debt, T_t denotes tax revenues, $(B^T_t - B^T_{t-1})$ denotes the new issues of interest-bearing debt, and RCB_t denotes any direct receipts from the Central Bank such as the US Federal Reserve turn over to the Treasury.[80] On the other hand, the monetary authority uses the following budget identity to balance changes in their assets and liabilities;

$$(B^M_t - B^M_{t-1}) + RCB_t = i_{t-1} B^M_{t-1} + (H_t - H_{t-1}) \qquad (2.A.2)$$

Where $B^M_t - B^M_{t-1}$ denotes the Central Bank's purchases of government debt, $i_{t-1} B^M_{t-1}$ denotes the Central Bank's receipt of interest payment from the Treasury, and $H_t - H_{t-1}$ denotes the changes in the Central Bank's own liabilities.[81]

We can write the consolidated government budget by combing the Treasury and the Central Bank budgets as follows.

$$G_t + i_{t-1}\ B_{t-1} = T_t + (B_t - B_{t-1}) + (H_t - H_{t-1}) \qquad (2.A.3)$$

Where $B = B^T - B^M$ presents the stock of government interest-bearing debt that is held by the public. According to the consolidated budget, government purchases plus its interest payments on outstanding public debt ($G_t + i_{t-1}\ B_{t-1}$) must be financed through one of these three alternative sources: tax revenues, T_t, borrowing from the private sector, $(B_t - B_{t-1})$, or printing currency to pay for government expenditures which can be represented by the change in the outstanding

[80] Note that superscript *T* denotes the total debt that are issued in period *t-1*, and earns the nominal interest rate i_{t-1}.
[81] These liabilities are called high-powered money or the monetary base as they form the stock of currency held by the public plus bank reserves to back deposits.

stock of non-interest-bearing debt $(H_t - H_{t-1})$. It is possible to rewrite the consolidated government budget in the real values deflated by price level, P_t, as Equation (2.A.4) shows.

$$\frac{G_t}{P_t} + i_{t-1}\left(\frac{B_{t-1}}{P_t}\right) = \frac{T_t}{P_t} + \frac{(B_t - B_{t-1})}{P_t} + \frac{(H_t - H_{t-1})}{P_t} \tag{2.A.4}$$

Note that $\left(\frac{B_{t-1}}{P_t}\right)$ can be multiplied and divided by P_{t-1} to obtain the real debt as follows;

$$\frac{B_{t-1}}{P_t} = \left(\frac{B_{t-1}}{P_t}\right)\left(\frac{P_{t-1}}{P_t}\right) = b_{t-1}\left(\frac{1}{1+\pi}\right)$$

Thus, the consolidated government budget can take the form as in Equation (2.A.5).

$$g_t + \bar{r}_{t-1}\, b_{t-1} = t_t + (b_t - b_{t-1}) + \left[h_t - \frac{h_{t-1}}{(1+\pi_t)}\right] \tag{2.A.5}$$

Where $\bar{r}_{t-1} = [(1+i_{t-1})/(1+\pi_t)] - 1$ denotes the ex-post real return from $t-1$ to t.

In Equation (2.A.5), the last term in bracket represents seigniorage or the revenue from money creation. Seigniorage can be written in the form of Equation (2.A.6).

$$s_t \equiv \frac{H_t - H_{t-1}}{P_t} = (h_t - h_{t-1}) + \left(\frac{\pi_t}{1+\pi_t}\right) h_{t-1} \tag{2.A.6}$$

According to Equation (2.A.6), seigniorage arises from two sources. The first source involves the changes in real high-powered money holdings $(h_t - h_{t-1})$. An increase in the amount of high-powered money that the private sector holds, leads to an increase in the government revenue from money creation.[82] The second part in Equation (2.A.6) shows that the private sector would increase their nominal holdings of money at the rate of inflation to offset the effects of inflation on their real holdings. To ensure this demand, the supply of money must be increased which generates extra revenue for government.[83]

[82] Given that in steady state equilibrium *h* is constant, thus, this source of seigniorage equals zero, see Walsh (2010) for more details.
[83] As Walsh (2010) discusses, in contrast to the high-powered money holdings, the private sector demand for money can be non-zero even in steady state.

As the definition of seigniorage in Equation (2.A.6) suggests, for small values of the rate of inflation, $\frac{\pi_t}{1+\pi_t}$ is approximately equal to π_t. Thus, the real value of base money is depreciated by inflation. The problem with this definition of seigniorage is the neglect of the real interest saving by the government for issuing h which is a non-interest-bearing debt compared to the interest-bearing debt, b, given that the level of government's total real liabilities is a combination of both , $d = b + h$. Thus, a shift from interest-bearing to non-interest bearing debt would allow the government to reduce total tax revenues or increase its expenditures.

It is possible to rewrite the government's budget constraint to express the total liabilities of the government as follows.

$$g_t + r_{t-1}\ d_{t-1} = t_t + (d_t\ - d_{t-1}) + \left(\frac{i_{t-1}}{1+\pi_t}\right)\ h_{t-1} \tag{2.A.7}$$

Accordingly, seigniorage in steady-state takes the form of Equation (2.A.8).

$$\bar{s} = \left(\frac{i}{1+\pi}\right)\ h \tag{2.A.8}$$

Equation (2.A.8) shows that the relevant tax rate on base money depends directly on the nominal interest rate. Thus, by reducing the nominal rates to zero, the government earns no revenue from seigniorage meaning that this lost revenue must be replaced by an increase in other taxes, real borrowing, or a reduction in the government expenditures, see Walsh (2010).

Now we turn our focus to infer the condition required for the Ricardian and non-Ricardian views on fiscal policy from the government's intertemporal budget constraint. The government's intertemporal budget constraint requires that government runs surpluses in present value terms equal to its current outstanding interest-bearing debt.

To write the inter-temporal government budget constraint, that shows government's limitations for borrowing, recalling and rewriting Equations (2.A.5), and (2.A.6) yields:

$$g_t + \bar{r}_{t-1} b_{t-1} = t_t + (b_t - b_{t-1}) + s_t \tag{2.A.9}$$

This Equation can be solved forward to obtain

$$(1+r)b_{t-1}+\sum_{i=0}^{\infty}\frac{g_{t+i}}{(1+r)^i}=\sum_{i=0}^{\infty}\frac{t_{t+i}}{(1+r)^i}+\sum_{i=0}^{\infty}\frac{s_{t+i}}{(1+r)^i}+\lim_{i\to\infty}\frac{b_{t+i}}{(1+r)^i} \qquad \text{(2.A 10)}$$

Where the interest factor *r* is a constant and positive value. The required condition to satisfy the inter-temporal balanced budget is that the last term in Equation (2.A.10) equals zero.

$$\lim_{i\to\infty}\frac{b_{t+i}}{(1+r)^i}=0.$$

It implies that the present discounted value of all current and future tax and seigniorage revenues must be equal to the present discounted value of all current and future expenditures plus current outstanding debt. Accordingly, by defining the primary deficit as $\Delta = g - t - s$, the inter-temporal government budget can be formulated as in Equation (2.A.11).

$$(1+r)b_{t-1}=-\sum_{i=0}^{\infty}\frac{\Delta_{t+i}}{(1+r)^i} \qquad \text{(2.A.11)}$$

As Equation (2.A.11) presents, if the government creates outstanding debt, $(b_{t-1}>0)$, the present value of future primary deficits must be negative meaning that government must run a primary surplus in present value through adjustments in expenditures, taxes, or seigniorage.

To focus on debt, taxes, and seigniorage, we assume that government expenditure equals zero. Thus, budget constraint can be rewritten in the form of Equation (2.A.12);

$$(1+r_{t-1})b_{t-1}=t_t+b_t+s_t \qquad \text{(2.A.12)}$$

Given that the macroeconomic policy outcome depends on how agents respond to the policy implemented, the budget constraint for the representative agents must also be identified. Assume that the agent receives an exogenous endowment *y* in each period, pays lump-sum taxes, t_t, and receives interest payments on bonds denoting by $(1+i_{t-1})B_{t-1}/P_t$ where i_{t-1} is the nominal interest rate, B_{t-1} is the number of bonds held at the start of period t, and P_t is the price level. This relationship can be written as $(1+r_{t-1})b_{t-1}$ where $r_{t-1}=(1+i_{t-1})/(1+\pi_t)-1$ represents the ex-post real interest rate. Furthermore, the agent has real money balances equal to $M_{t-1}/P_t=(1+\pi_t)^{-1}m_{t-1}$ that are carried into period t from period $t-1$. The agent allocates these resources to consumption, real money holdings, and real bond purchases as Equation (2.A.13) presents.

$$c_t + m_t + b_t = y + (1 + r_{t-1}) b_{t-1} + \frac{m_{t-1}}{1 + \pi_t} - t_t \qquad (2.A.13)$$

To understand the extent to which the price level depends on the stock of debt and debt policy, let ψ denotes the fraction of the government's interest-bearing debt that is financed with taxes, with $0 \le \psi \le 1$. As Walsh (2010) explains, $\psi = 1$ means that government interest-bearing debt liabilities are completely financed by taxes. This is the Ricardian interpretation of fiscal policy. However, $\psi < 1$ represents the non-Ricardian view on fiscal policy meaning that seigniorage must adjust to maintain the present value of taxes plus seigniorage equal to the government's outstanding debt.

Assume that T_t denotes the present discounted value of taxes, the net liability of the government must equal T_t, thus:

$$T_t = \psi \ (1 + r_{t-1}) \ b_{t-1} \qquad (2.A.14)$$

Given that T_t is a present value, it can be written in this form;

$$T_t = t_t + E_t \left(\frac{T_{t+1}}{1 + r_t} \right) = t_t + E_t \left[\frac{\psi (1 + r_t) b_t}{(1 + r_t)} \right] = t_t + \psi \ b_t \qquad (2.A.15)$$

Combining Equations (2.A.14) and (2.A.15) yields

$$t_t = \psi \ (R_{t-1} b_{t-1} - b_t) \qquad (2.A.16)$$

Where $R = (1 + r)$. The same procedure can be employed to formulate seigniorage as follows;

$$s_t = (1 - \psi)(R_{t-1} b_{t-1} - b_t) \qquad (2.A.17)$$

As Equation (2.A.17) suggests, $(1 - \psi)$ represents the remaining fraction of the government debt that is not financed by taxes backed by seigniorage.

Using Equations (2.A.13) and (2.A.16), it is possible to rewrite the household's budget constraint to distinct between the Ricardian and non-Ricardian view on fiscal policy in the form of Equation (2.A.18).

$$c_t + m_t + (1-\psi)b_t = y + (1-\psi)R_{t-1}b_{t-1} + \frac{m_{t-1}}{1+\pi_t} \tag{2.A.18}$$

Equation (2.A.18) suggests that in the case of the Ricardian regime with $\psi = 1$, the government's debt does not involve to determine inflation as the price level is proportional to the nominal stock of money. But, when $\psi < 1$, both the nominal money supply and the nominal stock of government's debt are involved in the determination of the price level, see Walsh (2010).

Chapter 3

Monetary and Fiscal Policy Interactions in the United States: Empirical Evidence from a TVP-FAVAR

Abstract

This chapter contributes to the empirical literature on the interaction between monetary and fiscal policy. We consider the impact of monetary and fiscal policy shocks on inflation and output dynamics using a Time-Varying Parameter Factor-Augmented VAR (TVP-FAVAR) method. In baseline results from a linear model, including fiscal policy in the factors has implications for the impact of monetary policy shocks on inflation. This can be explained by wealth effects. The wealth effect is the change in spending that accompanies a change in perceived wealth. Hence, increases in interest rates increase the wealth of bondholders. Moreover, results from our TVP-FAVAR indicate that price puzzles from monetary policy shocks are more accentuated during particular regimes. For example, under an active fiscal policy and passive monetary policy, inflation rose in response to a contractionary monetary policy shock. The underlying mechanism can be explained through the wealth channel. Finally, the results of a fiscal expansion provide support for the non-Ricardian view on fiscal policy within both the linear and non-linear FAVAR model. That is, inflation and output both responded to the fiscal shock.

Keywords: Monetary and Fiscal Policy Interaction, Ricardian Equivalence, Fiscal Theory of the Price Level, Price Puzzle, Time-Varying Parameter Factor-Augmented VAR (TVP-FAVAR).

JEL Classification Codes: E52; E62; E63; E65.

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3.1 Introduction

This chapter studies the interactions between monetary and fiscal policy in the United States. Before the Global Financial Crisis of 2008, the consensus view of mainstream macroeconomics was that monetary policy should actively respond to inflation using the nominal interest rate. In contrast fiscal policy should have a less activist role and passively respond to the business cycle using automatic stabilisers, while focusing upon balancing the government budget, see Walsh (2010). During the Great Recession however, the United States actively responded to the economic downturn using both monetary and fiscal policy. Consequently, the mainstream view was called into question and the interactions between monetary and fiscal policy became much more important. Moreover, sovereign debt levels have grown significantly after the Great Recession. For example, US Central Government Debt as a percentage of GDP has grown from just over 50% at the start of the millennium to over 100% recently, see Figure 3.1. Consequently, this debt build up may present substantial challenges for the conduct of monetary policy in more normal times, see Reinhart and Rogoff (2010) for a detailed discussions. In addition, fiscal policy is potentially important in influencing aggregate demand and inflation. This has recently been argued in Chung et al. (2007), Davig and Leeper (2007, 2011), and Sims (2011) that monetary policy should not be examined in isolation from fiscal policy.

As discussed in Chapter 2, the standard theoretical view is that monetary policy affects aggregate demand, and hence output and inflation in the short-run. According to Keynesian, Monetarist, and New Keynesian models changes in Central Bank nominal interest rate may lead to changes in real rates and therefore economic activity.[1] The latter emphasizes the importance of interest rate rules as a way of controlling inflation. Central Banks operating with discretion have a tendency to deviate from low inflation leading to an inflation bias in policy. Kydland and Prescott (1982) outline these incentives and emphasize the role of Central Bank credibility and

[1] According to monetarists view monetary aggregates is the main determinant of inflation. The monetarists view is synthesized by Milton Friedman's famous dictum that "inflation is always and everywhere a monetary phenomenon", see Leeper and Walker (2012).

pre-commitment in resolving the bias of policy. Ultimately, Rogoff (1985) emphasised monetary policy should be implemented by an independent Central Bank which would in turn separate monetary and fiscal policy.

In contrast, fiscal policy must reliably adjust surpluses to ensure that government debt is stable and fiscal policy should not seek to actively influence aggregate demand, see Walsh (2010), and Canzoneri et al. (2011). Ricardian Equivalence between debt and taxes suggests fiscal policy does not influence consumption. In the case that fiscal policy generates government debt, the issuance of new bonds to finance the incurred debt would imply additional taxes in the future; hence, bonds do not represent net wealth. However, we can also contrast this position with the non-Ricardian view: the fiscal authority sets the government budget regardless of intertemporal budget constraint. It implies that the monetary authority is forced to fully accommodate a fiscal deficit by financing the incurred debt with current and future money creation. Thus, any change in the current stock of debt indicates future money growth, see Aiyagari and Gertler (1985), Woodford (1996, 1998), Christiano and Fitzgerald (2000), Canzoneri et al. (2011), and Sims (1994, 2013).

An alternative approach to understand why fiscal policy can be important for inflation dynamics is the Fiscal Theory of the Price Level (FTPL). As discussed in Chapter 2, the FTPL was introduced by Sargent and Wallace (1981) in their famous paper on Unpleasant Monetarist Arithmetic, and developed further by Cochrane (1999, 2001, 2009), Leeper (1991, 2013), Sims (1994, 1997, 2011), and Woodford (1996, 1998). The FTPL points to the possibility of an independent role for the fiscal stance in determining and controlling inflation. While the monetary-focused literature deems that fiscal policy must reliably adjust to ensure government's debt sustainability, the FTPL counter argues that there are situations when the Central Bank does not target inflation due to other concerns, such as output stabilization or a financial crisis. In these circumstances, monetary policy may lose its credibility to control inflation and influence the real economy in the conventional way, see Chung et al. (2007), Davig and Leeper (2007), Sims (2011), Leeper and Walker (2012), and Leeper (2013).

Moreover, it is important to consider that monetary and fiscal policy interactions may change over time depending upon the macroeconomic framework. We can contrast two different regimes in particular in which monetary and fiscal policy interacts, see Leeper (1991) and Woodford (1996). Firstly, an active monetary policy and a passive fiscal policy, when the Central Bank responds to inflation and the fiscal authority satisfies the budget constraint. Secondly, a passive monetary policy and an active fiscal policy, when the fiscal authority independently determines its budget while the Central Bank is required to adjust monetary policy in order to satisfy the government budget constraint.[2,3,4]

Much of the monetary-focused literature considers the fiscal stance irrelevant for achieving price stability, as long as the government's intertemporal budget constraint is satisfied. However, the fiscal authority's decision can influence the impact of monetary policy. Bradley (1984), Sims (1994), Cochrane (1999), Canzoneri et al. (2011), Davig and Leeper (2011), Sims (2011), and Leeper and Walker (2012) discuss that the omission of the fiscal stance from models intended to evaluate monetary policy may produce inferior results, i.e. omitted variable bias. The reason is that fiscal variables can be a key source for changes in inflation, see Sims (2011).[5] To illustrate the important implication of fiscal and monetary policy interactions for the determination of the

[2] As discussed in Chapter 2, Woodford (1996) describes active monetary and passive fiscal policy case as the Ricardian because monetary shocks can change the price levels without involving the fiscal stance. This is generally considered as the conventional outcome. In contrast, the second case of passive monetary and active fiscal policy is the Non-Ricardian as the fiscal stance does impact the price levels by encouraging private expenditure.

[3] The importance of government liabilities' finance-source for the analysis of the inflation is first initiated by Sargent and Wallace (1981), and Sargent (1982).

[4] According to Sargent and Wallace (1981) when government deficits are considered as exogenous, monetary policy loses its ability to control inflation when the deficits reach the fiscal limit. It puts pressure on the monetary authority to generate seigniorage revenues for government to ensure the interest payments on the debt. In contrast to the idea that fiscal inflation is caused by monetizing deficits in Sargent and Wallace (1981), the FTPL relates the nominal bond to a nominal payoff in which the real value of the payoff depends on the price level. When the nominal debt is fully financed by real resources, i.e. real primary surplus and seigniorage, fiscal policy is inflationary only if the Central Bank monetizes deficits. However, when the government does not increase the real resources to finance the debt, the FTPL creates a direct link between current and expected deficits and inflation, see Leeper (2013).

[5] Sims (2011) provides a theoretical discussion of the way that fiscal authorities decision's may impact the monetary transmission mechanism. He concludes that if a Central Bank aims to consider all the factors that impact inflation and output growth, they should not ignore the fiscal stance.

price level, Leeper (1991, 2013) argues that to ensure the uniqueness of equilibrium, either monetary or fiscal policy must be active and the other one passive.

This chapter studies the impact of monetary policy on output growth and inflation, whilst accounting for the potential role for the government's fiscal stance. Earlier empirical evidence on monetary and fiscal policy interactions comes from either the VAR models or Structural Policy Rules approach, see Favero and Monacelli (2003), Davig and Leeper (2007), and Canzoneri et al. (2011) among others. As mentioned in Chapter 2, VAR models have been developed as one of the key empirical tools for analysing policy and evaluating theory.[6] One major problem concerns VAR models, however, is the occurrence of the puzzling behaviour of some Impulse Response Functions (IRF), with the price puzzle as the most common one. The price puzzle is an increase in the price level in response to a contractionary monetary policy shock. The dominant view in the literature relates the puzzle to the curse of dimensionality concerns VAR models to maintain the degree of freedom.[7,8] The curse of dimensionality is that as the dimension of the system increases the number of parameters to be estimated grows. This exhausts the available degree of freedom even for large datasets, see Sims (1980).

Several studies attempt to resolve the puzzle by changing the identification assumptions or by expanding the information set on which policy choices are based.[9] However, Hanson (2004) argues that the price puzzle was more pronounced in the 1960s and the 1970s, which is considered to be a period of active fiscal policy and passive monetary policy. This implies that the price puzzle may be explained through the way in which monetary and fiscal policy interacts and influences inflation rather than adding extra information to the model.[10] Chung et al. (2007) argue

[6] See, Bernanke and Blinder (1992), Bernanke and Boivin (2003), Bernanke et al. (2005), Del Negro and Schorfheide (2010), and Koop and Korobilis (2010).

[7]Sims (1992) first commented on the price puzzle as an unconventional response of the price level to a monetary contraction. The "price puzzle" was named by Eichenbaum (1992). Sims (1992) explains that the price puzzle occurs as a result of imperfect information that the Central Bank may use to predict the future inflation.

[8] Hanson (2004) provides a comprehensive survey on the price puzzle literature. One most common interpretation for the price puzzle relates it to the VAR misspecification which would be either disappear or lessen by adding further information to the estimated VAR.

[9] See Bernanke et al. (2005) for a detailed discussion.

[10] Another explanation for the price puzzle relates the counterintuitive reaction of prices to a monetary contraction to the cost channel of monetary transmission which impacts the supply-side of the economy as opposed to the demand-side, see Barth and Ramey (2002). The cost channel explains that to the extent that firms must borrow to

that the price puzzle that emerges in monetary VARs can be a natural outcome of periods when an active fiscal policy coordinates with a passive monetary policy, rather than the identification problems.

Recently, Factor-Augmented VAR models appear to help deal with the counter-intuitive price puzzle to some extent by incorporating additional information into the VAR, see Bernanke and Boivin (2003), Bernanke et al. (2005), and Stock and Watson (2005). However, FAVAR models are typically linear and it is difficult to justify this approach in the presence of changes in macroeconomic policy regimes. For example, there exists evidence of substantial fiscal regime instability, see Favero and Monacelli (2003), Chung et al. (2007), and Davig and Leeper (2007, 2011). Favero and Monacelli (2003) argue that the constant-parameter analysis of fiscal policy studies would be misleading in that it would predict a stabilizing fiscal regime throughout the sample. These arguments motivate us to employ a non-linear Time Varying Parameter approach to study the macroeconomic impact of monetary and fiscal policy interactions.

The non-linear analysis of VAR models first proposed by Primiceri (2005), namely TVP-VAR, to consider monetary shocks at different points in time. Another alternative to TVP-VAR method is the Regime-Switching models as proposed by Sims and Zha (2006). These models are developed to capture a determinant finite number of breaks representing rapid shifts in the policy.[11] One clear advantage of TVP models over the Regime-Switching approaches is that TVP models capture smooth changes of the coefficients over time, see Primiceri, (2005).

The idea of combining the FAVAR models with TVP was developed by Koop and Korobilis (2010), and Korobilis (2013). This has proved successful in addressing the problems associated with standard VAR models. That is low dimensionality and non-linear regimes. Comparing the results obtained from a Constant-Parameter FAVAR model in Bernanke et al.

finance the cost of production and new investment, higher interest rates increase the unit cost that induces an increase in the price level at least for some periods, see Barth and Ramey (2002), and Christiano et al. (2005).

[11] As explained in Primiceri (2005), the learning dynamics of the agents and the monetary authority can be better captured by a model with smooth and continuous drifting coefficients rather than a model with discrete breaks.

(2005) with those presented in Korobilis (2013) from a TVP-FAVAR model, it is clear that the latter approach corrects the price puzzle to a greater extent.

However, despite the promising results obtained from different combination of TVP and FAVAR methods to address the price puzzle, the potential impact of the fiscal stance on the economy has been ignored, see Bernanke et al. (2005), Primeciri (2005), Sims and Zha (2006), Koop and Korobilis (2010), and Korobilis (2013) among others. Table 3.1 presents a summary of the related literature in which this Chapter is closely related with. It shows that the empirical literature on the monetary transmission mechanism mainly relies on a Ricardian interpretation of the fiscal policy.[12]

We identify a gap in the literature on both the monetary transmission mechanism, and monetary and fiscal policy interactions. While the former studies the impact of monetary policy on the real activity measures isolated from fiscal policy, the latter one provide evidence on the macroeconomic policy interactions within small VAR models. Thus, this Chapter contributes to the empirical literature on monetary and fiscal policy interactions in the following ways. Firstly, we examine monetary-fiscal policy interactions by examining the responses to a monetary shock in a FAVAR model including fiscal policy variables. Secondly, we compare whether monetary policy interactions change over time. We do so by using a TVP-FAVAR model, which accounts for different periods of monetary and fiscal dominance. Thirdly, we examine the macroeconomic impact of fiscal policy shock within both a linear and non-linear FAVAR model.

To preview our results, firstly we find that including fiscal variables in the baseline linear FAVAR causes an increase in inflation in response to a contractionary monetary policy shock. This response can be explained through a wealth effect. In the presence of government debt, a higher interest rate can stimulate private expenditure, as agents may perceive an increase in their

[12] The monetary-focused literature on the transmission mechanism of monetary policy ignores the impact of the fiscal stance on the economy and implicitly assumes that fiscal policy can only change the composition of GDP rather than its level, see Table 3.1.

wealth, i.e. the issuance of new bonds or an increase in their disposable income. This in turns can encourage private consumption leading to an increase in aggregate demand and inflation.

Second, the results from the TVP-FAVAR model suggest that the fiscal-augmented model produce price puzzles. The mechanism works as follows. Higher interest rates induce bondholders to consume more in periods when fiscal policy is active. As defined in Chapter 2, an active fiscal policy means that the fiscal authority determines taxes and government expenditure independent of inter-temporal budget constraint. This finding provides evidence for the role of fiscal policy on the price determinations. The influence tends to be more accentuated in the case of an active fiscal and passive monetary policy as higher interest rates can lead to the issuance of more government bonds. This would increase government debt given that an active fiscal policy is in place. Thus, the outcome of a monetary contraction can be an increase in private consumption through a positive wealth effect. Third, the non-Ricardian view on the fiscal policy can find empirical support within both Constant and TVP-FAVAR models as both inflation and output increase in response to the fiscal shock.

Thus, the main contribution of this chapter is to empirically validate the alternative interpretation of the price puzzle explained in Chung et al. (2007). This fiscal interpretation differs from the Cost-Channel explanation of the price puzzle initiated by Barth and Ramey (2002), and Christiano, Eichenbaum, and Evans (2005). Our study, also, confirms the empirical inference drawn by Favero and Monacelli (2003), Davig and Leeper (2007, 2011), and Leeper and Walker (2012), Leeper (2013) on the non-Ricardian view of fiscal policy in the United States. Finally, as regards the outcome of monetary contractionary policy shock within a fiscal-excluded TVP-FAVAR model, our results are consistent with those presented in Korobilis (2013) in mitigating the price puzzle. The chapter is organised as follows. Section 3.2 is a brief review of the related literature. In section 3.3, the econometric methodology is explained. Section 3.4 presents model specifications and the empirical results. A brief summary of results is provided in section 3.5. Section 3.6 concludes the study.

Table 3.1. Key Literature on Monetary and Fiscal Policy

Study	Methodology	Monetary-Fiscal Policy Interactions	Main Contribution
Bernanke, Boivin, and Elliasz (2005)	FAVAR	Monetary-Focused	The appearance of the price puzzle is due to the lack of information. Their results show that adding extra information can reduce the price puzzle.
Primiceri (2005)	TVP-VAR	Monetary-Focused	Non-Systematic shocks may better explain the peaks in inflation over the 1970s and 1980s rather than weaker interest rate responses to inflation and real activity.
Korobilis (2013)	TVP-FAVAR	Monetary-Focused	Firstly, the responses of output, investment, and quantity of money to monetary shocks have been changed over the time. Secondly, the constructed TVP-FAVAR can correct the price puzzle to a great extent compared with those of Bernanke et al. (2005).
Favero and Monacelli (2003)	Markov-Switching VAR-Augmented Policy Rules	Monetary-Fiscal Policy does interacts	Monetary and fiscal policy interactions have inflationary effects. In addition, fiscal policy appears to perform as the non-Ricardian before 1987, while it turns to be Ricardian after 1987.
Chung, Davig, and Leeper (2007)	Markov-Switching Policy Rules	Monetary-Fiscal Policy does interacts	The price puzzle can be a natural outcome of an active fiscal policy and a passive monetary policy. In addition, under this macroeconomic policy coordination, the Ricardian view on policy interactions appears to be implusible.
Davig and Leeper (2007,2011)	Markov-Switching Policy Rules	Monetary-Fiscal Policy does interacts	The outcome of an active fiscal policy and a passive monetary policy is the non-Ricardian. That is inflation and output increase in response to a fiscal expansion by generating a positive wealth effect which encourage private consumption.

Note: This Table summarizes the related literature that the chapter is constructed upon it.

3.2 Review of the Literature on Monetary and Fiscal Policy Interactions

The general consensus on the dominant role of monetary policy has recently been subject to critique. Indeed, monetary and fiscal policy do interact through the intertemporal government budget. However, the government budget can be considered either as a constraint or as an equilibrium condition upon different monetary and fiscal policy coordination, see Favero and Monacelli (2003), Walsh (2010), Leeper and Walker (2011), Sims (2011), and Leeper (2013) among others. This suggests that the Ricardian view on fiscal policy, which assumes fiscal policy is ineffective and the government budget is a constraint, is difficult to justify as a fact that can be held under all circumstances.

Despite the existence of a vast literature on the impact of monetary policy on the economy, monetary studies often neglect to consider the potential role for fiscal policy in their analysis.[13] The empirical literature on the transmission of monetary policy shocks is mainly studied through VAR modelling.[14] This literature mainly studies the effect of unanticipated monetary policy shocks that are constructed using VAR models, assuming that the specified VAR models contain the present and past information of the agents. For example, much research attempts to investigate the cause of the US inflation in the 1970s, concludes that it can be explained by misconduct of monetary policy and that inflation is induced by a rapid growth of the money supply. Christiano et al. (1999) provide a comprehensive survey of the literature.

In contrast, Sims (1994, 2011) argues that in a fiat-money economy, inflation appears to be more a fiscal phenomenon rather than a monetary one, given that the value of fiat money always depends on public beliefs about future fiscal policy. Furthermore, when there is uncertainty about future fiscal policy, a monetary policy instrument may lose its influence on the economy, or produces unconventional effects such as the price puzzle.

[13] The exceptions are noted in Chapter 2.

[14] Another alternative approach to study the monetary transmission mechanism is Structural Policy Rules approach. The literature in this area is built and developed mainly based on Taylor (1993) in a way that the policy rules reflects systematic response of monetary policy to exogenous shocks. These studies focus on examining monetary policy as systematic response to variation in observable variables within the estimated Structural Policy Equations, see for example Clarida et al. (2000).

Sims (2011) explains that a debt-financed fiscal expansion, can account for volatility in US inflation over the sample 1960-2010.[15] He shows that an expansionary fiscal policy shock under an active fiscal policy and a passive monetary policy induces inflation and consumption to increase.[16] Accordingly, Sims (2011) suggests that the econometric models intended to analyse monetary policy should explicitly involve the fiscal stance, as this may be a primary cause of inflation.

Having said that fiscal policy is an important factor for the determination of inflation, the literature on the macroeconomic impact of fiscal policy is divided between two views, namely the Ricardian, and non-Ricardian. The empirical literature on the impact of fiscal policy supports the both views.[17] Examples for the Ricardian view include Barro (1979), Evans (1985,1987), Plosser (1987), Bohn (1998), and Canzoneri et al. (2001, 2011).[18] In an empirical study, Bohn (1998) examined the US fiscal policy and concluded that a rise in the debt-to-GDP ratio leads to an increase in the primary surplus and taxes respond to ensure that the intertemporal budget constraint is satisfied. According to his findings, fiscal policy appears to act in a Ricardian way. In another study, Canzoneri et al. (2011) examine the response of US liabilities to a positive shock to the primary surplus within a VAR model. They argue that a positive shock to the primary surplus can reduce real liabilities without negative correlation. Thus, they provide evidence supporting a Ricardian interpretation for fiscal policy in the sense that output and inflation is unresponsive to fiscal policy shocks. In contrast, a monetary contraction causes output and

[15] The results presented in Sims (2011) come from a structural VAR consists of real GDP, the personal consumption expenditure, price deflator, one-year US treasury rate, the 10-year treasury rate, the ratio of the primary deficit to the market value of privately held US government debt, the market value of privately held US government debt divided by nominal GDP, and interest expenses as a fraction of total receipts in the US federal budget.

[16] As explained in Chapter 2, an active fiscal policy refers to the situation in which the fiscal authority sets its expenditure without taking into account the government's intertemporal budget equation. It implies that tax revenues are not sufficient to finance the expenditure. A passive monetary policy implies that the monetary authority weakly adjusts the nominal interest rates in response to inflation.

[17] As explained in Chapter 2, the Ricardian view on fiscal policy states that an expansionary fiscal policy which generate debt implies higher taxes in the future to finance debt. Given that this policy only postpones the tax burdent and does not remove it, the outcome would be an increase in private saving rather than private expenditure. Thus, the policy cannot stimulate the economy. In contrast, a non-Ricardian fiscal policy holds that fiscal policy can effectively stimulate the economy by encouraging private expenditure, see Elmendorf and Mankiw (1999), and Christiano and Fitzgerald (2000).

[18] Bernheim (1987) provides a critical survey of the empirical literature on the non-Ricardian view to support the Ricardian view on fiscal policy.

inflation to fall as higher interest rate would lower aggregate demand through a reduction in private expenditure.

In contrast, several other studies show that a debt-financed fiscal expansion can be an effective policy to increase inflation and output that is a non-Ricardian view on fiscal policy. For example, Cochrane (2001, 2009) provide a non-Ricardian explanation for government debt dynamics in the post-war US data. Reade (2011) offers a non-Ricardian interpretation for fiscal policy in response to the 2008 financial crisis. Sims (2011) argues that the non-Ricardian view on fiscal policy can explain the high inflation of the 1970s and the early 1980s in the US economy. Davig and Leeper (2007) find that a monetary contraction combined with a fiscal expansion in which taxes do not respond sufficiently to debt, can induce a positive wealth effect leading to an increase in private consumption. This, in turns, would increase inflation and output. Note that the increase in interest rate induced by the monetary contraction may cause the incurred deficit more expensive to finance, thus more government liabilities needs to be issued. Until the price levels start to increase, the new issued bonds would create a positive wealth effect. Moreover, with sticky prices the wealth effect would stay for some time to affect households' consumption.

As another example from the literature that accounts for the role of fiscal policy in the monetary transmission, we can refer to Bradly (1984). He estimates two semi-structural equations representing the demand and supply equations for reserves to examine the influences of fiscal policy on monetary policy.[19] Bradly (1984) finds that during 1970s-1980s monetary policy does react to fiscal policy both directly, i.e. through changing the reserves, and indirectly, i.e. through changing the nominal interest rates. He concludes that the government deficits induce an increase in money demand due to increasing the public demand for bonds. Consequently, the monetary authority would be forced to accommodate the growth in money demand.

[19] The demand representative equation relates the Fed funds rate to non-borrowed reserves, government debt, and other demand determining variables. The supply equation is a Federal Reserve reaction function which determines the supply of reserves.

Given that the outcome of fiscal policy depends on the way that the government's intertemporal budget constraint is satisfied, i.e. the Ricardian and non-Ricardian views, different monetary and fiscal policy regimes also contribute to the outcome. In a seminal paper, Leeper (1991) argues that under an active monetary policy and a passive fiscal policy regimes, the monetary authority targets nominal interest rate and does not respond to the government's debt. In this case, the fiscal authority would adjust taxes to ensure the government's intertemporal budget requirements. In contrast, an active fiscal policy and a passive monetary policy suggests that the monetary authority adjusts seigniorage revenues to satisfy the government's budget balance while the fiscal authority remains unresponsive to the debt.[20]

Having said that different monetary and fiscal policy regimes may substantially change the policy outcome, it is also crucial that macroeconomic policy analysis accounts for the potential policy changes. The literature on monetary and fiscal policy interaction provides evidence for monetary and fiscal policy regime changes. For example, Favero and Monacelli (2003) estimate fiscal policy regime changes, using a Markov-switching VAR model, to illustrate the post-war US inflation and output dynamics. They find that fiscal policy has been active before 1987 and then switched to passive until 2001.[21] They also find that the behaviour of fiscal policy has changed over the time: after a prolonged period of fiscal policy instability, it switches to a stable period in 1986:Q3 with a Ricardian feature coupled with an active monetary policy. In addition, they provide evidence that fiscal policy significantly influences the price level when fiscal policy is active and monetary policy is passive, exactly as it was before 1987. Their finding support the hypothesis that an active monetary policy may not have been a sufficient condition to stabilize

[20] As discussed in Leeper (1991) a combination of active monetary policy and active fiscal policy would generate unstable inflation. Also, the price levels would be undetermined if both policies performs passively.

[21] Favero and Monacelli (2003) report active episode for fiscal policy in periods 1965:Q3-1968:Q1; 1974:Q2-1986:Q2, and passive fiscal policy in periods 1960:Q4-1965:Q2; 1968:Q2-1974:Q1; 1986:Q3-2000:Q4. As regards monetary policy regime changes, Davig and Leeper (2007,2011) find that monetary policy has been active in 1980:Q3-1990:Q4 and 1995:Q1-2000:Q2; and passive in 1950:Q3-1980:Q2, 1991:Q1-1994:Q4, and 2000:Q3-until recently. Note that they define an active monetary policy when interest rates respond aggressively to inflation while a passive monetary policy refers to a weak response of interest rates to inflation when the monetary authority sets interest rates to accommodate fiscal policy. In addition, an active fiscal policy means that the fiscal authority sets its budget regardless of intertemporal budget constraint while the opposite is considered as passive fiscal policy.

inflation. They explain that under a constant fiscal regime assumption, the policy-generated inflation switches to a divergent path even if the monetary authority continue to respond aggressively to any rise in inflation expectations. They argue that a more accurate description of the US macroeconomic policy outcome for the post-1987 can be obtained using monetary and fiscal policy interactions, rather than solely relying on a Taylor Rule-based monetary policy.[22] Favero and Monacelli (2003) conclude that neglecting the monetary and fiscal policy interactions can lead to an imprecise assessment of the macroeconomic policy outcome.

Woodford (1998), Favero and Monacelli (2003), Muscatelli et al. (2004), Chung et al. (2007), and Davig and Leeper (2007, 2011) argue that active fiscal policy and passive monetary policy during 1960s and 1970s may explain the inflation dynamics better than monetary factors.[23] As discussed in Chung et al. (2007) and the references therein, there is evidence that over the 1960s and 1970s the Federal Reserve followed an interest rate rule that weakly responded to inflation, failing to satisfy the Taylor principle.[24] Then, from the mid-1980s, it appears that the Taylor principle has been satisfied again.

As another evidence for monetary and fiscal policy regime changes, we can refer to Davig and Leeper (2007, 2011). They provide evidence for substantial regime changes in macroeconomic policy during the 1970s and 1980s, see Figure 3.B.1. Their finding, within a Markov-Switching model, suggests that the Federal Reserve has switched from a passive monetary policy to an active one, with an opposite shift for fiscal policy. They explain that with an active fiscal policy in place, any increase in government expenditure is not expected to be financed with higher taxes. Therefore, an increase in government debt would induce an increase in aggregate demand, prices, and output.

[22] This issue also is noted in Primiceri (2005).

[23] Muscatelli et al. (2004), within a NK model, find evidence suggesting that over the 1980s the US monetary and fiscal policies were as substitute, and then turned to be complementary since the 1990s. They show that the linkage between fiscal and monetary policy has shifted post-1980. Monetary and fiscal policies are called as complements if a fiscal expansion is jointed with monetary expansion, and vice versa. In the case of substitute policy coordination, a fiscal expansion is jointed with a monetary contraction and vice versa.

[24] As explained in Taylor (1993), Taylor principle indicates that for each one percent increase in inflation, the Central Bank should raise the nominal interest rate by more than one percent.

Furthermore, Davig and Leeper (2007, 2011) discuss that when agents expect that the fiscal authority would switch to an active fiscal policy regime, their spending decisions in response to a monetary contraction can generate a positive wealth effect. This in turns can stimulate the aggregate economy. They find that the price puzzle in response to monetary contraction is more severe when the monetary regime is passive and fiscal policy is active. According to this finding, with a passive monetary policy, nominal interest rates do not respond sufficiently to inflation, so the real rates declines. The lower real rates reduces saving that causes an increase in current consumption. On the other hand, an active fiscal policy can indicate that the government expenditure would not be financed with higher tax revenues. This can be perceived as an increase in wealth by agents leading to a further increase in private expenditure and inflation. Thus, an active fiscal policy can contradict the effect of monetary contraction.

The potential role of different monetary and fiscal policy regimes in the appearance of the price puzzle is also investigated in Chung et al. (2007). They provide an alternative explanation for the appearance of the price puzzle following a contractionary monetary policy shock. They comment on the potential rule of the fiscal stance in generating the price puzzle as monetary and fiscal policy interactions have substantial implications for prices. They argue that when an active fiscal policy and a passive monetary policy are in place, the price puzzle can be explained as a normal response of prices rather than a puzzle. As discussed in Chapter 2, if agents anticipate that the monetary and fiscal authorities' decisions would have debt implication, it can generate a positive wealth effect. This in turns can increase private expenditure leading to an increase in prices and output. Thus, it is possible that inflation increases in the short-run in response to a monetary contraction.[25] Thus, as Christiano and Fitzgerald (2000), and Sims (2011) argue understanding the price puzzle is a prerequisite for measuring the effect of monetary policy.

As regards the appearance of price puzzle in monetary studies, a large number of studies find that the price puzzle is associated with a monetary contraction, see Hanson (2004) for a

[25] Chung et al. (2007) presents results suggest that there is a positive correlation between interest rate and inflation under the non-Ricardian case. The results come from a Markov-Switching VAR model using Choleski identification.

survey of the literature. Several approaches have been proposed to correct the puzzle including the addition of extra information related with inflation, i.e. commodity price indices or global inflation measures.[26] However, Hanson (2004) argues that it is not a plausible solution. He examines a number of alternative indicator variables that contains extra information for inflation forecasting, and reports little correlation between the price puzzle and indicator variables to explain inflation. More importantly, Hanson (2004) finds that the appearance of the price puzzle primarily is associated with the 1959-1979 sample period. This period is known in the literature as a combination of active fiscal policy and passive monetary policy, or the non-Ricardian episode of US fiscal policy as is acknowledged in Woodford (1998).

Further to the potential role of different macroeconomic policy regimes, and lack of information in the appearance of the price puzzle in monetary literature, Barth and Ramey (2002) explain the cost-channel interpretation of the price puzzle that focuses on the impact of shock on the supply-side of the economy. They argue that in circumstances in which capital is an essential component of output, a monetary contraction can influence output through the supply-channel together with the traditional demand-type channel. Their empirical results come from an industry-level VAR model. Their results support the idea that for many industries output falls in response to monetary contraction, while the price-wage ratio increases. This is consistent with a supply shock. They also, find that the effects are noticeably more pronounced for the period before 1979.

Having discussed the literature on monetary and fiscal policy interactions and before proceeding to the empirical analysis, the next section presents some stylised facts of the US macroeconomic policy indicators for the various Chairmen of the Federal Reserve.

[26] The reason for the role of commodity prices in mitigating the price puzzle may be due to an information channel that commodity prices respond more quickly than aggregate goods prices to future inflationary pressures, rather than serving as a proxy for marginal costs of production, see Hanson (2004), and Bernanke et al. (2005).

Table 3.2. Key Indicators of the US Macroeconomics policy

	Policy Coordination		Federal Funds Rate	Inflation	Industrial Production Growth	Government Debt-to-GDP
Martin (1959-1970)	PM AF&PF	Mean	4.57	2.08	0.01*	37.00
		Std	1.68	1.91	0.02†	2.95
Burns (1970-1978)	PM AF&PF	Mean	8.36*	7.06*	0.01*	32.08
		Std	3.52†	2.45†	0.02†	1.04
Volcker (1978-1987)	AM AF&PF	Mean	6.62	4.72	0.01	50.56
		Std	2.36	1.42	0.01	10.73
Greenspan (1987-2006)	AM&PM PF&AF	Mean	3.60	4.45	0.01	59.20
		Std	1.71	1.98	0.01	2.97
Bernanke (2006-2013)	PM AF	Mean	1.23	4.18	0.00	82.09*
		Std	1.85	2.39	0.02†	15.03†

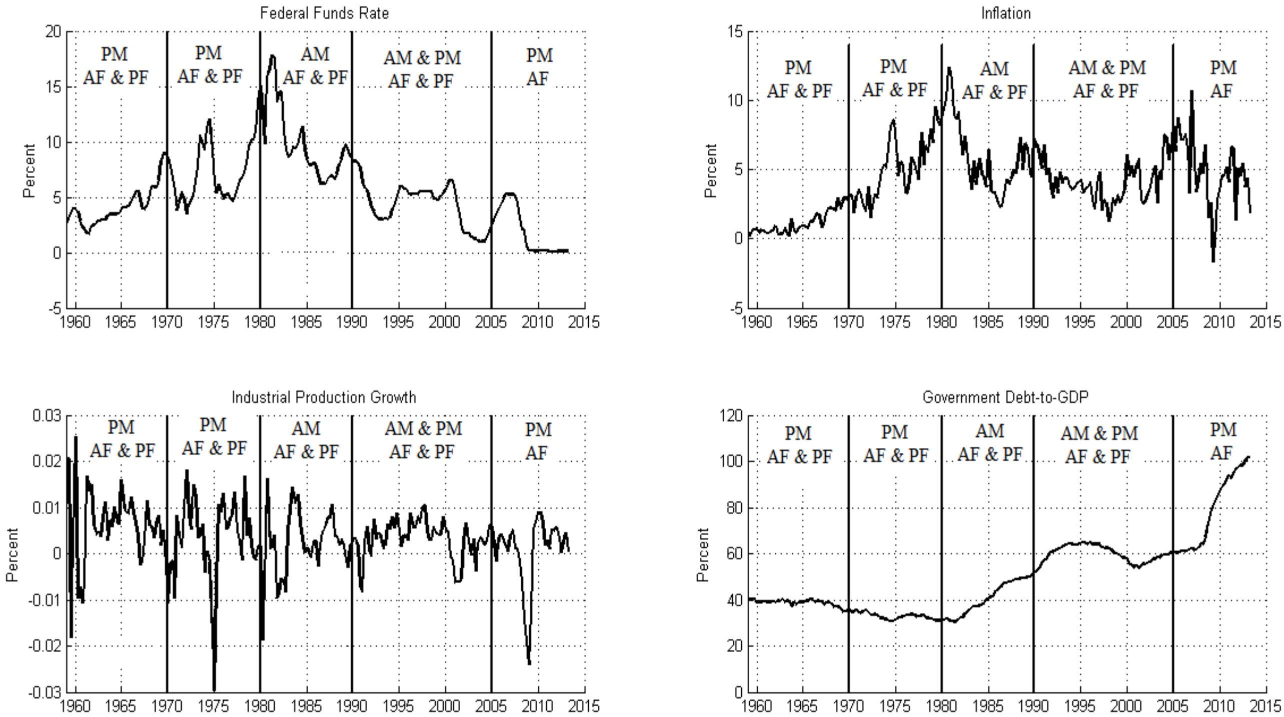
Note: This Table reports the mean and standard deviation for key indicators of the US economy under the selected representative chairmanships of the Federal Reserve. Inflation is the change in CPI. Values marked by asterisks, *, present the largest Mean, and values marked by † present the largest Standard deviation. The policy coordination is reported according to monetary and fiscal policy regimes estimated by Favero and Monacelli (2003), and Davig and Leeper (2007, 2011). AM and PM abbreviate active and passive monetary policy, respectively. In addition, AF and PF abbreviate active and passive fiscal policy, respectively.

Stylised Facts

Table 3.2 details a descriptive account of the US macroeconomic policy indicators over the 1959:Q1-2013:Q2 sample. A probability estimation of different macroeconomic policy regimes for the sample is illustrated in Appendix 3.B that is adopted from Davig and Leeper (2011). We can see from the Table that between 1959 and 1970, the Chairman Martin raised short-term interest rate to control inflation. However, this is identified as a period of passive monetary policy, see Davig and Leeper (2007, 2011), and Figure 3.B.1. Although the average nominal interest rates were more than two percent points above inflation during the time, but the monetary authority has not endogenously responded to the accumulation of debt.

As presented in Table 3.2, during Burns administration an expansionary monetary policy contributed to the high inflation in 1970-1980 with a weak response of interest rates to inflation, referred as a passive monetary policy. Then, tight monetary policy under Paul Volcker dragged the economy into a deep recession. From 1987, Greenspan was associated with a decline in both short-term interest rates and inflation. Then, the short-term rate further falls and reaches its zero lower bound in Bernanke period, while inflation fluctuates around the mean value over the sample.

Figure 3.1. US Macroeconomic Policy Indicators



Note: This Figure presents US Interest rates, Inflation, Debt, and GDP growth over the period 1959:Q1-2013:Q2. All time-series are taken from the St Louis Fed FRED database as detailed in Appendix 3.A. The policy coordination is reported according to monetary and fiscal policy regimes estimated by Favero and Monacelli (2003), and Davig and Leeper (2007,2011). AM and PM abbreviate active and passive monetary policy, respectively. In addition, AF and PF abbreviate active and passive fiscal policy, respectively.

Figure 3.1 plots key macroeconomic variables. As can be seen, inflation and short-term interest rate are positively correlated as expected. A higher real interest rate would generate lower inflation. A higher nominal rate is expected to be positively related to inflation through the Fisher Equation. As Figure 3.1 illustrates, Chairman Burns adopted a passive approach to monetary policy; between the late 1960s and 1970s, we see a small increases in interest rates in response to inflation. Then, in Volcker administration, interest rates responded more aggressively to inflation.[27] Notice that 1980 stands out as a peak for both inflation and interest rates. After 1980, a more active, anti-inflationary, monetary policy seems to be responsible for real interest rates being persistently above the real growth rate of the economy.

[27] These policy breaks have also been identified in Davig and Leeper (2007).

Regarding fiscal policy, US government debt-to-GDP fell until 1982.[28] After 1982, debt rose until 1995. This can be explained as the period 1974-1986 contains at least three episodes: (i) the 1975 fiscal expansion caused by tax cut following the oil price increase, (ii) the US military build-up, (iii) the 1982 tax cut. Hence the pre-1980 period appears as one in which the government budget constraint is more binding relative to the post 1980 period as government debt starts to accelerate, see Favero and Monacelli (2003). The debt accumulation trend continues until 1995. Then, it starts to fall up to 2002 followed by a sharp increase after that, see Figure 3.1.

Then, the tax cuts program in early 1979 in order to stimulate the economy, initiates a period of active fiscal policy that persisted by the mid-1980s. In 1984, fiscal policy switched to passive that has been lasted until 2002, in response to the sharp increase in debt-to-GDP ratio. Finally, fiscal policy switches to active in response to the 2008 crisis, see Davig and Leeper (2011). These changes in fiscal policy regimes account for adopting a non-linear approach to examine macroeconomic policy interactions.

Note that we follow Favero and Monacelli (2003), and Davig and Leeper (2007, 2011) to define periods of active fiscal policy when the fiscal authority sets its expenditure regardless of whether tax revenues are sufficient to finance the expenditure or not. While periods of passive fiscal policy are when the fiscal authority considers the balanced budget requirements to set its expenditure.[29]

With reference to the outcome of monetary and fiscal policy as presented in Table 3.2, four features emerge. First, inflation peaked in 1970s, around of 7.06 percent on average, when an

[28] We pick the government debt-to-GDP as our fiscal policy instrument. Favero and Giavazzi (2011), and Farhi and Werning (2012) argue that government debt-to-GDP as fiscal policy instrument can capture the dynamic of government budget over the time rather than representing the current figure as with government budget deficit.

[29] Favero and Monacelli (2003) estimate US fiscal policy regime changes within a Markov-Switching VAR model. They report active fiscal regimes, or "fiscal indiscipline" in their terminology, spans 1965:Q3-1968:Q1, and 1974:Q2-1986:Q2. As is explained in Favero and Monacelli (2003), active fiscal policy covers these periods of fiscal discretionary expansion: (i) government spending on the Vietnam War and the War on poverty during 1965-1967 that ended by the tax increase of 1968, and (ii) the 1975 Ford's tax cut following the oil price increase and the military build-up, and (iii) the 1982 Regan's tax cut. They identify passive fiscal regimes, or "fiscal discipline", are during 1960:Q4-1965:Q2,1968:Q2-1974:Q1, and 1986:Q3-2000:Q4. Favero and Monacelli (2003) note that 1986:Q3 makes a clear breaks in the conduct of fiscal policy as after a prolonged regime instability fiscal policy seems to switch to a stable regime with a strong concern on output gap stabilization and a typical Ricardian feature of systematic reaction to the evolution of the government debt.

active fiscal policy and a passive monetary policy regime have been in place. Second, the highest volatility of inflation, around of 2.45 percent on average, is associated with active fiscal policy and passive monetary policy regimes. Third, the highest mean and standard deviation values for the Federal Funds rate are experienced under active fiscal policy and passive monetary policy regimes. Forth, the highest debt-to-GDP ratio is associated with active fiscal and monetary policy coordination when the macroeconomics policy has responded to the 2008 financial crisis aggressively.[30]

These are consistent with our overall discussion of different macroeconomic policy regimes. According to the literature, the post 1986:Q3 period can be characterized by an active monetary and a passive fiscal policy. That is the Ricardian view on the fiscal policy indicating a regime of monetary dominance. The policy outcome under this management is expected to be conventional. However, the literature acknowledges that 1965-1979 period can be characterised as the non-Ricardian episodes, see Favero and Monacelli (2003), Davig and Leeper (2007, 2011).

Having discussed the literature on the monetary and fiscal policy interactions, the next section discusses our econometric methodology.

3.3 Econometric Methodology

Recall from Chapter 2, the Factor-Augmented VAR approach by construction summarizes the information of a large number of time-series into a small number of estimated factors providing an econometric model for policy evaluation purposes within a data-rich environment. In doing so, this section studies the construction of the FAVAR model followed by the Time-Varying Parameter FAVAR approach.

3.3.1 The Factor-Augmented VAR Framework

Consider a standard reduced-form VAR model to study the transmission of monetary policy in the economy as presented in Equation (3.1):

[30] This happens as a result of a rapid decline in the Federal Funds rate up to the ZLB jointed with the American Recovery and Reinvestment Act that increases government debt-to-GDP ratio.

$$Y_t = B_1 Y_{t-1} + \cdots + B_P Y_{t-P} + u_t \tag{3. 1}$$

Where $Y_t^{'} = [Z_t^{'}, R_t]$, Z_t is a $(L \times 1)$ vector of variables representing the economy, and R_t is a single serie representing the policy instrument. The coefficients B_i $, i = 1$ $, \cdots, P$ have $(L+1) \times (L+1)$ dimensions, and $u_t \sim N(0, \Omega)$ where Ω is a covariance matrix and has $(L+1) \times (L+1)$ dimensions. The number of variables included in $Y_t^{'}$ depends on the modelling objectives. In a standard VAR model, it usually does not exceed 20 variables in order to avoid the over-parameterization problem, see Bernanke et al. (2005), and Korobilis (2013). To address this problem the FAVAR approach produce results that are more precise by involving as many theory-based variables as possible into the VAR model. In other words, it is possible to decompose the N dimensional vector of observable variables, X_t with $(N \times 1)$ dimension into a lower dimensional vector of K factors namely F_t, where $K < N$, see Bernanke et al. (2005).

Let Y_t be a vector with dimension of $M \times 1$ representing a set of observable economic variables as indicators of the economy. Likewise the standard approach for assessing monetary policy in the VAR literature, Y_t can contain a policy indicator and some observable variables to measure real activity and price levels. Given the possibility of imprecise results when the economy is represented by a few variables, addition of supplementary economic information motivated by theory can increase the explanatory ability of the estimated model. Suppose that this additional information can be outlined into a $K \times 1$ vector of unobserved factors, F_t where K is small. These unobservable factors can capture the fluctuations in main economic indicators such as economic activity, price forces, or credit conditions that are hard to be proxied by a few numbers of variables.

As Bernanke et al. (2005) explain, the FAVAR model includes the joint dynamics of Y_t and F_t nested in the standard VAR framework formulated as follows.

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi \ (L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + u_t \tag{3. 2}$$

Where $\Phi(L)$ is a lag polynomial of finite order d , and u_t is error term vector with $(K+M)\times 1$ dimension that $u_t \sim i.i.d, N(0,Q)$. Equation (3.2) represents a Factor-Augmented VAR. It can be reduced to a standard VAR in the form of Y_t if $\Phi(L)$ that relates Y_t to F_{t-1} equals zero.

Equation (3.2) cannot be estimated directly because the factors, F_t, are unobservable. Given that these factors are representing forces that potentially affect many economic variables, it is possible to infer some information about the factors from observation of large number of economic time series, see Bernanke et al. (2005). Let X_t represents the informational time series with the dimension of $N\times 1$, while $K+M \le N$. Assuming that the informational time series X_t are related to the unobservable factors F_t and the observed variables Y_t, the unobservable components summarized in F_t can be estimated as formulated in Equation (3.3).

$$X_{it} = \Lambda_i^f F_t + \Lambda_i^y Y_t + e_t \tag{3. 3}$$

Where Λ^f is an $N\times K$ matrix of factor loadings, Λ^y is an $N\times M$, and e_i is the vector of error terms with $N\times 1$ dimension, which are mean zero and assumed to be either normal and uncorrelated or weakly cross-correlated depending on the model estimation method.[31] Furthermore, it is assumed that the error terms of Equations (3.2) and (3.3) are independent of each other. Thus, X_t measures the unobservable factors conditional on Y_t, see Bernanke, et al. (2005).

There are two approaches to estimate the state and measurement Equation denoted as Equations (3.2) and (3.3) herein: (i) a two-step Principal Component method, and (ii) a single-step Bayesian Likelihood method. As is discussed in Bernanke et al. (2005), it is hard to favour one approach over the other one, given that the two methods are different in many dimensions.

[31] As is discussed in Bernanke et al. (2005), the Principal Components method allows for some cross-correlation in e_t that disappears as $N \to \infty$.

However, the factors estimated using the PC method might carry more information compared with the likelihood method that imposes additional structure on the model. Furthermore, the two-step approach is non-parametric, implying that there is no requirement for imposing restriction in the measurement Equation (3.3). In contrast, the likelihood-based approach is fully parametric that the accuracy of the results depends very much on the model specification and the imposed restrictions. Hence, for the sake of computation-simplicity, we employ the two-step PC method to estimate our FAVAR model.[32]

As mentioned the PC approach provides a non-parametric solution to uncover the common space spanned by the factors of X_t, denoted by $C(F_t, Y_t)$. In the first step, PC analysis is applied to the measurement Equation (3.3) in order to estimate the space spanned by the factors based on the first $K+M$ Principal Components of X_t, denoted by $\hat{C}(F_t, Y_t)$. It must be mentioned that the estimation of the first step does not rely on the fact that the observed variables, Y_t are among the common components, see Bernanke et al. (2005). Thus, the factors $(\hat{F}_t^1, \hat{F}_t^2, \cdots, \hat{F}_t^K)$ are estimated in the first step as follows.

$$\begin{bmatrix} X_t^1 \\ X_t^2 \\ \vdots \\ X_t^K \end{bmatrix} = \begin{bmatrix} \Lambda_1^f & 0 & \cdots & 0 \\ 0 & \Lambda_2^f & \cdots & 0 \\ \vdots & \cdots & \ddots & \vdots \\ 0 & \cdots & \cdots & \Lambda_K^f \end{bmatrix} \begin{bmatrix} F_t^1 \\ F_t^2 \\ \vdots \\ F_t^K \end{bmatrix} + e_t \qquad (3.4)$$

Furthermore, the loadings $(\hat{\Lambda}_1^t, \hat{\Lambda}_2^t, \cdots, \hat{\Lambda}_K^t)$ are obtained by estimating Equation (3.5) that employs the Ordinary Least Squares (OLS) method.

$$\begin{bmatrix} X_t^1 \\ X_t^2 \\ \vdots \\ X_t^K \end{bmatrix} = \begin{bmatrix} \Lambda_1^f & 0 & \cdots & 0 \\ 0 & \Lambda_2^f & \cdots & 0 \\ \vdots & \cdots & \ddots & \vdots \\ 0 & \cdots & \cdots & \Lambda_K^f \end{bmatrix} \begin{bmatrix} \hat{F}_t^1 \\ \hat{F}_t^2 \\ \vdots \\ \hat{F}_t^K \end{bmatrix} + e_t \qquad (3.5)$$

[32] It is worth noting that Bernanke et al. (2005) compute and present the results using the both approaches. Given the comparison of the results therein, there is no clear advantage between these two methods for the estimation of factors.

In the second step, we replace the unobserved factors in the transition Equation (3.2) by their PC estimates, and run a standard VAR model to obtain $\hat{\Phi}(L)$ as follows.

$$\begin{bmatrix} \hat{F}_t^1 \\ \hat{F}_t^2 \\ \vdots \\ \hat{F}_t^K \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} \hat{F}_{t-1}^1 \\ \hat{F}_{t-1}^2 \\ \vdots \\ \hat{F}_{t-1}^K \\ Y_{t-1} \end{bmatrix} + e_t \tag{3. 6}$$

As is mentioned earlier, computational simplicity together with allowing for some degree of cross-correlation in the idiosyncratic error terms e_t , and the fact that the two-step estimation method impose few distributional assumptions are the main advantages for this approach. One disadvantage of the approach, however, is the presence of "generated regressors" in the second step. As is addressed in Bernanke et al. (2005) it is possible to obtain accurate confidence intervals on the IRFs by implementing Kilian' bootstrap procedure that accounts for the uncertainty in the factor estimation.[33] Following Bernanke et al. (2005) this procedure is employed for estimation of IRFs confidence intervals.

3.3.2 The Time-Varying Parameter FAVAR Framework

The parameters of the linear FAVAR model presented earlier are time-invariant. However, having considered structural changes in the economy induced by the conduct of different macroeconomic policies, it is important to measure the impact of monetary policy shocks over different points in time by allowing the parameters of the model to change over the time, see Primiceri (2005), Del Negro and Schorfheide (2010), and Korobilis (2013).

Parameters can vary either gradually over time following a Multivariate Autoregressive process, or they can change abruptly as in a Markov-Switching or Structural-Breaks pattern. Following Primiceri (2005), Koop and Korobilis (2010), and Korobilis (2013) we adopt the TVP approach to capture structural changes in the economy within the two-step PC approach to

[33] As explained in Bernanke et al. (2005) and the reference therein, in theory, when N is large relative to T , the uncertainty in the factor estimates can be ignored.

estimate the FAVAR model. However, the estimated factors now are allowed to drift in both the mean and variance parameters with a random walk pattern.

Thus, to assess the effects of policy actions over the time, the parameters of the FAVAR model now are allowed to vary over the time. Accordingly, the TVP-FAVAR version of Equation (3.1) will take the below form.

$$Y_t = B_{1t}\ Y_{t-1} + \cdots + B_{Pt}\ Y_{t-P} + u_t \tag{3. 7}$$

Where $Y_t^{'} = [F_t^{'}, Z_t^{'}, R_t]$, and F_t is a $(K \times 1)$ vector of latent factors. Likewise, the standard VARs $[Z_t^{'}, R_t]$ is a vector consists of observed variables and the monetary policy tools with $((L+1)\times 1)$ dimension. Also, B_{jt} , $j = 1\ ,\cdots, P$ are a $M \times M$ matrices of coefficients, and $u_t \sim N(0,\Omega)$ where Ω is a $M \times M$ full covariance matrix for each $t = 1\ ,\cdots, T$, with $M = K + L + 1$.

Comparable with the FAVAR model, a general specification for the TVP-FAVAR can be written as follows.

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi_t(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + u_t \tag{3. 8}$$

$$X_{it} = \Lambda_{it}^{f}\ F_t + \Lambda_{it}^{y}\ Y_t + e_t \tag{3. 9}$$

Where Equations (3.8) and (3.9) represent the state and measurement equation, respectively. Each of the $i = 1,\ldots,N$ original observed series X_{it} is linked to the factors, the other observed variables, $Z_t^{'}$, and the monetary policy tool, R_t, by a factor analysis regression with cross auto-correlated errors and stochastic volatility defined as follows;

$$X_{it} = \hat{\Lambda}_i^F F_t + \hat{\Lambda}_i^Z Z_t + \hat{\Lambda}_i^R R_t + u_{it} \tag{3. 10}$$

And

$$u_{it} = \rho_{i1} u_{it-1} + \ldots\ + \rho_{iq} u_{it-q}\ + \varepsilon_{it} \tag{3. 11}$$

Where $\hat{\Lambda}^Z, \hat{\Lambda}^R$ are $(N \times 1)$, and $\hat{\Lambda}^F$ is $(N \times K)$. The errors are $\varepsilon_{it} \sim N(0, \exp(h_{it}))$, and are assumed to be uncorrelated with the factors. As is explained in Korobilis (2013), working with uncorrelated errors required that Equation (3.10) to be transformed as formulated in Equation (3.12);

$$X_t = \Lambda^F F_t + \Lambda^Z Z_t + \Lambda^R R_t + \Gamma(L)X_t + \varepsilon_t \tag{3. 12}$$

Where $\Gamma(L) = diag(\rho^1(L),\cdots,\rho^n(L))$, $\rho^i(L) = \rho_{il}L + \ldots + \rho_{iq}L^q$,and $\Lambda^i = (I_n - \Gamma(L))\hat{\Lambda}^f$ for $j = F, Z, R$. Also, $\varepsilon_t \sim N(0, H_t)$ where $H = diag(\exp(h_{1t}),\cdots,\exp(h_{nt}))$, and the individual log-volatilities evolves as a drift-less random walk as follows;

$$h_{it} = h_{it-1} + \eta_t^h \tag{3. 13}$$

Where $\eta_t^h \sim N(0,\sigma_t)$. As has been discussed in Korobilis (2013), in attempt to parameterize the large covariance matrices related to Equation (3.7) which presents a VAR system on the factors and observable variables, $Z_t^{'}$ and R_t, with drifting coefficients and stochastic volatility, it is possible to decompose the FAVAR error covariance matrix in the following form;

$$A_t \Omega_t A_t' = \Sigma_t \Sigma_t' \tag{3. 14}$$

Where A_t is a unit lower triangular matrix, and Σ_t is the diagonal matrix.

$$A_t = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ \alpha_{21,t} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{m1,t} & \cdots & \alpha_{m(m-1),t} & 1 \end{bmatrix}, \quad \Sigma_t = \begin{bmatrix} \sigma_{1,t} & 0 & \cdots & 0 \\ 0 & \sigma_{2,t} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_{n,t} \end{bmatrix}$$

To proceed with parameter estimation, let $B_t = (vec(B_{1t})', \cdots, vec(B_{pt})')'$ be a vector consists of all the parameters of the Equation (3.7). In addition, $\alpha_t = (a_{j1}^{'}, \cdots, a_{j(j-1),t}^{'})'$ where $j = 1,\ldots,m$ be the vector of non-zero and non-one elements of the matrix A_t, and $\log\sigma_t = (\log\sigma_{1t}^{'}, \cdots, \log\sigma_{nt}^{'})'$ be the vector of the diagonal elements of the matrix Σ_t. Assuming that all these three drifting parameters, $B_t, \alpha_t, \log\sigma^{'}$ follow random walks, for each period the innovations of the parameters can be formulated as follows;

$$B_t = B_{t-1} + J_t^B \eta_t^B \tag{3. 15}$$

$$\alpha_t = \alpha_{t-1} + J_t^\alpha \eta_t^\alpha \tag{3. 16}$$

$$\log \sigma_t = \log \sigma_{t-1} + J_t^\sigma \eta_t^\sigma \tag{3. 17}$$

Where $\eta_t^\theta \sim N(0, Q_\theta)$ are independent innovation vectors, Q_θ are innovation covariance matrices associated with each of the parameters vectors, and $\theta_t \in \{B_t, \alpha_t, \log \sigma_t\}$.[34]

Furthermore, the random variables J_t^θ are defined to take only two values: one and zero at each period *t*. This property allows that the state errors be a mixture of a normal component with covariance Q_θ, and a second component that places all probability point mass at zero, see Korobilis (2013). The random variables J_t^θ are updated and determined based on the data likelihood allowing them to take either the specification of constant-parameters as $J_t^\theta = 0, t = 1, \cdots, T$, or Time-Varying Parameters as $J_t^\theta = 1, t = 1, \cdots, T$.

The unobserved variables and the model parameters can be estimated in one-step by employing the Markov Chain Monte Carlo (MCMC) approach. However, as has been discussed in Koop and Korobilis (2010), and Korobilis (2013) the MCMC method makes the estimation procedure unnecessarily complicated for computing the latent factors compared with the two-steps PC estimator method. As explained earlier it is simpler to obtain the factors from PC method and employ them in a TVP-FAVAR model allowing that the drifting mean and variance parameters to follow a random walk. This assumption, which is based on a standard state-space method, simplifies the estimation procedure, see Koop and Korobilis (2010), and Korobilis (2013). Thus, likewise FAVAR model, the PC method is applied to estimate the factors, while the MCMC simulation method is adopted to estimate the Time-Varying Parameters in Equations (3.15) to (3.17).

[34] A detailed discussion can be found in Primiceri (2005) and Korobilis (2013).

The next section proceeds to estimate a FAVAR model with Constant-Parameters followed by estimating a TVP-FAVAR model with monetary and fiscal policy variables. These two versions of the FAVAR model are employed for monetary and fiscal policy analysis.

3.4 Empirical Results

This section presents the empirical findings. As mentioned earlier the study pursues two objectives. First, examining the impact of monetary and fiscal policy interactions and investigating whether the impact is changes over the time. Second, identifying the extent to which the transmission of monetary policy is affected by US fiscal policy. For this purpose, we extend the Constant-Parameter FAVAR and the TVP-FAVAR models presented in Bernanke et al. (2005), and Korobilis (2013) in two regards.

First, we account for fiscal policy to examine the impact of fiscal policy on monetary policy and its effect on the economy. Second, we incorporate the period after the financial crisis in our analysis. Prior to presenting the results, the model specification together with the dataset is explained followed by the identification approach. Then, the section proceeds to estimate the linear and TVP-FAVAR models.

3.4.1 Model Specification

Given this chapter motivation, we estimate two different models namely the simple model and the fiscal-augmented model under Constant-Parameter FAVAR and TVP-FAVAR specifications. The simple model is specified as it excludes fiscal-related information while the fiscal stance is captured in the fiscal-augmented model.

The model is estimated over the 1959:Q1-2013:Q2 sample. The choice of the sample is driven by the idea to assess the conduct of monetary policy over four representative periods: 1975:Q1, 1981:Q3, 1996:Q1, and 2006:Q2 as representative of the chairmanships of Burns, Volcker, Greenspan, and Bernanke respectively. The study involves dataset consists of 195 US macroeconomic time series collected from the St Louis Fed FRED database.[35] Following common

[35] A detailed description of database is provided in Appendix 3.A section.

practice in this literature, all variables are transformed to be stationary using a number of methods including the computation of their first difference.[36] Appendix 3.A provide a detailed explanation of the procedure. All the time series are seasonally adjusted were this is applicable.[37]

Consistent with the Factor Modelling literature, macroeconomic time series is selected to represent the following categories: Real Output and Income, Employment and Hours, Consumption, Housing Starts and Sales, Real Inventories and Orders Indices, Exchange Rates, Interest Rates, Money and Credit Quantity Aggregates, Price Indices, Average Hourly Earnings, the Fiscal Stance, and Consumers Expectations, see Appendix 3.A. As regards determining the number of factors involved in the FAVAR model, we follow Bernanke et al. (2005) approach that is based on the sensitivity of the results to the alternative number of factors. As have been reported in Bernanke et al. (2005), and Korobilis (2013) the qualitative results are not altered when the number of factors increased from three to five factors. We also estimate our specified Constant-Parameter FAVAR model with three and five factors. As the obtained results appear to have fairly the same qualitative pattern, both the linear and TVP-FAVAR models are constructed with three factors to maintain parsimony.[38]

The lag length of the state Equations (3.2) and (3.8) is another important specification to be determined. The lag lengths are selected in the VAR literature based on statistical criterion such as AIC, BIC, or SIC. In the FAVAR literature, however, no specific criterion is used, to our knowledge. Bernanke et al. (2005) employ 13 lags in order to allow sufficient dynamics in their model. On the other hand, Stock and Watson (2005) estimate a 2-lag model. We follow Bernanke et al. (2005) approach and construct our model with 13 lags.

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[36] We follow Bernanke et al. (2005), Stock and Watson (2005), and Korobilis (2013) procedure to ensure stationary properties of the time series.

[37] The time series are seasonally adjusted using the Demetra+ package developed by Eurostat. To seasonally adjust the time series, the TRAMOSEATS method has been employed. This method can be divided into two main parts: a pre-adjustment step, which removes the deterministic component of the series by means of a regression model with Arima noises and the decomposition part itself. See Grudkowska (2013) for a detailed explanation.

[38] As discussed in Bernanke et al. (2005) increasing the number of factors does not appear to improve the results.

With reference to the observable variables required to be isolated in the VAR part, $\boldsymbol{Y_t}$, our VAR includes inflation, Industrial Production growth, and the Federal Funds rate.[39] Thus, our FAVAR is a trivariate VAR augmented with three unobservable factors, F_t, which are extracted from the large set of time series macroeconomic variables as is addressed in Appendix 3.A, and includes fiscal variables. We use the PC approach to extract the factors. The use of PC method ensures identification of the model since it normalizes all factors to have zero mean and unit variance, see Korobilis (2013).

3.4.2 Monetary Policy Shock Identification

There are a number of approaches for identification of monetary policy shocks in the VAR literature. These includes recursive identification approach, long-run restrictions, or structural VAR procedures that can also be implemented in the FAVAR framework, see Bernanke et al. (2005). The recursive identification is standard in much of the VAR literature and straightforward to apply.[40] On the other hand, the other competing identification approaches would require restrictions to be imposed on the factors to identify them as specific economic concepts.[41]

Thus, we follow Bernanke et al. (2005) and focus upon a recursive approach to identify monetary policy shock. This approach assumes that the monetary authority reacts simultaneously to macroeconomic shocks. However, macroeconomic variables react to monetary impulses with lags. Thus, monetary policy actions influence inflation and Industrial Production growth with at

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[39] We followed Bernanke et al. (2005) approach to put Industrial Production growth as observable variable in the VAR to proxy output. As Bernanke et al. (2005) explain, "Output in the theoretical model may correspond more closely to a latent measure of economic activity than to a specific data series such as real GDP". Thus, we include GDP as a time series in our information to extract the unobserved factors. We, then, present the IRFs of GDP to the policy shock within the FAVAR model.

[40] See Christiano et al. (1999), Favero and Monacelli (2003), Bernanke et al. (2005), Primiceri (2005), Koop and Korobilis (2010), and Korobilis (2013) among others.

[41] As is addressed in Bernanke et al. (2005) implementing long-run restrictions requires these restrictions to be identified separately from the other factors. One potential way to achieve this is extracting Principal Components from blocks of data corresponding to different dimensions of the economy. For example, real-activity measure is possible to be considered as is obtained solely from the output gap. This identification approach is explored in Korobilis (2013) together with the recursive approach. Comparing the IRFs results obtained from recursive identification approach and those from the block factors in Korobilis (2013), it appears that there is no substantial difference between responses.

least one period of lag, while the time lag for interest rate is zero by ordering it last in the VAR part.[42] Furthermore, it treats inflation as predetermined, which is consistent with estimating a Taylor Rule that regresses the nominal interest rate on inflation, see Bernanke et al. (2005), and Chung et al. (2007).

The standard recursive approach implies that the Fed Funds rate, R_t, as monetary policy instrument is ordered last and its innovations are treated as the policy shocks while the unobservable factors and variables respond to the policy shock with time lags which is a quarter in this study. As discussed in Bernanke et al. (2005) two blocks of information variables can be defined: (i) the slow-moving variables, and (ii) the fast-moving variables. The slow-moving block of variables is assumed that respond to monetary policy shocks with a quarter lag. In contrast, the fast-moving block of variables reacts instantly to the policy shocks.[43]

To estimate the FAVAR model using the two-step PC approach, the first step $\hat{C}(F_t, Y_t)$ must be calculated. Given that Y_t is not explicitly imposed as a common component in the first step, it is possible that any of the linear combinations of $\hat{C}(F_t, Y_t)$ involves the policy instrument, R_t. Thus, the dependency of $\hat{C}(F_t, Y_t)$ on R_t must be eliminated in order that the policy shock recursive identification to be valid, see Bernanke et al. (2005). One potential solution here is to estimate the coefficients of $\hat{C}(F_t, Y_t)$ from a multiple regression as follows.

$$\hat{C}(F_t, Y_t) = b_{C^*}\hat{C}^*(F_t) + b_R R_t + e_t \tag{3. 18}$$

Where $\hat{C}^*(F_t)$ is an estimate of all the common components subtracted R_t. Then, $\hat{C}^*(F_t)$ can be obtained by extracting PC from the slow-moving block of variables which cannot be affected

[42] As explained in Primiceri (2005) ordering interest rates last in the VAR is not simply an ordering issue, but an identification condition that is essential for isolating monetary policy shock.

[43] The slow-moving block of variables includes Real Output and Income, Employment and Hours, Consumption, Price Indices, Average Hourly Earnings, the Fiscal Stance, and Consumers Expectations. The fast-moving block of variables includes Housing Starts and Sales, Real Inventories and Orders Indices, Exchange Rates, Interest Rates, and Money and Credit Quantity Aggregates, see Appendix 3.A for details.

instantly by R_t. Now, $\hat{F}_t$ can be constructed as $\hat{C}(F_t, Y_t) - \hat{b}_R R_t$, and a VAR between $\hat{F}_t$ and Y_t will be estimated which is identified recursively, and the monetary policy instrument, R_t, is ordered last.[44]

Now we proceed to the TVP-FAVAR model identification. To study the way that monetary policy interactions may evolve over the time, the parameters of the FAVAR are allowed to vary through time. The sources of time variation are both coefficients and the variance-covariance matrix of the shocks. This way, it is possible to distinguish between the exogenous shocks and changes in the transmission mechanism, see Primiceri (2005). As is discussed in Koop and Korobilis (2010), and Korobilis (2013) obtaining sensible results from TVP-FAVAR model requires the imposing of restrictions to allow only particular parameters to vary over time.

A general specification for TVP-FAVAR model can be acquired using these following restrictions imposed to the measurement and the state equation of the TVP-FAVAR in the form of Equations (3.19) and (3.20) respectively. Note that X_t represents all the information in time series using to extract the unobservable factors, F_t represents the factors, and R_t represents the monetary policy instrument.

$$X_{it} = \Lambda_{oit} + \Lambda_{it} F_t + \Lambda_{it} R_t + \varepsilon_{it} \tag{3. 19}$$

$$\begin{pmatrix} F_t \\ R_t \end{pmatrix} = \hat{\Phi}_{1t} \begin{pmatrix} F_{t-1} \\ R_{t-1} \end{pmatrix} + \cdots + \hat{\Phi}_{pt} \begin{pmatrix} F_{t-p} \\ R_{t-p} \end{pmatrix} + \hat{\varepsilon}_t^F \tag{3. 20}$$

As regards the estimation of Equations (3.19) and (3.20), the following issues must be taken into account.

1. Each innovation term, ε_{it}, in the measurement equation follows an univariate stochastic volatility process,
2. var $(\hat{\varepsilon}_t^F) = \hat{\Sigma}_t^F$ has a multivariate stochastic volatility process,

[44] A detailed explanation of the identification using the PC approach can be found in Bernanke et al. (2005).

3. $\hat{\Phi}_{1t},\cdots,\hat{\Phi}_{pt}$ Which are the coefficients of the state equation are allowed to vary in accordance with random walk model.[45]

Following Primiceri (2005), Koop and Korobilis (2010), and Korobilis (2013) the simulations is carried based on 10,000 iterations of the Gibbs sampler, discarding the first 2000 for convergence. Given the dimension of the model and the presence of TVP, some shrinkage in the model is required. One potential approach to provide shrinkage in the model is to employ the prior. This study follows Koop and Korobilis (2010) and employs the Minnesota prior that is a standard one in the VAR literature. The key property of this prior is that the own lags of each variable is weighted more than lags of other variables.[46]

Having established the identification of monetary policy shock, the next section presents the IRFs for both the linear and TVP-FAVAR models.

3.4.3 The FAVAR Model Specification Results to Monetary Shock

This section presents the empirical results for the Constant-Parameter FAVAR model estimated by the two-step Principal Components approach. The objective is to investigate the impact of monetary and fiscal policy interactions on the US economy. In particular, it aims to examine the way in which monetary policy transmission mechanism may be influenced by the fiscal stance.

Two FAVAR models are specified for estimation: a simple FAVAR model, and a fiscal-augmented FAVAR model. The simple model is based on the Bernanke et al. (2005) FAVAR model that excludes the fiscal variables. It is instructive to compare the results obtained from the simple FAVAR model with the fiscal-augmented one to understand the potential impact of the fiscal stance on the economy.

Figure 3.2 presents the Impulse Response Functions (IRF) to a recursively identified contractionary monetary policy shock. The IRFs are generated within the simple FAVAR model with three unobserved factors and three observed variables in the VAR. The three observed

[45] As explained in Koop and Korobilis (2010), it is difficult to estimate time variation of coefficients in both the measurement and the state equation in absence of strong prior information.
[46] A more detailed discussion of this choice compared with the alternative prior specification can be found in Koop and Korobilis (2010), and Korobilis (2013).

variables in the VAR section include Inflation, Industrial Production growth, and the nominal Federal Funds rate.[47] It is expected that a monetary contraction shall induce small and transitory effects on interest rates with a rather large and persistent impact on output and prices, see Barth and Ramey (2002) and Eichenbaum (1992). As can be seen in the graph, inflation is unresponsive first, and then slightly falls in response to a monetary contraction although this is statistically insignificant. There is no evidence of the price puzzle. Moreover, Industrial Production growth declines in response to the shock that is consistent with the conventional view in the literature. However, the response of output appear to be statistically insignificant.

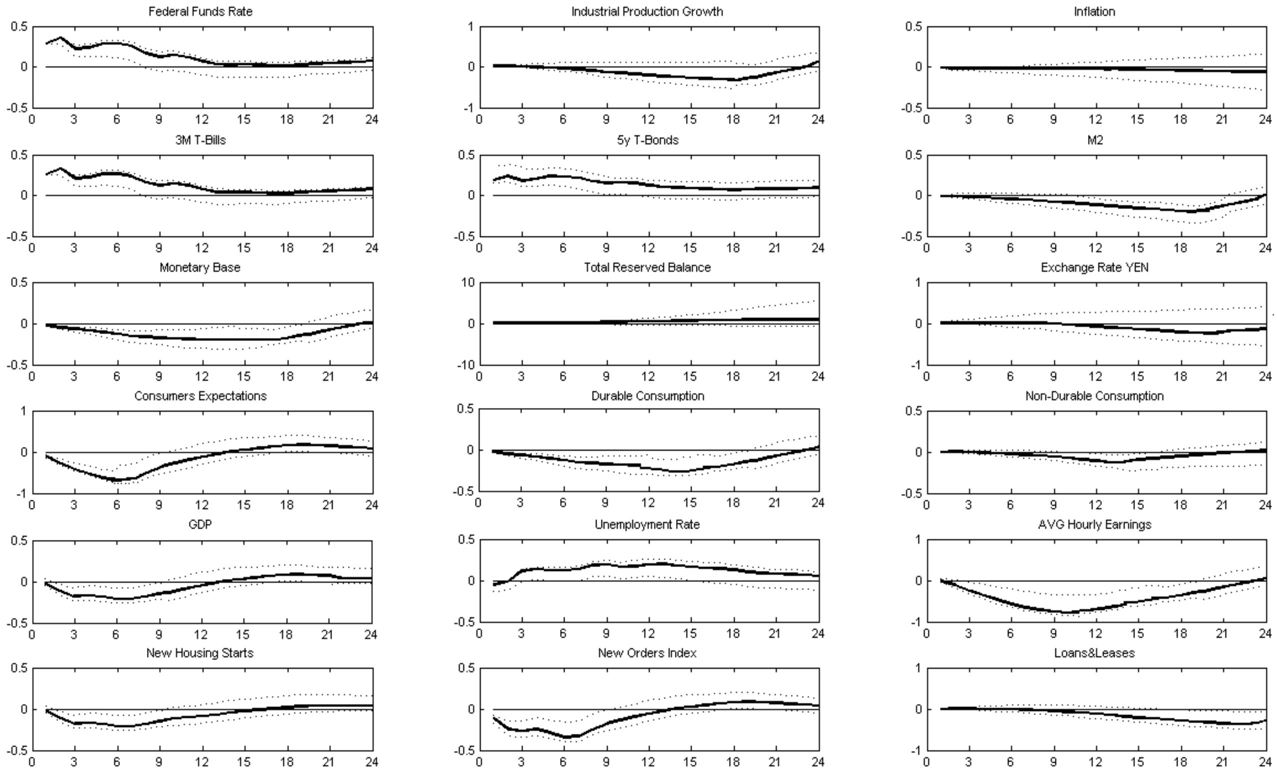
The FAVAR model provides us with a broad set of responses to the monetary shocks, to which we turn now. According to IRFs plotted in Figure 3.2, the responses of the other macroeconomic variables in the FAVAR are generally consistent with economic intuition. A monetary contraction reduces the growth rate of real activity measures including GDP, new orders index, new housing starts, and average hourly earnings. Unemployment also increases. The response of these real activity indicators appears to be statistically significant. In addition, both durable and non-durable consumption fall in response to the shock that appears to be statistically significant.[48] This can be explained through a negative wealth effect. A rise in Fed Funds rates would induce asset prices to fall as equities would be substituted by bonds, see Mishkin (1995). This, in turns, would generate a negative wealth effect leading to a reduction in private expenditure including consumption and new housing starts.

Moreover, the response of money aggregate measures such as monetary base, money supply, and loans is consistent with the intuition: all appear to decline in response to a monetary contraction as the opportunity cost of holding money increases. As Figure 3.2 shows, the responses of monetary aggregate measures appear to be statistically significant.

[47] We follow Bernanke et al. (2005), Primeceri (2005), and Korobilis (2013) and construct both the FAVAR and TVP-FAVAR models using nominal variables.

[48] Fuhrer and Rudebusch (2004) point out that expenditure on durable goods is the most interest-sensitive components of aggregate consumption.

Figure 3.2.The IRFs to a US Monetary Contraction within the Simple FAVAR



Note: This Figure illustrates IRFs to a contractionary monetary shock from a FAVAR with constant parameters. The VAR part of the model includes the Federal Funds rate, Industrial Production growth, and Inflation on top panel. The IRFs of other key variables in the monetary transmission mechanism is estimated based on three unobserved factors. The Impulse Responses together with their confidence intervals (10^{th}, 50^{th}, and 90^{th}) are generated based on Bernanke et al. (2005) FAVAR model specification corresponds to a one standard deviation increase to the Federal Fund Rate. The FAVAR model is estimated using the Two-Step Principal Components approach from Bernanke et al. (2005) over the 1959:Q1-2013:Q2 sample.

We are now looking at the monetary transmission in which monetary policy influences the economy. As regards the impact of the policy upon the exchange rate, it is expected that higher interest rates appreciate the domestic currency and cause asset prices to fall. As is visible in Figure 3.2, the US exchange rate to Japanese Yen remains unresponsive up to 12 quarters and falls after that. An increase in the Federal Funds rate, also, induces the long-term interest rate to increase which remains significant up to 9 quarters. Furthermore, as the opportunity cost of holding money increasing, it would induce bank reserves to fall, see Mishkin (1995). Confronting the IRFs results presented in Figure 3.2 with the literature on the monetary transmission, it appears that responses are consistent and excluding inflation, industrial production growth, and the exchange rate, the response of others remains statistically significant for quite some time.

Comparing the results from the simple FAVAR, which excludes fiscal variables in the factors, with those of Bernanke et al. (2005) a few notable features emerge.[49] Unlike Bernanke et al. (2005) there is no evidence of the price puzzle in our simple FAVAR model specification, however, inflation stays unresponsive to the policy shock for half of the period and then slightly falls.[50] This is a dissatisfactory aspect of our most basic FAVAR model, since it is generally believed that monetary policy can influence inflation. It appears that increasing the time span under study and involving extra information for extracting factors could contribute to disappearance of the price puzzle. According to Sims (1992) if the addition of extra information mitigates the price puzzle, it can be concluded that the new time series contain useful information for the economy. Moreover, the response of average hourly earnings is counterintuitive in Bernanke et al. (2005), that is the same pattern as inflation in response to monetary contraction. However, our results seem to be reasonable as it falls in response to the policy shock that statistically is significant for quite large interval, see Figure 3.2.

Having presented the main results from the simple FAVAR model, now we proceed to consider the impact of fiscal policy on the economy and the monetary transmission mechanism. Figure 3.3 presents the IRFs results of the benchmark linear FAVAR model augmented with the fiscal variables in the factors.[51] We consider the case of a contractionary monetary policy shock. In general, as the IRFs suggest including the fiscal stance influence the responses and the transmission mechanism. Similar to the simple FAVAR model specification, Industrial Production growth falls in the fiscal-augmented model in response to a monetary contraction.

[49] Note that the simple FAVAR models is estimated based on information from 165 macroeconomic time series representing economic activity except the fiscal stance, while those presented in Bernanke et al. (2005) relies on 120 macroeconomic time series.

[50] The results obtained from a FAVAR model in Bernanke et al. (2005) display the price puzzle which disappears after a short while.

[51] In order to study the impact of monetary policy shock, the fiscal-augmented FAVAR model, in both linear and non-linear approaches, is constructed by including the fiscal-stance related variables in X_t to estimate the factors as Appendix 3.A details. The VAR part of the model, Y_t , stays the same as the simple specification that includes the Federal Funds rate, Inflation, and Industrial Production growth. Given that we employ IRF results and not the GIRFs or OIFs, by inserting both fiscal and monetary policy shocks instruments into the VAR, orthogonality would be an issue to obtain reasonable results. Note that both the GIRFs and OIFs guarantee that various imposed shocks to the system are uncorrelated. Chapter 4 explores this idea further.

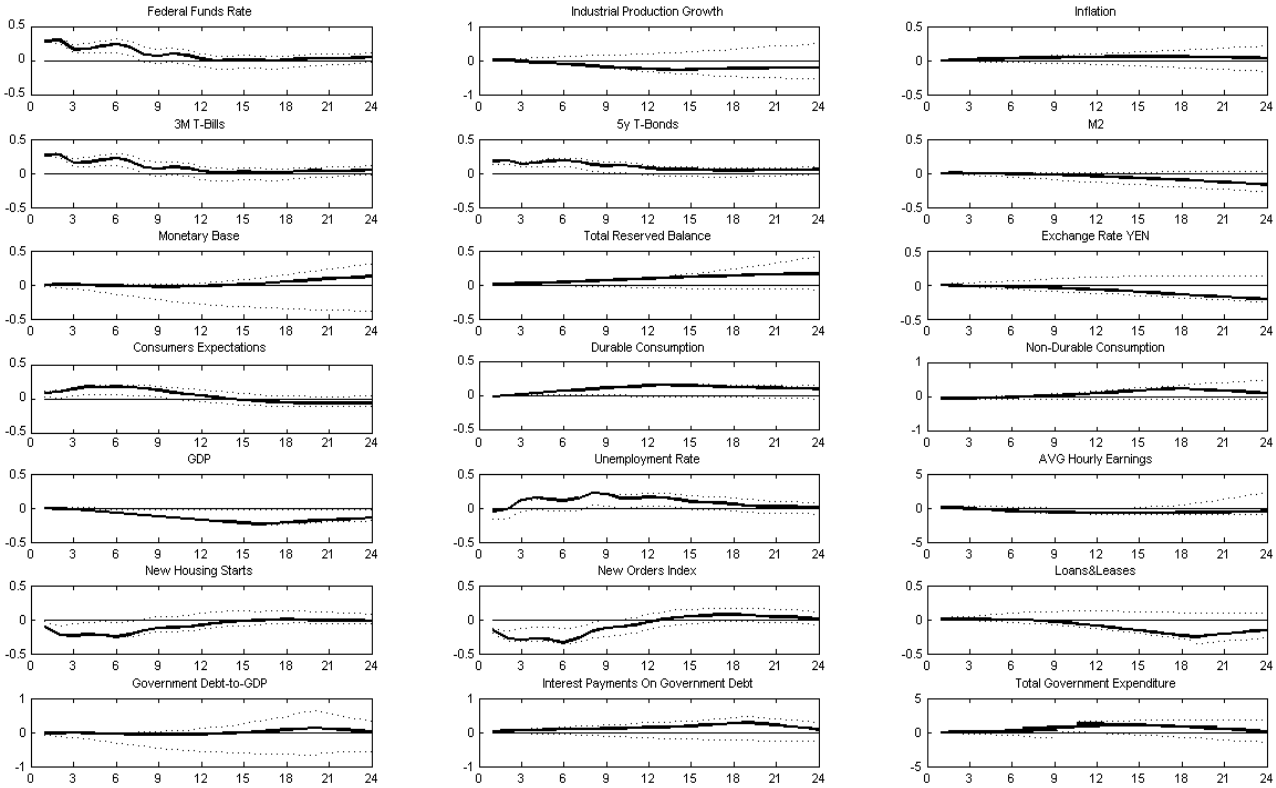
However, comparing the response of inflation from the simple model with the fiscal-FAVAR, it is evident that inflation increases in the latter model while it remains unresponsive and eventually falls within the simple model. It worthy to note that the response of both Industrial Production growth and inflation remains statistically insignificant.

Taking account of fiscal variables may explain the response of inflation within the fiscal-augmented FAVAR model. In the presence of large and persistent government debt, the monetary authorities are forced to increase the money supply in order to accommodate the growth in money demand induced by the debt, see Bradley (1984). The mechanism works as follows. A monetary contraction would force the fiscal authority to issue new bonds to finance the increase in government debt induced by higher interest rates. This would increase the demand for money as the demand for bonds increase. This can lead to an increase in inflation. In addition, the issuance of new bonds and the higher interest rates can generate positive wealth effects, see Canzoneri et al. (2011). This positive wealth effect can induce aggregate demand to increase through private consumption leading to a raise in inflation.

Turning to Figure 3.3, we can see that consumption increases and then falls in response to monetary contraction. Consumers' expectations also rises on impact, and then gradually returns to zero. The increase in consumption, both durable and non-durable, can suggest that this policy-induced increase in the interest rates generates a positive wealth effect contributing to an increase in inflation. Thus, it appeared that involving fiscal policy within linear fiscal-augmented can influence the response of inflation to a monetary policy shock compared with the more limited model FAVAR.

With reference to a fall in Industrial Production growth and a rise in inflation associated with a monetary contraction, these results might be in line with the cost-channel interpretation of the price puzzle as proposed by Barth and Ramey (2002). That is a policy-induced increase in the interest rate causes the unit cost of production to increase leading to a rise in prices and a fall in output when capital is an important component of output.

Figure 3.3. The IRFs to a US Monetary Contraction within the Fiscal-Augmented FAVAR



Note: This Figure illustrates IRFs to a contractionary monetary shock within a constant parameter FAVAR augmented with fiscal variables. The VAR part of the model includes the Federal Funds rate, Industrial Production growth, and Inflation on top panel. The IRFs of other key variables in the monetary transmission mechanism is estimated based on three unobserved factors. The Impulse Responses together with their confidence intervals (10^{th}, 50^{th}, and 90^{th}) are generated based on Bernanke et al. (2005) FAVAR model specification corresponds to a one standard deviation increase to the Federal Fund Rate. The FAVAR model is estimated using the Two-Step Principal Components approach from Bernanke et al. (2005) over the 1959:Q1-2013:Q2 sample.

Another clear distinction between the two FAVAR model specifications is related to the measure of monetary aggregate. As illustrated in Figure 3.3, both monetary base and money supply increase in response to the policy shock in the fiscal-augmented model while both fall in the simple FAVAR. This finding is consistent with Bradley (1984) explanation of the impact of debt on monetary aggregate and prices consequently, which can be referred to as the debt monetizing.

Within the simple FAVAR, there is a fall in other real activity measures, i.e. GDP, unemployment, the average hourly earnings, new housing starts, and new orders index, in response to monetary contraction. The fiscal-FAVAR also indicates that real activity falls. As regards the fiscal variables, Figure 3.3 indicates that total government expenditure and the interest payments on the public debt increase in response to a monetary contraction, while government debt-to-GDP is particularly unchanged. However, the fiscal variables responses are statistically insignificant.

To summarize, the IRFs so far suggests that a monetary contraction reduces output growth and real activity measures within a linear FAVAR, irrespective of whether the fiscal stance is included or not. However, while inflation falls within the simple model, it increases in response to the policy shock in the fiscal-augmented model. It worthy of note, though, that the responses of Industrial Production growth and inflation are statistically insignificant for the both model specifications. The insignificant results may suggest that the impact of monetary policy shocks are time varying, given the existing literature on monetary and fiscal policy regime changes, see Favero and Monacelli (2003), and Davig and Leeper (2007, 2012). This can also be seen in the results presented in Bernanke et al. (2005) as the response of inflation and Industrial Production growth are not statistically significant.

To study the way that monetary and fiscal policy interactions may evolve over the time, the next section presents the results from a TVP-FAVAR model.

3.4.4 The TVP-FAVAR Model Specification Results to Monetary Shock

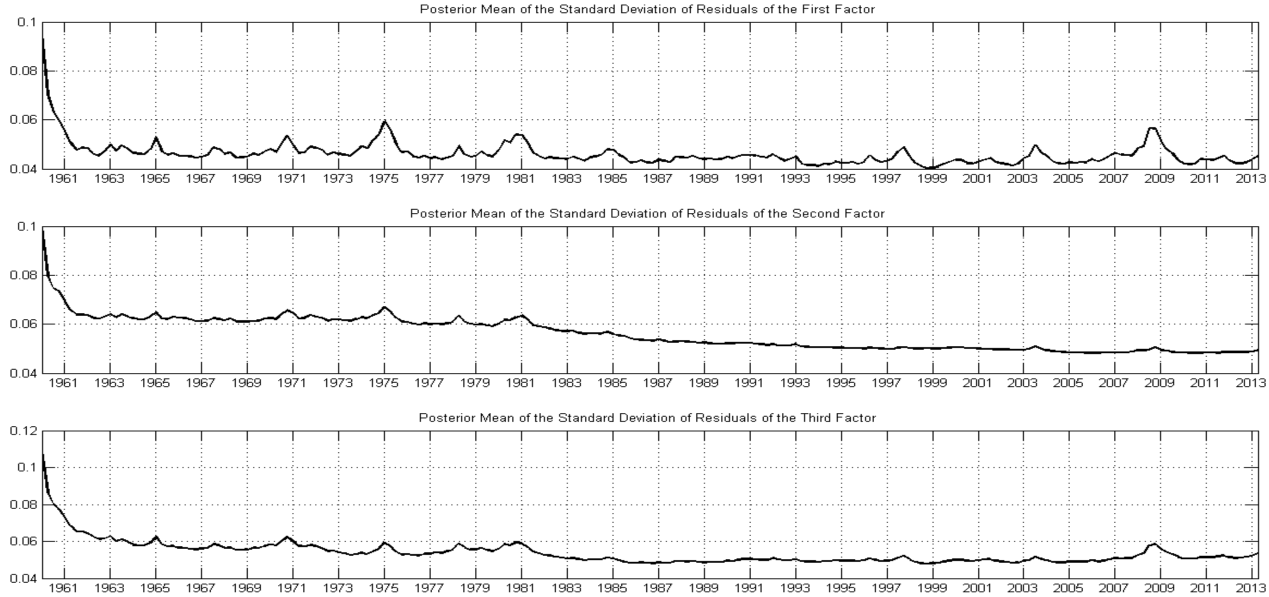
Several studies find evidence supporting that macroeconomic policy in the United States changed regimes, see Favero and Monacelli (2003), Chung et al. (2007), and Davig and Leeper (2007, 2011). Given this chapter motivation, we examine the potential influence of changes in monetary and fiscal policy performance on the economy, and the transmission mechanism of policy shocks. Likewise the linear FAVAR model, the impact of the fiscal variables on the monetary policy over the time is examined within both the simple and the fiscal-augmented TVP-FAVAR model. The model specification and identification of the shocks is the same as explained in the linear FAVAR model.

Figures 3.4 to 3.11 present the results for both the simple and the fiscal-augmented TVP-FAVAR models. The monetary policy shock is assumed as non-systematic. It means that the policy shock can captures policy mistakes and movements in the Federal Funds rate and not the changes in the structure of the economy, see Primiceri (2005), and Korobilis (2013). The posterior mean estimates of the standard errors for the three unobserved factors and the three observable variables in the VAR are plotted in Figures 3.4 to 3.7. The standard deviation values are the square roots of the main-diagonal elements of the matrix Ω_t, for all t. Hence, higher standard deviation of monetary policy shocks is associated with higher policy mistakes, see Korobilis (2013).

As Figures 3.4 and 3.5 illustrate, including the fiscal stance to the TVP-FAVAR model decreases the posterior mean of the standard deviations for the estimated factors. In comparison with those presented in Korobilis (2013), that is estimated under Bernanke et al. (2005) identification, it appears that the mean values of the standard deviations in our results within both the simple and the fiscal-augmented model are much lower. This decline in the standard deviations of the residuals may imply that including the fiscal stance and extending the sample have influence on reducing policy errors, specifically after the 1980s.

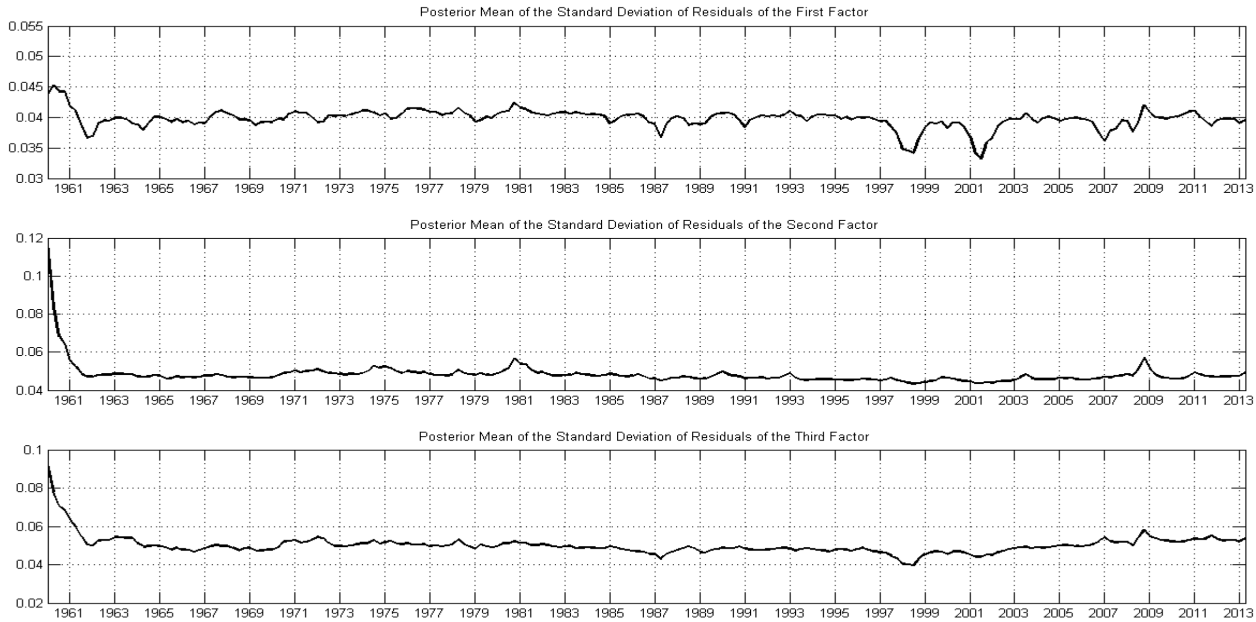
As can be observed in Figures 3.6 and 3.7, the standard deviations of the residuals of the observable variables in the VAR decrease when fiscal variables are included in the model compared with the simple TVP-FAVAR. As regards with the posterior mean of the standard deviations of inflation, mainly two episodes within the fiscal-augmented model can be identified: one before 1975 that the mean values ranging around of 0.8, and another one after 1981 that the mean values falling around of 0.4.

Figure 3.4. Posterior Mean of the SD of Residuals of the Factors within the Simple TVP-FAVAR



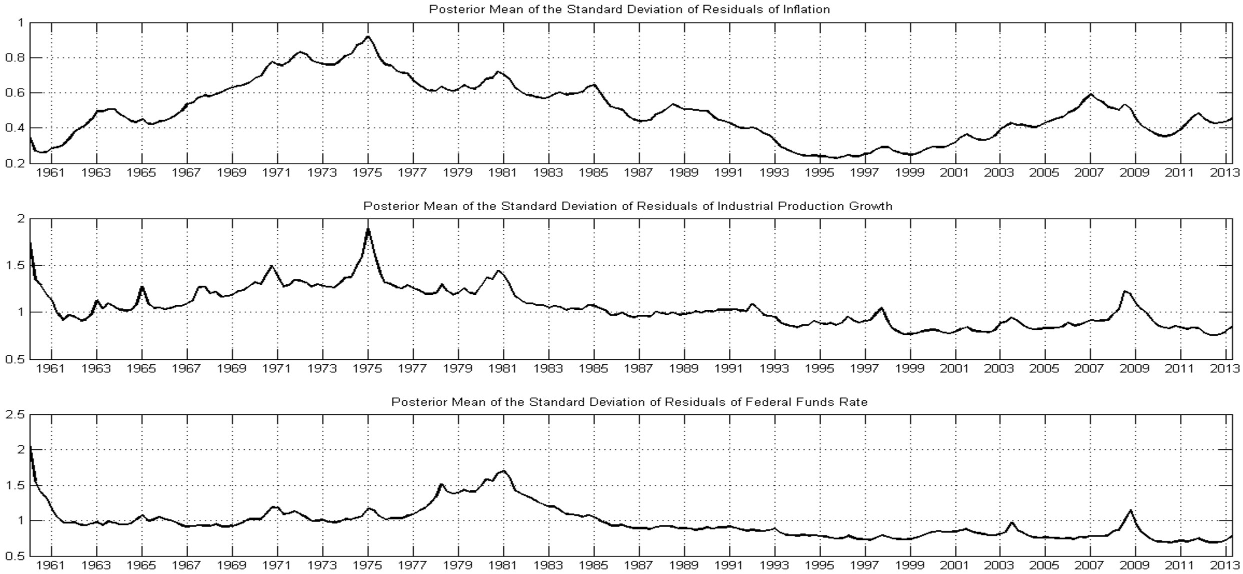
Note: Figure presents the Time-Varying Standard Deviations (SD) of the errors within the simple TVP-FAVAR model with Three Unobserved Factors over the 1959:Q1-2013:Q2 sample. The FAVAR part of the model is estimated using the Two-Step Principal Components method based on Bernanke et al. (2005) identification approach.

Figure 3.5. Posterior Mean of the SD of Residuals of the Factors within the Fiscal-Augmented TVP-FAVAR



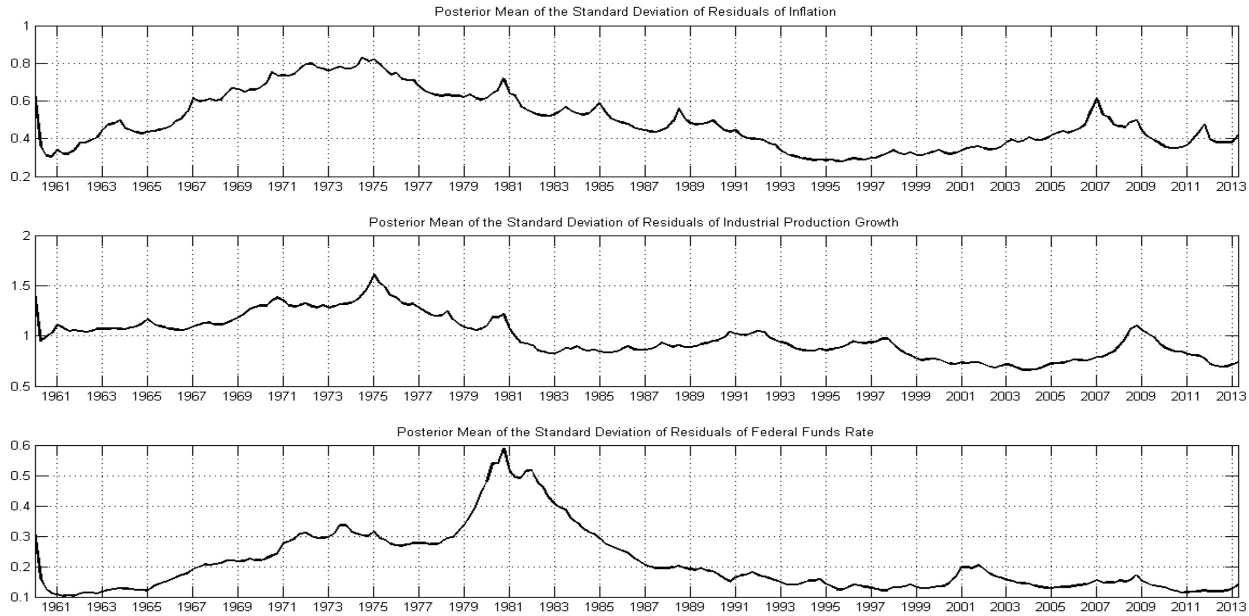
Note: Figure presents the Time-Varying Standard Deviations (SD) of errors within the fiscal-augmented TVP-FAVAR model with Three Unobserved Factors over the 1959:Q1-2013:Q2 sample. The FAVAR part of the model is estimated using the Two-Step Principal Components method based on Bernanke et al. (2005) identification approach.

Figure 3.6. Posterior Mean of the SD of Residuals for the Observable Variables within the Simple TVP-FAVAR



Note: Figure presents the Time-Varying Standard Deviations (SD) of errors within the simple TVP-FAVAR model with Three Unobserved Factors over the 1959:Q1-2013:Q2 sample. The FAVAR part of the model is estimated using the Two-Step Principal Components method based on Bernanke et al. (2005) identification approach.

Figure 3.7. Posterior Mean of the SD of Residuals for the Observable Variables within the Fiscal-Augmented TVP-FAVAR



Note: Figure presents the Time-Varying Standard Deviations (SD) of errors within the fiscal-augmented TVP-FAVAR model with Three Unobserved Factors over the 1959:Q1-2013:Q2 sample. The FAVAR part of the model is estimated using the Two-Step Principal Components method based on Bernanke et al. (2005) identification approach.

There is an overlap between the higher mean value and the periods that have been known as the active episodes of fiscal policy and vice versa. As is visible in the fiscal-augmented model, Figure 3.7, the highest peak in volatility of residual for inflation occurred in 1975. This finding is reported by Primiceri (2005), and Korobilis (2013). They relate these peaks in volatility to the Great inflation, e.g. the shock in price of oil in 1974, and the Monetarist experiment by the increase of interest rates in 1981. The interval is also associated with a change in the conduct of monetary policy targeting bank reserves, i.e. monetary aggregate, instead of interest rates that lead to a rapid increase in interest rates. Then, the second peak, which appears to be quite modest, is associated with the financial crisis in 2008. Having considered monetary and fiscal policy regimes as identified in Favero and Monacelli (2003), and Davig and Leeper (2007, 2011) we can see that the both peaks are associated with an active fiscal policy coordinated with a passive monetary policy.

As regards the residuals of Industrial Production growth, the highest peak in volatility for both model specifications is occurred in 1975. However, the mean value of residuals appears to be higher, around of 2, for the simple model compared with the fiscal-augmented model, around of 1.5. Furthermore, as can be observed in Figures 3.6 and 3.7, the volatility of the standard deviation of residuals for the Federal Funds rate reaches its highest value at 1981 that is consistent with the results presented in Primiceri (2005), and Korobilis (2013) that is referred as the Monetarist Experiment in the literature. In addition, as is visible in the graph, the mean value of the residuals falls in the model includes fiscal variables.

The interval between 1985 and 2007 demonstrates a very modest pattern for the both estimated factors and indicator variables within both the simple and the fiscal-augmented model. This period is known in the literature as the Great Moderation associated with an active monetary policy and a passive fiscal policy regimes. This suggests that active monetary policy, when the nominal interest rate responds aggressively to inflation, in coordination with a passive fiscal policy may attribute to a lower volatility in inflation and output.[52]

Having compared the standard deviations of the errors for both the simple and the fiscal-augmented models, it appears that the fiscal stance contributes to decreasing the volatility and the posterior mean of the responses to the monetary policy shock. The occurrence is more visible for residuals of inflation matched with an active fiscal policy and a passive monetary policy regimes. This suggests that involving the fiscal stance variables may contain important information to explain the volatility of inflation and may influence the monetary transmission mechanism.

We now compare IRFs of the three observable variables in the VAR part to the identified monetary contraction shock from the simple model with the fiscal-augmented one as presented in Figures 3.8 and 3.9. The selected sub-samples are 1975:Q1, 1981:Q3, 1996:Q1, and 2006:Q2. These represent the chairmanships of Burns, Volcker, Greenspan, and Bernanke respectively. These different dates allow us to capture the transmission of monetary shocks under different macroeconomic policy regimes and business cycles phases.[53]

Before discussing the results, it is useful to specify monetary and fiscal policy regime at the time when we impose policy shocks. Table 3.3 illustrate our policy shocks in terms of whether monetary and fiscal policy are active or passive. We follow Favero and Monacelli (2003), and Davig and Leeper (2007, 2011) to specify these different macroeconomic policy regimes.

[52] Primiceri (2005) mentions that a Taylor-type Rule, that the Federal Funds rate responds to inflation strongly, may better approximate US monetary policy over the Great Moderation.

[53] The 1975:Q1 represents a NBER business cycle trough date; 1981:Q3 is a NBER business cycle peak date, 1996:Q1 represents both NBER trough and peak dates, i.e. 1991:Q1: trough and 2001Q1: peak, and 2006:Q2 represents both NBER peak and trough, i.e. 2007:Q4: peak, and 2009:Q2: trough. The detailed historical record of US business cycles can be found in NBER US Business Cycle Expansions and Contractions.

Table 3.3. US Macroeconomic Policy Regimes

	Burns **1975**	**Volcker** **1981**	**Greenspan** **1996**	**Bernanke** **2006**
Monetary Policy	Passive	Active	Active	Passive
Fiscal Policy	Active	Active	Passive	Active

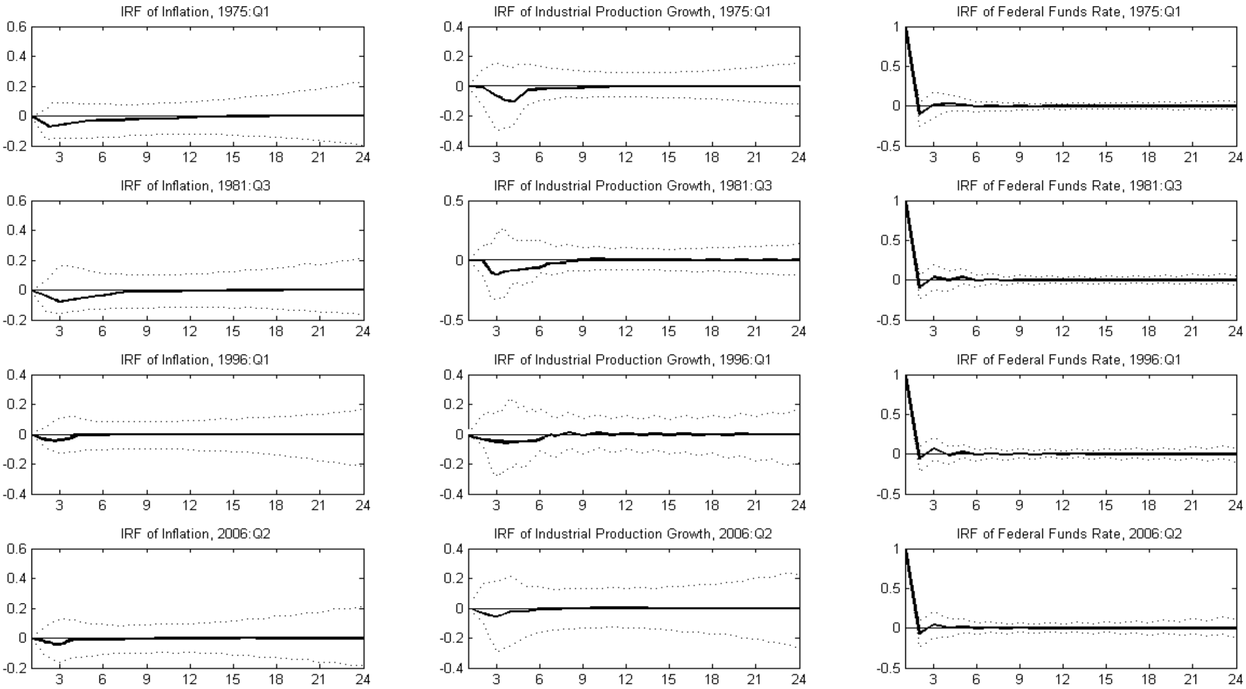
Note: This Table reports different macroeconomic policy regimes. Different fiscal policy regimes are based on Favero and Monacelli (2003), and Davig and Leeper (2007, 2011). Monetary policy regimes are based on those reported in Davig and Leeper (2007, 2011).

It is expected that a contractionary monetary shock cause both inflation and Industrial Production growth to decrease. Figure 3.8 shows that inflation declines within the simple TVP-FAVAR model over the four representative periods. This is as expected. This is also consistent with the results presented in Korobilis (2013) using the same identification as in Bernanke et al. (2005) over the period 1981:Q3 and 1996:Q1.[54] Moreover, Industrial Production growth falls in response to a monetary contraction within the simple TVP-FAVAR model. The response for both inflation and Industrial Production growth appears to be statistically insignificant which quickly returns to zero, see Figure 3.8.

Figure 3.9 gives the TVP-FAVAR results with fiscal policy. In contrast to the simple model, a monetary shock now increases inflation for 1975:Q1, 1981:Q3 and very marginally 1996:Q1. Inflation again falls with a shock in 2006:Q2. As Table 3.3 illustrates, fiscal policy has been active during the administration of Burns and Volcker. Then we can see that fiscal policy switched to be passive in Greenspan's Chairmanship. It again turned to be active during the administration of Bernanke. However, monetary policy was passive in the Burns's administration and turned to be active over both the Volcker and Greenspan period. Then it switched to passive in Bernanke's administration.

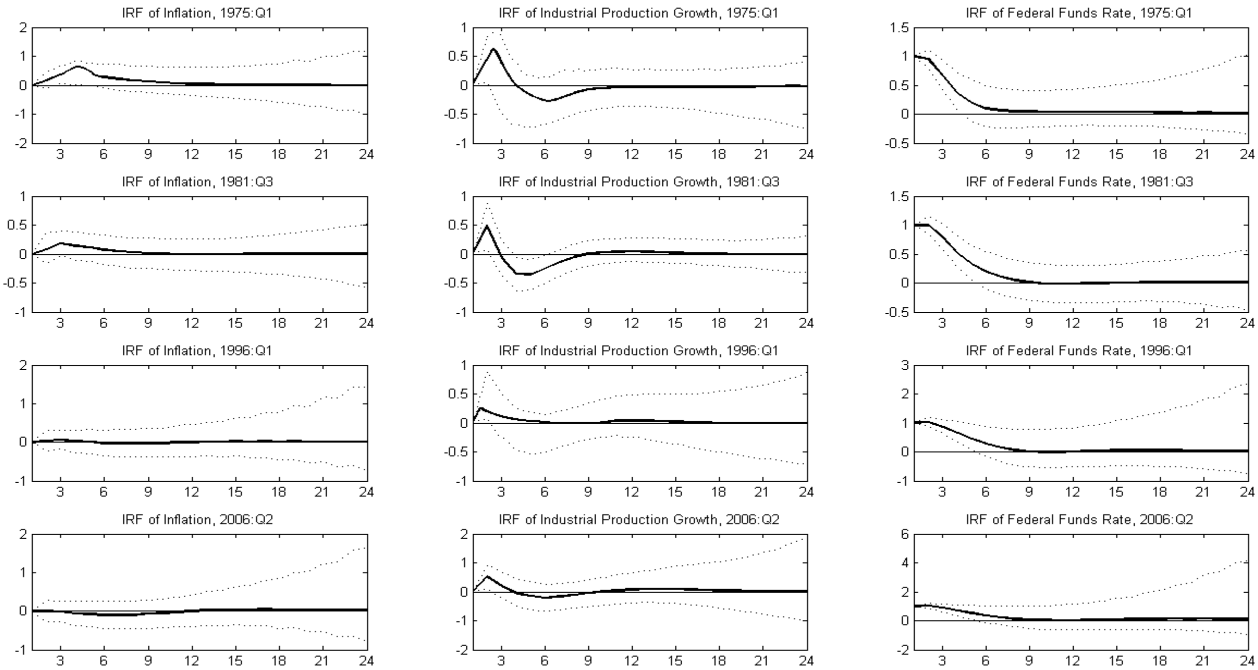
[54] Note that the results presented in Korobilis (2013) show the occurrence of the price puzzle over the 1975:Q1. His work, however, does not cover the 2006:Q2 period and is constructed upon 143 US macroeconomic time series.

Figure 3.8. IRFs of the Observable Variables within the Simple TVP-FAVAR



Note: The Figure shows IRFs for monetary contraction. The Impulse Responses (10th, 50th, and 90th percentiles) are generated within the simple TVP-FAVAR model with Three Unobserved Factors corresponds to a one standard deviations increase to the Federal Funds rate. The Impulse Responses are presented for four representative points in time, 1975:Q1, 1981:Q3, 1996:Q1, and 2006:Q2 as representative of the chairmanships of Burns, Volcker, Greenspan, and Bernanke respectively.

Figure 3.9. IRFs of the Observable Variables within the Fiscal-Augmented TVP-FAVAR



Note: The Figure shows IRFs for monetary contraction. The Impulse Responses (10th, 50th, and 90th percentiles) are generated within the fiscal-augmented TVP-FAVAR model with Three Unobserved Factors corresponds to a one standard deviations increase to the Federal Funds rate. The Impulse Responses are presented for four representative points in time, 1975:Q1, 1981:Q3, 1996:Q1, and 2006:Q2 as representative of the chairmanships of Burns, Volcker, Greenspan, and Bernanke respectively.

It appears that the price puzzle is accentuated within the periods that fiscal policy is active and monetary policy is passive. This counter-intuitive response can be explained through a positive wealth effect induced by a monetary contraction in the presence of an active fiscal policy. The price puzzle then tends to reduce and disappear when fiscal policy switches to passive and monetary policy switches to active episode.[55]

The mechanism can be explained as follows. An increase in the Federal Funds rate when coordinates with an active fiscal regime, may contribute to higher interest rate payments to bondholders. This is happening as the government debt becomes more expensive to finance. Thus, the government must issue more liabilities. Until the price levels start to increase, the new issued bonds create a positive wealth effect. Moreover, with sticky prices the wealth effect would stay for some time to influence households' consumption. Thus, this positive wealth effect can shift aggregated demand upward through increasing private consumption. This, in turns, would raise inflation and output. Consequently, the policy outcome can be higher prices and output.

With reference to the price puzzle appeared in the fiscal-augmented model, our results are consistent with the provided argument in Chung et al. (2007). As is argued therein, inflation sharply increases in short-run in response to a monetary contraction. They show that the price puzzle, which emerges in monetary VARs, can be explained as a natural outcome of periods when monetary policy fails to obey the Taylor principle and taxes do not respond to the state of government debt.[56] Their interpretation of the price puzzle is also consistent with those of Hanson (2004). He concludes that the price puzzle cannot be solved by the conventional method such as adding commodity prices to the Federal Reserve's information set. Hanson (2004) also finds that the puzzle is more pronounced in the 1960s and the 1970s that is identified as active fiscal policy and passive monetary policy.

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[55] See Favero and Monacelli (2003), and Davig and Leeper (2007, 2011) for a detailed explanation on the estimation of active and passive monetary and fiscal policy regime changes.
[56] They find empirical results from a Markov-Switching VAR model suggest that there is a positive correlation between interest rate and inflation under the non-Ricardian and non-monetarist combination case.

Furthermore, the response of inflation for 1975:Q1 and 1981:Q3, under active fiscal policy regime, can validate the Sargent and Wallace (1981) view on the inflationary effects of monetary and fiscal interactions. However, it seems that monetary policy would better account for inflation determination for the Greenspan period, in 1996:Q1, when fiscal policy switches to passive and monetary policy is active. A similar finding is reported in Davig and Leeper (2007,2011).

As regards Industrial Production growth, the same response as inflation within the fiscal model is obtained suggesting that the fiscal stance can influence the responses of inflation and output growth. The response of both inflation and Industrial Production growth is very short-lived, in contrast to the results from the linear FAVAR, and remains statistically significant for a short while.

The positive response of inflation and output growth to a monetary contraction are accentuated under active fiscal policy and passive monetary policy. This is consistent with the results presented in Chung et al. (2007), Davig and Leeper (2007, 2011), Eusepi and Preston (2011), and Leeper and Walker (2012). As Figure 3.9 shows, the price puzzle is more pronounced in the Burns and Volcker periods. Then, it tends to reduce in Greenspan period, and disappears in Bernanke administration. These are consistent with Primiceri (2005) interpretation of the non-systematic monetary policy shock. He provides evidence supporting that monetary shock become less important in Greenspan period.

Given the descriptive statistics on the US key indicator variables over the representative sub-samples as reported in Table 3.4, a number of features emerge that can shed light on these unconventional responses with reference to the macroeconomic policy coordination. First, the Federal Funds rate on average has been greater than inflation in Burns and Volcker administration. With an increase in public debt, it implies that the new government bonds issued in coordination with higher interest rate, due to monetary contraction, may generate positive wealth effect.[57] This wealth effect, in turns, induces private spending and inflation to increase.

[57]As discussed in Chapter 2, a monetary contraction makes government debt more expensive to finance. This can lead the government to issue new debt. In the circumstance when government issues debt that is not fully backed by

Table 3.4. Mean Values for the Key Macroeconomic Indicators over the Representative Sub-Samples

Chairmanships	Policy Coordination	Output Gap	Inflation	The Federal Funds Rate	Real Rates	Government Debt-to-GDP
Burns (1970-1978)	PM- AF&PF	-0.78	6.21	7.1	0.90	32.68
Volcker (1978-1987)	MP&MA-FA&FP	-1.48	4.97	6.79	1.82	50.22
Greenspan (1987-2006)	AM-AF&PF	1.04	4.36	3.6	-0.76	59.16
Bernanke (2006-2013)	MA-FA	-3.47	4.30	1.35	-2.95	81.36
Overall Sample		-1.17	4.96	4.71	-0.25	55.86

Note: This Table reports the mean values for the key indicator variables of the US economy under the selected representative chairmanships of the Federal Reserve. The output gap information is collected from IMF database that shows the percentage deviation between the actual GDP and its potential level. Inflation is the percentage change in the CPI. The real rates are calculated by subtracting the inflation from the Federal Funds rate. The policy coordination is reported according to monetary and fiscal policy regimes estimated by Favero and Monacelli (2003), and Davig and Leeper (2007, 2011). AM and PM abbreviate active and passive monetary policy, respectively. In addition, AF and PF abbreviate active and passive fiscal policy, respectively.

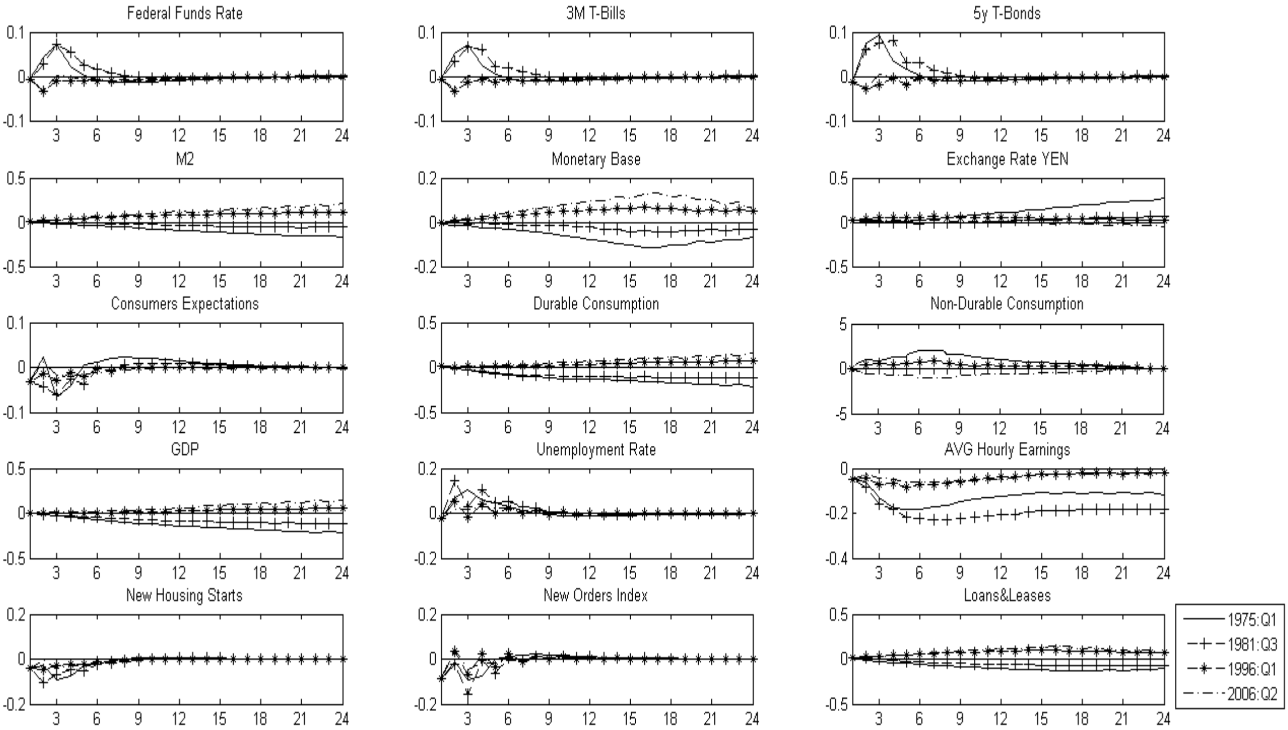
Second, during Greenspan and Bernanke periods, the Federal Funds rate has declined significantly while inflation nearly remains close to the overall sample mean value. Thus, the real rates turn to be negative. As reported in Table 3.4, the government debt continues to rise, in both sub-samples. However, it seems that the low Federal Funds rate coordinated with a passive fiscal policy in Greenspan period to be insufficient to stimulate the private spending.

This explanation is consistent with the idea discussed in Clarida et al. (2000), and Romer and Romer (2004) stating that monetary policy has been mainly accommodative in Burns and Volcker period.[58] Thus, the positive response of inflation to monetary contraction is in accord with the view that active fiscal policy and passive monetary policy may generate inflationary effects. In contrast, over Greenspan administration, monetary policy switches to active coordinated with a passive fiscal policy resulting in disappearance of the price puzzle. During Bernanke administration, fiscal policy switches to active with a passive monetary policy in a sense that the short-term interest rates stays irresponsive and there is no changes in inflation either. However, as an UMP has been adopted over this period, it makes the comparison difficult.

taxes, any policy-generated increase in the interest rate would increase inflation, instead of decrease, see Cochrane (2001, 2009), Sims (2011), and Canzoneri et al. (2011). Under this circumstance, the higher interest rates will lead to the expansion of nominal government debt, particularly when interest expenses are a major part of the government budget.

[58] A detailed discussion of policy actions and outcomes over the chairmanships of Burns, Volcker, and Greenspan can be found in Romer and Romer (2004), and Bae et al. (2012).

Figure 3.10. IRFs to a US Monetary Contraction within the Simple TVP-FAVAR



Note: The impulse responses is generated within the simple TVP-FAVAR model with Three Unobserved Factors corresponds to a one standard deviations increase to the Federal Funds rate. The VAR part of the model includes the Federal Funds rate, Industrial Production growth, and Inflation. The factors are estimated using the Two-Step Principal Components approach from Bernanke et al. (2005). Posterior medians of Impulse Responses are presented for four representative periods, 1975:Q1, 1981:Q3, 1996:Q1, and 2006:Q2 as representative of the chairmanships of Burns, Volcker, Greenspan, and Bernanke respectively.

Having discussed the impact of contractionary monetary policy on inflation and output, now we proceed to examine the monetary transmission mechanism as displayed in Figures 3.10 and 3.11 within the simple and the fiscal TVP-FAVAR model, respectively. Figure 3.10 illustrates that the response of other real activity measures, such as GDP, consumption, hourly earnings, new orders index, new housing starts, and unemployment, within the simple model are generally as expected.

A monetary contraction induces the real activity to decline over Burns and Volcker periods. For Greenspan these variables remain unresponsive to the policy shock, while during Bernanke administration durable consumption, and GDP slightly increase in response to the shock that is counterintuitive. The very weak response of inflation in Bernanke period, as presented in Figure 3.8, may clarify this result. As regards monetary variables, it can be seen that broad money, money supply, and loans fall in the Burns and Volcker period, while they increase in the

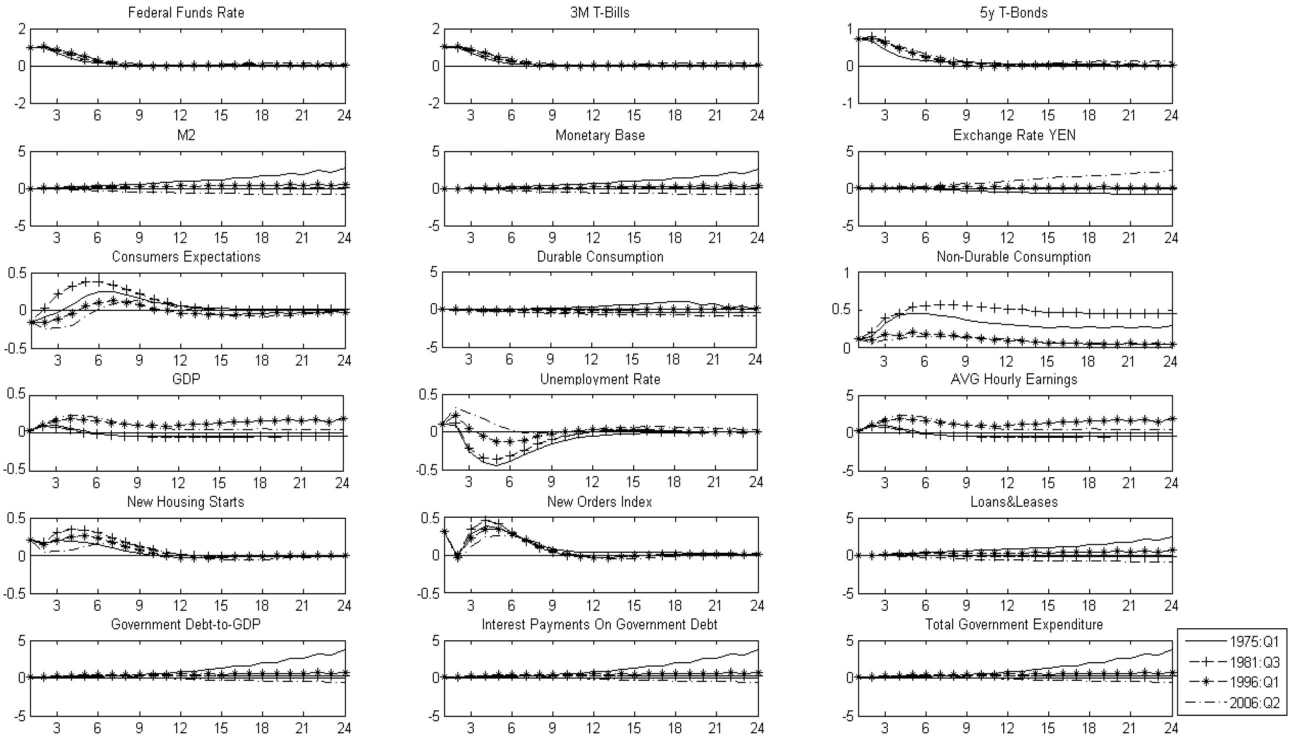
Greenspan and Bernanke periods, respectively. The IRFs results within the simple model are consistent with those presented in Korobilis (2013).

The IRFs results from the fiscal model, as plotted in Figure 3.11, show that real activity measures variables increase during the Chairmanships of Burns and Volcker. This is unconventional. These two sub-samples are associated with an active fiscal policy. We can see the potential positive wealth channel in these two episodes as non-durable consumption increase. When fiscal policy switches to passive while there is an active monetary policy, the monetary contraction generates results that are more reasonable.

Figure 3.11 indicates that over Greenspan and Bernanke administration, real activity measures shows a sharp increase on impact, and then fall. Our results are overall consistent with the discussion in Davig and Leeper (2007, 2011), Sims (2011), and Leeper and Walker (2012) regarding inflationary impact of a monetary contraction under an active fiscal policy and a passive monetary policy regimes.

The same unconventional responses are obtained for monetary aggregates. As Figure 3.11 demonstrates, under active fiscal policy and passive monetary policy regimes, monetary base, supply of money, and loans increases instead of falling. In contrast, the IRFs results of these variables appear to be conventional in the case of a passive fiscal policy and an active monetary policy during Greenspan and Bernanke period. These results suggest that the fiscal stance may influence the monetary transmission mechanism. In addition, our results are consistent with finding presented in Favero and Monacelli (2003) that fiscal policy significantly influences the price level determination when fiscal and monetary policy appears in mismatch exactly as it appears to happen before 1987.

Figure 3.11. IRFs to US Monetary Contraction within the Fiscal-Augmented TVP-FAVAR



Note: The impulse responses is generated within the fiscal-augmented TVP-FAVAR model with Three Unobserved Factors corresponds to a one standard deviations increase to the Federal Funds rate. The VAR part of the model includes the Federal Funds rate, Industrial Production growth, and Inflation. The factors are estimated using the Two-Step Principal Components approach from Bernanke et al. (2005). Posterior medians of Impulse Responses are presented for four representative periods, 1975:Q1, 1981:Q3, 1996:Q1, and 2006:Q2 as representative of the chairmanships of Burns, Volcker, Greenspan, and Bernanke respectively.

As regards the fiscal stance variables responses, monetary contraction shock induces government debt and total government expenditures to increases as the interest payments on government debt increase under an active fiscal policy periods: 1975:Q1 and marginally over 1981:Q3. During these periods, the Federal Funds rate has been much higher compared with the 1996:Q1 and 2006:Q2. Then, as the interest payments on debt stay unresponsive and falls, both the debt-to-GDP ratio and total government expenditure follow the same path, see Figure 3.11.

Table 3.5 clarifies the monetary-fiscal interactions with reference to the macroeconomic policy regimes. As can be seen in the Table, the generated wealth effect is associated with the periods that fiscal policy is active and the growth rate of the interest expenses of public debt are positive. It implies that a monetary contraction may contribute to the issuance of new government bonds. This, in turns, may induce an increase in consumption through a positive wealth effect. The impact can be traced under active fiscal policy and passive monetary policy regimes.

Table 3.5. The US Monetary-Fiscal Interactions and the Monetary Transmission Results

Chairmanships	Policy Coordination	Wealth Effects	Non-Durable Consumption	Price Puzzle	Growth Rate of Interest Share of Government Debt
Burns (1970-1978)	PM- AF&PF	YES	Increase	YES	1.28
Volcker (1978-1987)	MP&MA-FA&FP	YES	Small Increase	YES	0.19
Greenspan (1987-2006)	AM-AF&PF	NO	Unresponsive	NO	-0.98
Bernanke (2006-2013)	MA-FA	NO	Falls	NO	-3.89

Note: This Table reports the outcome of US monetary-fiscal interactions under the selected representative chairmanships of the Federal Reserve. The policy coordination is reported according to monetary and fiscal policy regimes estimated by Favero and Monacelli (2003), and Davig and Leeper (2007, 2011). AM and PM abbreviate active and passive monetary policy, respectively. In addition, AF and PF abbreviate active and passive fiscal policy, respectively.

Thus, the IRFs presented in Figures 3.9 and 3.11 confirm the different interpretation for the price puzzle discussed in Chung et al. (2007). They explain that an increase in prices in response to monetary contraction may be a normal response rather than a puzzle when fiscal policy is active and considered in the monetary transmission mechanism.

In summary, comparing the IRFs results from the fiscal-augmented TVP-FAVAR with those from the simple model, three features emerge. First, including the fiscal stance to examine the monetary transmission mechanism can results in the price puzzles. Second, the price puzzle is accentuated under an active fiscal policy and a passive monetary policy coordination. Third, a positive wealth effects appears to contribute to increasing prices through consumption within the fiscal-augmented TVP-FAVAR.

Now we proceed to examine the impact of fiscal policy on the economy within both Constant and TVP-FAVAR framework. The next section presents the results.

3.4.5 Fiscal Policy Shock Identification

This section, first explains the identification approach for fiscal policy shock. Then, we proceed to presenting the IRF results in both constant and TVP-FAVAR framework. We are interested in particular in whether fiscal policy is non-Ricardian or Ricardian. That is, whether inflation and output respond to the fiscal shocks or not, respectively.

With reference to the identification of fiscal policy shock, a number of approaches can be used.[59] Following the common practice in the literature and to maintain the consistency with monetary policy identification we focus upon a recursive approach as employed in Favero and Monacelli (2005), and Fatas and Mihov (2006) to identify our fiscal policy shocks.

As regards the policy instrument, we assume that the fiscal authority uses the first difference of government debt-to-GDP ratio as its policy instrument. Favero and Giavazzi (2011), and Farhi and Werning (2012) argue that government debt-to-GDP as fiscal policy instrument can capture the dynamic of government budget over the time rather than representing the current figure as with government budget deficit. Furthermore, the possibility of the wealth effects generated within the transmission mechanism justifies our choice of policy instrument.[60]

The VAR part of our model consists of three observable variables including Inflation, Industrial Production growth, and government debt-to-GDP ratio as the fiscal policy instrument. The factor part of our model, also, consists of the other time series to extract three unobserved factors. As mentioned earlier, further to the addition of government debt-to-GDP to proxy the fiscal policy instrument, we include government budget deficits as time series information to

[59] As a few example of identification approaches we can refer to narrative approach to isolate a specific event as in Ramey and Shapiro (1999), identification of fiscal shocks based on the elasticity of fiscal variables as in Blanchard and Perotti (2002), and sign restriction approach as in Mountford and Uhlig (2009). The sign restriction approach holds the assumption that under all circumstances the responses to the certain shocks would be equally the same. However, plausible responses to policy shocks require further restrictions combined with the sign restrictions to capture different circumstances, see Killian and Murphy (2012). Furthermore, as is explained in Korobilis (2013) it is hard to justify the results from sign restrictions when using a VAR with unobservable factors.

[60] We repeated the experiment with budget deficit as the policy instrument. It gives almost the same qualitative results. In addition, in Chapter 4, we study the international spillovers of a US contractionary monetary policy to some major economies. Since the data availability for budget deficit has been an issue for some of the selected economies, to ensure the consistency among the chapters, we choose government's debt as the fiscal policy instrument.

extract the factors upon it, too. Having established model identification, the next section presents the Impulse Response Functions results to an expansionary fiscal policy shock.

3.4.6 The FAVAR Model Specification Results to Fiscal Shock

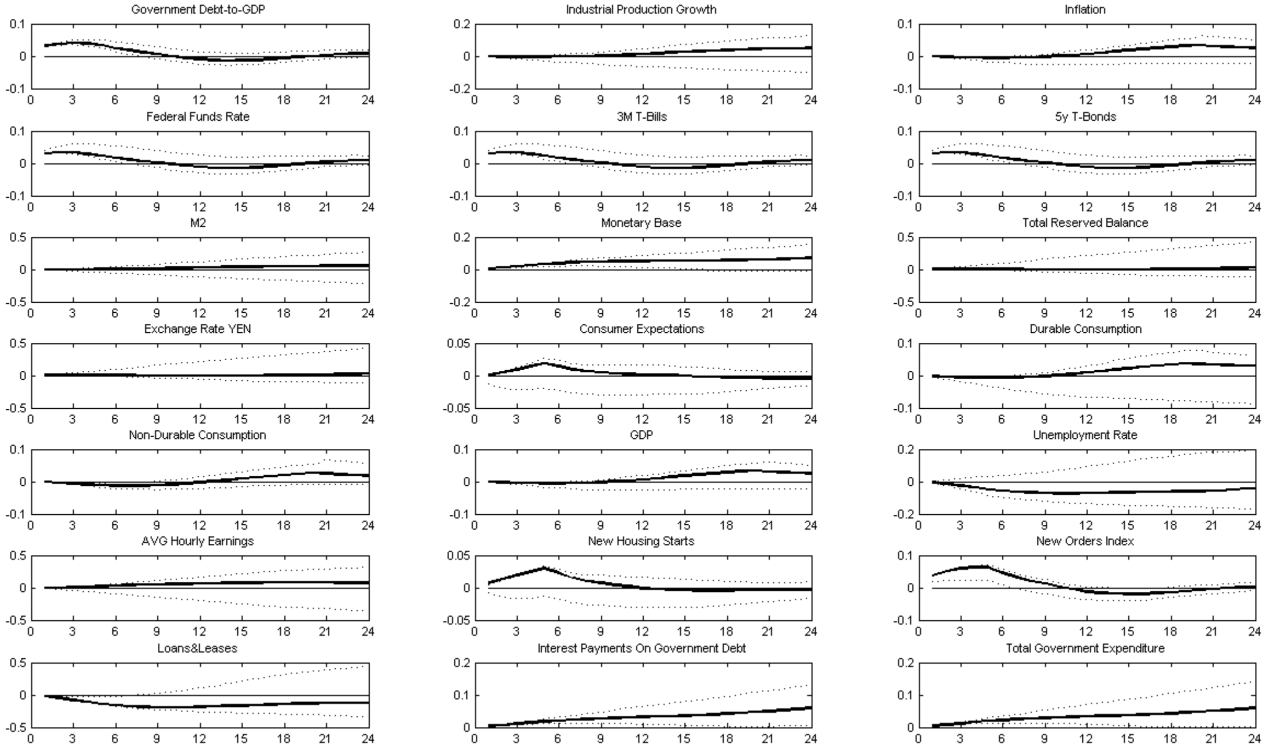
This section presents the way in which an expansionary fiscal policy shock may influence the economy within a linear FAVAR model. Likewise monetary policy, the extent to which fiscal policy can impact the economy depends on its ability to stimulate aggregate demand through private expenditure. As discussed in Chapter 2, the impact takes effect mainly by generating a positive wealth effect. Assume that fiscal policy is associated with an increase in government debt through a debt-financed tax reduction. Further public debt requires the government to issue more bonds. Thus, extra government debt would increase the bonds holding by the public. This would create a positive wealth effect.[61] Thus, households may adjust their demand patterns in response to the fiscal authorities' decisions, potentially leading to a rise in the private expenditure.

Figure 3.12 illustrates the IRFs of the main macroeconomic indicators to an increase in government debt-to-GDP within the Constant-Parameter FAVAR. From the responses, we can see that the policy shock succeed in stimulating the economy through increased private consumption: an increase in government debt increase GDP and inflation. Furthermore, the shock stimulates other real activity measures such as new orders index and average hourly earnings, while it causes the unemployment rate to decline.

As regards the impact of fiscal expansionary policy on the interest rates, it can be observed that the responses are consistent with the economic intuition: both short and long-term interest rates increase. This can be explained as the stock of government debt increase it crowds out the private saving that contributes to increasing the interest rates.

[61] The positive wealth effect induced by the adjustment in fiscal policy can influence the asset values or change the composition of the wealth bundle, see Afonso and Sousa (2012).

Figure 3.12. IRFs to a US Fiscal Expansion within the FAVAR



Note: This Figure provides IRFs to an expansionary fiscal shock from a linear FAVAR. The VAR part of the model includes the government debt-to-GDP, Industrial Production growth, and Inflation on top panel. The IRFs of other key variables in the fiscal transmission mechanism is estimated based on three unobserved factors. The Impulse Responses together with their confidence intervals (10th, 50th, and 90th) are generated based on Bernanke et al. (2005) FAVAR model specification corresponds to a 1 standard deviation increase to the Government Debt-to-GDP. The FAVAR model is estimated using the Two-Step Principal Components approach from Bernanke et al. (2005) over the 1959:Q1-2013:Q2 sample.

As Figure 3.12 displays, this fiscal shock also increases money aggregates including the monetary base and supply of money while the total reserved balance only marginally falls. It can be explained by agents' expectations about the government debt. If agents expect that the debt would be financed by future taxation, the shock would enhance private saving rather than spending. Thus, this may lead to a fall in aggregate expenditure and inflation with the same impact on the money aggregates. The opposite effect is anticipated if agents expect that there is no further taxation. This will be associated with higher inflation and an increase in money aggregates through an increase in consumption.

Given that an increase in government debt has been caused on increase in monetary base, it can be inferred that new bonds has been issued. As explained in Bradley (1984) an increase in demand for bonds induced the increase in supply of money.

Concisely, the IRFs results of the linear FAVAR model suggest that an increase in government debt can stimulate the economy through increasing private consumption, which in turn would stimulate real activity measures and money aggregates. These results are in line with the non-Ricardian view of fiscal policy. Our results are consistent with those of Davig and Leeper (2007, 2011), Sims (2011), and Afonso and Sousa (2012) suggesting that government spending shock have a positive but small effect on inflation and output. The next section presents the IRF results for a fiscal expansion from a non-linear FAVAR.

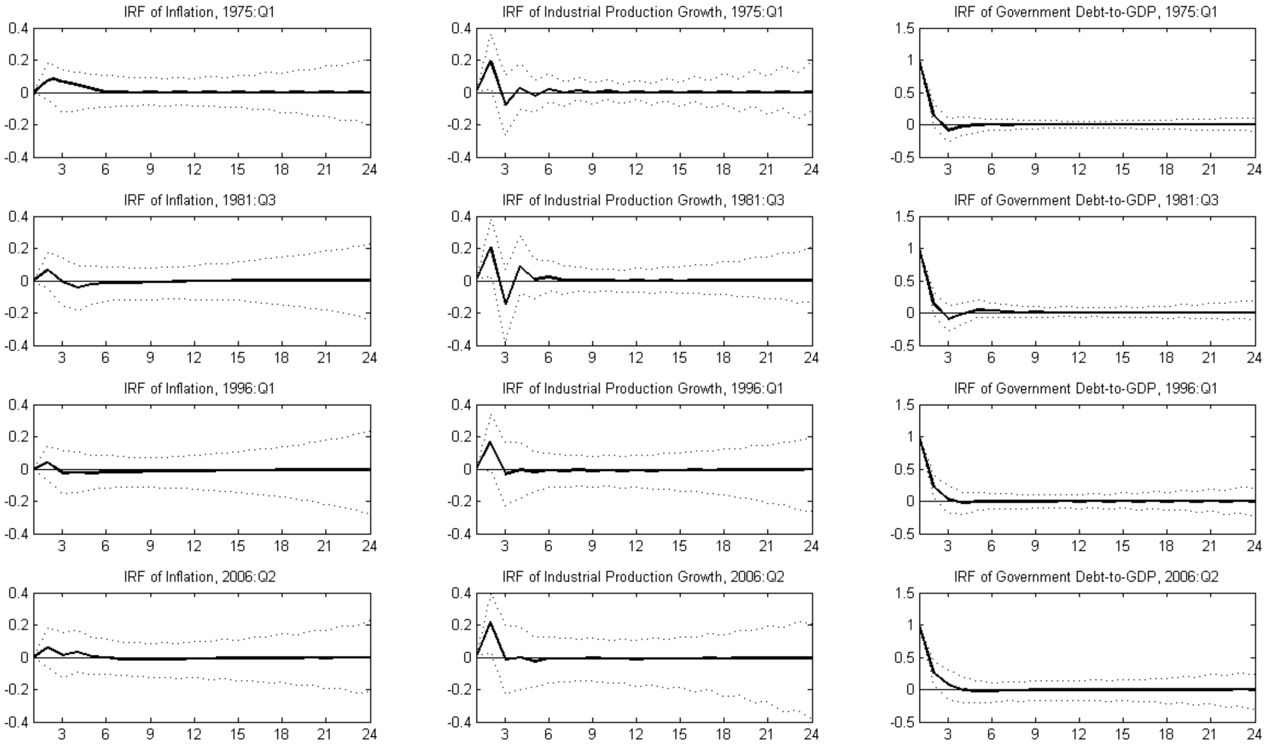
3.4.7 The TVP-FAVAR Model Specification Results to Fiscal Shock

Now we proceed to examining the impact of an expansionary fiscal policy within a TVP-FAVAR model. Likewise the constant-parameter model, it is assumed that the fiscal authority uses the first difference of government debt-to-GDP as the policy instrument. The median posterior estimates of the standard errors for the unobservable factors, and the observable variables are presented in Appendix 3.B.[62]

Turning to the IRFs of inflation and Industrial Production growth to this fiscal expansion, Figure 3.13 shows that they both increase and then sharply returns back to zero. Furthermore, while the response of Industrial Production growth remains statistically significant only for a quarter, those of inflation appears to be insignificant over the period.

[62] The results presented in Appendix 3.B show that the mean values falls after 1985 as fiscal policy switches from active to passive. Furthermore, the volatility of residuals declines as fiscal regime changes. As regards the posterior mean values of the residuals of the observable variables, Figure 3.B.3 displays that while the standard deviations of residuals of inflation peaks in 1975, those of Industrial Production growth peaks in 1978 and 1981. This can be explained with time lags associated with fiscal policy to take effect.

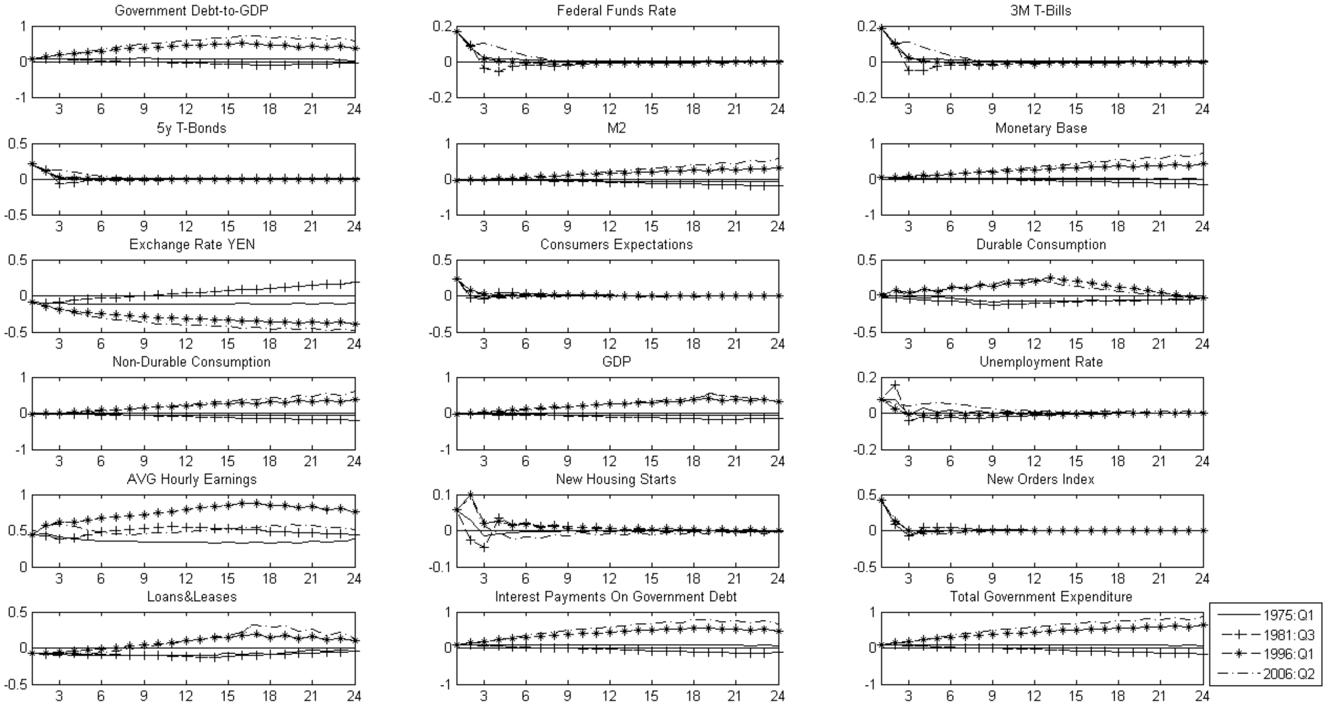
Figure 3.13. IRFs of the Observable Variables within the TVP-FAVAR



Note: The Figure shows IRFs to a US fiscal Expansion. The Impulse Responses (10^{th}, 50^{th}, and 90^{th} percentiles) are generated within the simple TVP-FAVAR model with Three Unobserved Factors corresponds to a one standard deviations increase to the Government Debt-to-GDP. The VAR part of the model includes the Government Debt-to-GDP, Industrial Production growth, and Inflation. The factors are estimated using the Two-Step Principal Components approach from Bernanke et al. (2005).The Impulse Responses are presented for four representative points in time, 1975:Q1, 1981:Q3, 1996:Q1, and 2006:Q2 as representative of the chairmanships of Burns, Volcker, Greenspan, and Bernanke respectively.

The transmission mechanism of US fiscal policy expansion is presented in Figure 3.14. The IRFs appears to be generally conventional. Both short and long-term interest rates increase. This finding is reported in Laubach (2009) as he reports a raise in medium to long-term interest rates following an increase in debt-to-GDP ratio. With reference to the real activity measure, consumption, average hourly earnings, and GDP increase. In addition, new housing starts and new orders index show an initial raise which sharply drops. However, unemployment appears to increase on impact instead of falling followed by an immediate returning back to zero.

Figure 3.14. IRFs to US Fiscal Expansion within the TVP-FAVAR



Note: The Impulse Responses is generated within the TVP-FAVAR model with Three Unobserved Factors corresponds to a one standard deviations increase to the Government Debt-to-GDP. The VAR part of the model includes the Government Debt-to-GDP, Industrial Production growth, and Inflation. The factors are estimated using the Two-Step Principal Components approach from Bernanke et al. (2005). Posterior medians of Impulse Responses are presented for four representative periods, 1975:Q1, 1981:Q3, 1996:Q1, and 2006:Q2 as representative of the chairmanships of Burns, Volcker, Greenspan, and Bernanke respectively.

As regards the monetary aggregates, monetary base, supply of money, and loans increase in response that is conventional. Finally, both interest payments on public debt and government expenditure increase as a result of the increase in government debt-to-GDP ratio shock. Overall, these results provide evidence for the non-Ricardian view on the fiscal policy over the sample. To this end our results are consistent with those presented in Favero and Monacelli (2003), Davig and Leeper (2007, 2011), and Reade (2011). They also report that an expansionary fiscal policy has expansionary impact on the economy.

3.5 Results Summary

This section summarizes the results. Table 3.6 presents the results summary for a US contractionary monetary policy obtained from both the Constant and TVP-FAVAR models. A number of features emerge from Table 3.6.

First, the IRFs results from the simple linear FAVAR model show a conventional response as consumption, inflation, and GDP fall in response to the policy shock. Second, the IRFs results from the fiscal-augmented FAVAR to monetary contraction suggest that including the fiscal stance has inflationary impact on the economy by increasing consumption and generating a positive wealth effect. Third, while the policy shock induces a rise in prices, it reduces output. This may suggest that monetary contraction causes the unit cost of production to increase that is in line with the cost-channel interpretation of the price puzzle.

Likewise the linear FAVAR, the simple TVP-FAVAR produces conventional responses as both inflation and output falls. However, the fiscal-augmented TVP-FAVAR generates the price puzzle. The price puzzle is more accentuated in the case of an active fiscal policy and passive monetary policy regimes. This influences the monetary transmission mechanism through generating positive wealth effect and increasing consumption, consequently.

As regards the results of an expansionary fiscal policy shock, Table 3.7 summarizes the IRFs within both Constant and TVP- FAVAR model. According to the impulse responses, the policy shock induces both inflation and output to increase. Thus, the non-Ricardian view on fiscal policy can find empirical support within both linear and TVP-FAVAR model. Having examined the transmission of the policy shock, it appears that fiscal expansion takes effect through increasing private consumption. This, in turns, increases inflation and output.

Table 3.6. Impact of Monetary Policy Shock: Results Summary

		Federal Funds Rate	Inflation	Industrial Production Growth	Non-Durable Consumption	Broad Money
The Simple Constant-Parameter FAVAR		+*	-	-	-*	-*
The Fiscal-Augmented Constant-Parameter FAVAR		+*	+	-	+*	-*
The Simple TVP-FAVAR	1975:Q1	+	-	-	+	-
	1981:Q3	+	-	-	+	-
	1996:Q1	+	-	-	Unresponsive	+
	2006:Q2	+	-	-	-	+
The Fiscal-Augmented TVP-FAVAR	1975:Q1	+*	+*	+*	+	+
	1981:Q3	+*	+	+*	+	Unresponsive
	1996:Q1	+*	Unresponsive	+*	+	Unresponsive
	2006:Q2	+*	Unresponsive	+*	-	-

Note: The Table summarizes the response of the selected macroeconomic variables to monetary contraction. The simple vs. the fiscal-augmented model indicates that the fiscal stance is excluded from the model. An asterisk ,*, indicates that the responses are statistically significant. Macroeconomic policy regimes are provided in Table 3.3.

Table 3.7. Fiscal Policy Shock: Results Summary

		Government Debt-to-GDP	Inflation	Industrial Production Growth	Non-Durable Consumption	Broad money
Constant-Parameter FAVAR		+*	+	+	+*	Unresponsive
TVP-FAVAR	1975:Q1	+*	+	+*	Unresponsive	Unresponsive
	1981:Q3	+*	+	+*	Unresponsive	Unresponsive
	1996:Q1	+*	+	+*	+	+
	2006:Q2	+*	+	+*	+	+

Note: The Table summarizes the response of the selected macroeconomic variables to fiscal expansion. The simple vs. the fiscal-augmented model indicates that the fiscal stance is excluded from the model. An asterisk ,*, indicates that the responses are statistically significant. Macroeconomic policy regimes are provided in Table 3.3.

3.6 Concluding Remarks

This chapter explores the impact of monetary and fiscal policy interactions on the US economy. Two main objectives are pursued in this study. First, to examine the potential role of fiscal policy on the conduct of monetary policy and its transmission mechanism. Second, to study the macroeconomic impact of fiscal policy on the real economy.

We explain that the existing literature neglects macroeconomic policy interactions in assessing monetary policy outcome. We provide evidence from both Constant-Parameter and TVP-FAVAR models to support the substantial impact of fiscal policy on the conduct of monetary policy. Hence, we estimate both linear and non-linear FAVAR models with and without fiscal variables to study the impact of monetary and fiscal policy interactions. We discuss that employing a TVP-FAVAR method allows us to understand whether the impact of policy interactions evolves over the time.

Having examined the responses to monetary and fiscal policy shocks a number of features emerge. First, a US contractionary monetary policy shock in a Constant-Parameter FAVAR model reduces output growth as expected. This is irrespective of whether the fiscal stance is included or not. However, while inflation falls in response to a monetary contraction within the simple model, it increases in the fiscal-augmented model. Our finding from the fiscal-augmented FAVAR model show that this monetary contraction induces consumption to increase. The increase in consumption and inflation may suggest that the policy generates a positive wealth effect. As is discussed in Bernanke et al. (2004), a large and prolonged government debt in conjunction with monetary contraction can cause prices to increase. In particular, if the interest share of government debt is considerable. In this case, a contractionary monetary policy can increase disposable income and generate a positive wealth effect leading to an increase in private expenditure and prices.

Second, comparing the IRFs results from the fiscal-augmented TVP-FAVAR with those from the simple model, our finding from the fiscal-augmented model confirms that a monetary contraction may cause an increase in the price levels when monetary policy is passive and fiscal policy is active. This finding suggests that price puzzle can be a normal response of prices to monetary contraction when fiscal policy is active which means the fiscal authority sets the government budget regardless of tax revenues. Thus, this monetary shock can generate a positive wealth effect. This can encourage private consumption and raise the price levels. This is the case during the 1970s that influenced the monetary transmission mechanism.

The positive response of inflation and output growth to monetary contraction, which is more accentuated under active fiscal policy and passive monetary policy coordination, is consistent with the results presented in Favero and Monacelli (2003), Primiceri (2005), Chung et al. (2007), Davig and Leeper (2007, 2011), Sims (2011), and Leeper and Walker (2012). Chung et al. (2007) argue that the price puzzle can be a natural outcome of periods when monetary policy fails to follow a Taylor Rule and taxes fail to respond to the state of debt. In addition, this result is consistent with Hanson's (2004) explanation of the price puzzle that it cannot be solved by the conventional method of adding extra information to the VAR models and it tends to be severe under an active fiscal policy and a passive monetary policy regime.

Finally, the impulse responses within both the linear and TVP-FAVAR model show that fiscal policy has an inflationary impact on the economy. We find evidence to support the non-Ricardian view on the fiscal policy from both model specifications. That is an expansionary fiscal policy stimulates demand and output. This finding is consistent with finding presented in Favero and Monacelli (2003), Davig and Leeper (2007, 2011), and Reade (2011).

It is worth noting that our results are limited to the FAVAR models that only allow a limited scope of macroeconomic policy interactions to be traced. A number of limitations emerge from this study, which is left to future work. As concerns the results from the linear FAVAR model, it may be insightful to explore the experiment within the Block of Factors framework as in Korobilis (2013). In addition, our non-linear FAVAR model does not explicitly allows for monetary and fiscal policy Regime-Switching as in Davig and Leeper (2011). This implies that the obtained results allow limited conclusion. Thus, replicating our analysis within a Markov-Switching method may enhance our results that has also been left to future work. Finally, it may be useful to further investigate our research questions by adopting a Time-Varying Factor loadings as in Del Negro and Otrok (2008).

Appendix 3.A: Data series

All the time series are taken from the St Louis Fed FRED database. Following Stock and Watson (2005), all variables are transformed to be approximately stationary using the appropriate transformation codes (T code) as follows: 1- No Transformation; 2- First Difference; 4- Logarithm; 5- First Difference of Logarithm. The slow code column indicates that variables respond to the policy either slowly or fast. Following Bernanke et al. (2005), the fast moving variables includes Housing Starts and Sales variables, Real Inventories and Orders Indices, Exchange Rates, Interest Rates, and Money and Credit Quantity Aggregates. The rest of variables include Real Output and Income, Employment and Hours, Consumption, Price Indexes, Average Hourly Earnings, and Fiscal Stance of the economy are the slow moving variables.

	Mnemonic	Description	T code	Slow Code
	Real Output and Income			
1	NAPM	ISM Manufacturing: PMI Composite Index	1	1
2	EXPGSC96	Real Exports of Goods & Services	5	1
3	IMPGSC96	Real Imports of Goods & Services, 3 Decimal	5	1
4	DIVIDEND	Corporate Profits after tax with IVA and CCAdj: Net Dividens	5	1
5	RENTIN	Rental Income of Persons with Capital Consumption Adjustment (CCAdj)	5	1
6	ULCNFB	Nonfarm Business Sector: Unit Labour Cost	5	1
7	GDP	Gross Domestic Product	5	1
8	FSDP	Final Sales to Domestic Purchasers	5	1
9	FINSAL	Final Sales of Domestic Product	5	1
10	FPI	Fixed Private Investment	5	1
11	IPFINAL	Industrial Production: Final Products (Market Group)	5	1
12	IPCONGD	Industrial Production: Consumer Goods	5	1
13	INDPRO	Industrial Production Index	5	1
14	IPDCONGD	Industrial Production: Durable Consumer Goods	5	1
15	IPNCONGD	Industrial Production: Nondurable Consumer Goods	5	1
16	FINSLC96	Real Final Sales of Domestic Product	5	1
17	PRFI	Private Residential Fixed Investment	5	1
18	GDPCTPI	Gross Domestic Product: Chain-type Price Index	5	1
19	GDPC96	Real Gross Domestic Product	5	1
20	GSAVE	Gross Saving	5	1
21	NANIPI01USQ189	Personal Income in Constant Prices for the United States	5	1
22	ALSGVAQ027S	All sectors; gross value added (IMA)	5	1
23	GDI	Gross Domestic Income	5	1
24	BOPBCA	Balance on Current Account	1	1
25	CP	Corporate Profits After Tax (without IVA and CCAdj)	5	1
26	ULCBS	Business Sector: Unit Labour Cost	5	1
	Employment and Hours			
27	UNRATE	Civilian Unemployment Rate	1	1
28	NAPMEI	ISM Manufacturing: Employment Index	1	1
29	EMRATIO	Civilian Employment-Population Ratio	1	1
30	UEMPLT5	Civilians Unemployed - Less Than 5 Weeks	5	1
31	UEMP15OV	Civilians Unemployed - 15 Weeks & Over	5	1

	Mnemonic	Description	T code	Slow Code
32	UEMP5TO14	Civilians Unemployed for 5-14 Weeks	5	1
33	UEMP15T26	Civilians Unemployed for 15-26 Weeks	5	1
34	UEMP27OV	Civilians Unemployed for 27 Weeks and Over	5	1
35	NDMANEMP	All Employees: Nondurable goods	5	1
36	MANEMP	All Employees: Manufacturing	5	1
37	SRVPRD	All Employees: Service-Providing Industries	5	1
38	USTPU	All Employees: Trade, Transportation & Utilities	5	1
39	USWTRADE	All Employees: Wholesale Trade	5	1
40	USTRADE	All Employees: Retail Trade	5	1
41	USFIRE	All Employees: Financial Activities	5	1
42	USEHS	All Employees: Education & Health Services	5	1
43	USPBS	All Employees: Professional & Business Services	5	1
44	USINFO	All Employees: Information Services	5	1
45	USSERV	All Employees: Other Services	5	1
46	USPRIV	All Employees: Total Private Industries	5	1
47	USGOVT	All Employees: Government	5	1
48	USLAH	All Employees: Leisure & Hospitality	5	1
	Consumption			
49	PCEC	Personal Consumption Expenditures	5	1
50	PCDG	Personal Consumption Expenditures: Durable Goods	5	1
51	PCND	Personal Consumption Expenditures: Nondurable Goods	5	1
	Housing Starts and Sales			
52	HOUSTNE	Housing Starts in Northeast Census Region	4	0
53	HOUSTMW	Housing Starts in Midwest Census Region	4	0
54	HOUSTS	Housing Starts in South Census Region	4	0
55	HOUSTW	Housing Starts in West Census Region	4	0
56	HOUST1F	Privately Owned Housing Starts: 1-Unit Structures	4	0
57	HOUST	Housing Starts: Total: New Privately Owned Housing Units Started	4	0
58	PERMIT	New Private Housing Units Authorized by Building Permits	4	0
	Real Inventories and Orders Indices			
59	NAPMSDI	ISM Manufacturing: Supplier Deliveries Index	1	0
60	NAPMNOI	ISM Manufacturing: New Orders Index	1	0
61	NAPMII	ISM Manufacturing: Inventories Index	1	0
62	CIVA	Corporate Inventory Valuation Adjustment	1	0
63	CBI	Change in Private Inventories	1	0
	Exchange Rates			
64	EXSZUS	Switzerland / U.S. Foreign Exchange Rate	5	0
65	EXJPUS	Japan / U.S. Foreign Exchange Rate	5	0
	Interest Rates			
66	FEDFUNDS	Effective Federal Funds Rate	1	0
67	AAA	Moody's Seasoned Aaa Corporate Bond Yield	1	0
68	BAA	Moody's Seasoned Baa Corporate Bond Yield	1	0
69	MPRIME	Bank Prime Loan Rate	1	0
70	TB3MS	3-Month Treasury Bill: Secondary Market Rate	1	0

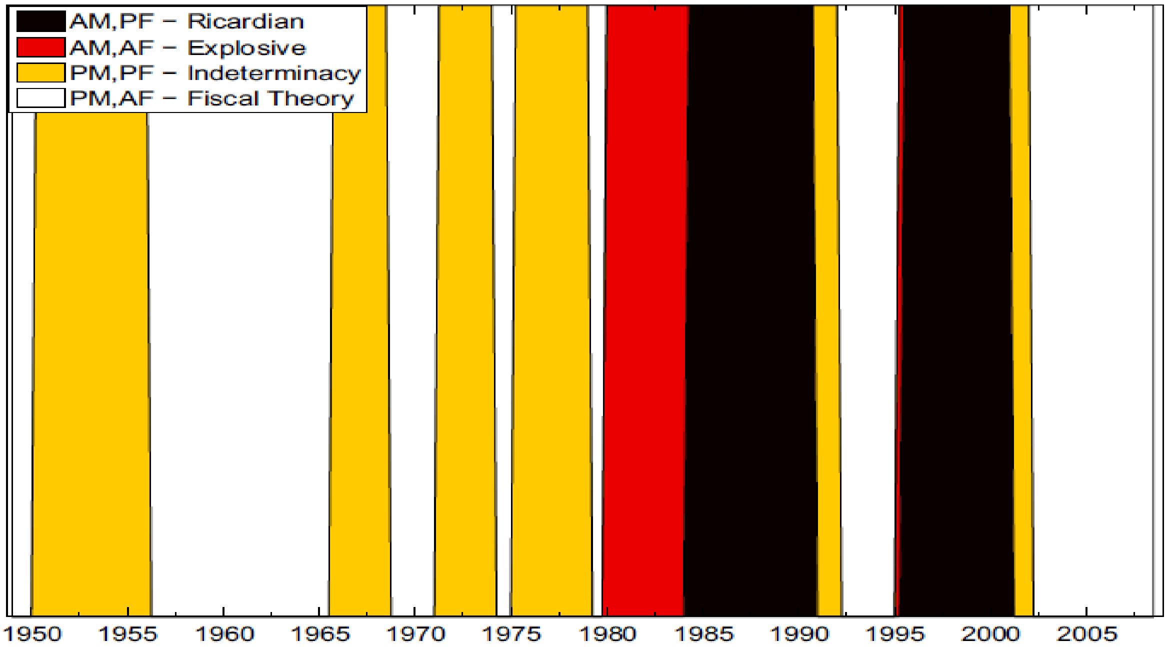
	Mnemonic	Description	T code	Slow Code
71	TB6MS	6-Month Treasury Bill: Secondary Market Rate	1	0
72	GS1	1-Year Treasury Constant Maturity Rate	1	0
73	GS3	3-Year Treasury Constant Maturity Rate	1	0
74	GS5	5-Year Treasury Constant Maturity Rate	1	0
75	GS10	10-Year Treasury Constant Maturity Rate	1	0
76	INTGSBUSM19N	Interest Rates- Government Bonds for United States	1	0
77	IRLTLT01USQ1N	Long-Term Government Bond Yields: 10-year: Main (Including Benchmark)	1	0
	Money and Credit Quantity Aggregates			
78	REQRESNS	Required Reserves of Depository Institutions	5	0
79	RESBALNS	Total Reserve Balances Maintained with Federal Reserve Banks	5	0
80	BORROW	Total Borrowings of Depository Institutions from the Federal Reserve	5	0
81	TVCKSSL	Travellers Checks Outstanding	5	0
82	M2SL	M2 Money Stock	5	0
83	M2OWN	M2 Own Rate	5	0
84	SVSTCBSL	Savings and Small Time Deposits at Commercial Banks	5	0
85	SVSTSL	Savings and Small Time Deposits - Total	5	0
86	SVGCBSL	Savings Deposits at Commercial Banks	5	0
87	SVGTI	Savings Deposits at Thrift Institutions	5	0
88	SAVINGSL	Savings Deposits - Total	5	0
89	STDCBSL	Small Time Deposits at Commercial Banks	5	0
90	STDTI	Small Time Deposits at Thrift Institutions	5	0
91	STDSL	Small Time Deposits - Total	5	0
92	M2MSL	M2 Less Small Time Deposits	5	0
93	M2MOWN	M2 Minus Own Rate	5	0
94	MZMSL	MZM Money Stock	5	0
95	DDDFCBNS	Demand Deposits Due to Foreign Commercial Banks	5	0
96	DDDFOINS	Demand Deposits Due to Foreign Official Institutions	5	0
97	USGVDDNS	U.S. Government Demand Deposits and Note Balances - Total	5	0
98	USGDCB	U.S. Government Demand Deposits at Commercial Banks	5	0
99	CURRCIR	Currency in Circulation	5	0
100	INVEST	Total Investment-Securities in Bank Credit at All Commercial Banks	5	0
101	CNCF	Corporate Net Cash Flow with IVA	5	0
102	M1	M1 Money Stock	5	0
103	CURRSL	Currency Component of M1	5	0
104	CURRDD	Currency Component of M1 Plus Demand Deposits	5	0
105	DEMDEPSL	Demand Deposits at Commercial Banks	5	0
106	TCDSL	Total Checkable Deposits	5	0
107	AMBSL	St. Louis Adjusted Monetary Base	5	0
108	MABMM301657S	M3 for the United States	5	0
109	MABMBM01657S	Broad Money	5	0
110	LOANS	Loans and Leases in Bank Credit	5	0
111	LOANINV	Loans and Investment in Bank Credit	5	0
112	TCMAH	All Sectors; Credit Market Instruments; Asset	5	0
113	TCMDO	All Sectors; Credit Market Instruments; Liability	5	0

	Mnemonic	Description	T code	Slow Code
114	USGSEC	US Government Treasury and Securities at All Commercial Banks	5	0
115	OTHSEC	Other Securities at All Commercial Banks	5	0
116	TOTALSL	Total Consumer Credit Owned and Securitized, Outstanding	5	0
117	BUSLOANS	Commercial and Industrial Loans at All Commercial Banks	5	0
118	CONSUMER	Consumer Loans at All Commercial Banks	5	0
119	BOGAMBSL	Board of Governors Monetary Base, Adjusted for Changes in Reserve	5	0
120	TRARR	Board of Governors Total Reserves, Adjusted for Changes in Reserve	5	0
121	BOGNONBR	Non-Borrowed Reserves of Depository Institutions	5	0
122	NFORBRES	Net Free or Borrowed Reserves of Depository Institutions	1	0
123	CMDEBT	Households and Non-profit Organizations; Credit Market Instruments; Liability	5	0
124	REALLN	Real Estate Loans at All Commercial Banks	5	0
125	FBTALDQ027S	Financial business; total assets (does not include land)	5	0
126	FBLIEQQ027S	Financial business; total liabilities and equity	5	0
127	FBTMASQ027S	Financial business; total mortgages; asset	5	0
128	FBTSAAQ027S	Financial business; Treasury securities; asset	5	0
129	BOPIO	Foreign Official Assets in the U.S.: Net	1	0
130	HHMSDODNS	Households and Non-profit Organizations; Home Mortgages; Liability	5	0
	Price Indexes			
131	CPALTT01USQ66	Consumer Price Index: Total All Items for the United States	5	1
132	USACPIFODQIN	Consumer Price Index: Food for the United States	5	1
133	CPIENGSL	Consumer Price Index for All Urban Consumers: Energy	5	1
134	CPITRNSL	Consumer Price Index for All Urban Consumers: Transportation	5	1
135	CUSR0000SAS	Consumer Price Index for All Urban Consumers: Services	5	1
136	CUSR0000SAC	Consumer Price Index for All Urban Consumers: Commodities	5	1
137	CUSR0000SAD	Consumer Price Index for All Urban Consumers: Durables	5	1
138	CPIMEDSL	Consumer Price Index for All Urban Consumers: Medical Care	5	1
139	CPIAPPSL	Consumer Price Index for All Urban Consumers: Apparel	5	1
140	MCOILWTICO	Crude Oil Prices: West Texas Intermediate (WTI) - Cushing	5	1
141	PPIACO	Producer Price Index: All Commodities	5	1
142	PPIFGS	Producer Price Index: Finished Goods	5	1
143	PPIFCG	Producer Price Index: Finished Consumer Goods	5	1
144	PPIITM	Producer Price Index: Intermediate Materials: Supplies & Components	5	1
145	PPICRM	Producer Price Index: Crude Materials for Further Processing	5	1
146	PPIFCF	Producer Price Index: Finished Consumer Foods	5	1
147	PPICPE	Producer Price Index: Finished Goods: Capital Equipment	5	1
148	PPIENG	Producer Price Index: Fuels & Related Products & Power	5	1
149	PPIIDC	Producer Price Index: Industrial Commodities	5	1
150	NAPMPRI	ISM Manufacturing: Prices Index	1	1
151	CPIHOSSL	Consumer Price Index for All Urban Consumers: Housing	5	1
	Average Hourly Earnings			
152	HCOMPBS	Business Sector: Compensation Per Hour	5	1
153	HOABS	Business Sector: Hours of All Persons	5	1
154	RCPHBS	Business Sector: Real Compensation Per Hour	5	1
155	COMPNFB	Nonfarm Business Sector: Compensation Per Hour	5	1
156	HOANBS	Nonfarm Business Sector: Hours of All Persons	5	1

	Mnemonic	Description	T code	Slow Code
157	COMPRNFB	Nonfarm Business Sector: Real Compensation Per Hour	5	1
158	ALWASPQ027S	All sectors; wages and salaries paid (IMA)	5	1
159	AHECONS	Average Hourly Earnings Of Production: Construction	5	1
160	AHEMAN	Average Hourly Earnings Of Production: Manufacturing	5	1
161	AHETPI	Average Hourly Earnings of Production: Total Private	5	1
162	AWOTMAN	Average Weekly Overtime Hours of Production: Manufacturing	5	1
163	AWHMAN	Average Weekly Hours of Production : Manufacturing	5	1
164	RCPHBS	Business Sector: Real Compensation Per Hour	5	1
	Fiscal Stance			
165	TGDEF	Net Government Saving	1	1
166	SLINV	State & Local Government Gross Investment	5	1
167	SLEXPND	State & Local Government Current Expenditures	5	1
168	GGSAVE	Gross Government Saving	5	1
169	DGI	Federal Government: Real National Defence Gross Investment	1	1
170	NDGI	Federal Nondefense Gross Investment	5	1
171	FGSL	Federal government current transfer payments	5	1
172	FGCE	Federal Consumption Expenditures & Gross Investment	5	1
173	ASTIWPQ027S	All sectors; current taxes on income, wealth, etc. received (IMA)	5	1
174	A823RS2Q224EA	Government - consumption expenditures and gross investment: Federal	1	1
175	A824RS2Q224EA	Government-consumption expenditures and gross investment: National defence	1	1
176	A991RS2Q224EA	Government-consumption expenditures State and local	1	1
177	FGEXPND	Federal Government: Current Expenditures	5	1
178	A091RC1Q027EA	Federal government current expenditures: Interest payments	5	1
179	W068RCQ027SA	Government total expenditures	5	1
180	W070RC1Q027EA	State and local government current tax receipts	5	1
181	W077RC1Q027EA	State and local government total receipts	5	1
182	A997RC1Q027EA	Government consumption expenditures: Federal: National defence	5	1
183	A542RC1Q027EA	Government consumption expenditures: Federal: Nondefense	5	1
184	W101RC1Q027EA	Government consumption expenditures: Gross output of general government	5	1
185	GRECPT	Government Current Receipts	5	1
186	GEXPND	Government Current Expenditures	5	1
187	W054RC1Q027EA	Government current tax receipts	5	1
188	A084RC1Q027EA	Government current transfer payments	5	1
189	W060RC1Q027EA	Government current transfer receipts	5	1
190	B223RC1	Government unemployment insurance benefits	5	1
191	GFDEGDQ188S	Federal Debt: Total Public Debt as Percent of Gross Domestic Product	1	1
192	W019RCQ027SBEA	Federal government total expenditures	5	1
193	W018RC1Q027SBEA	Federal government total receipts	5	1
194	GDFICITS	Deficit based on total receipts and expenditures	5	1
	Miscellaneous			
195	HHSNTN	University. OF MICH. INDEX OF CONSUMER EXPECTATIONS(BCD-83)	1	1

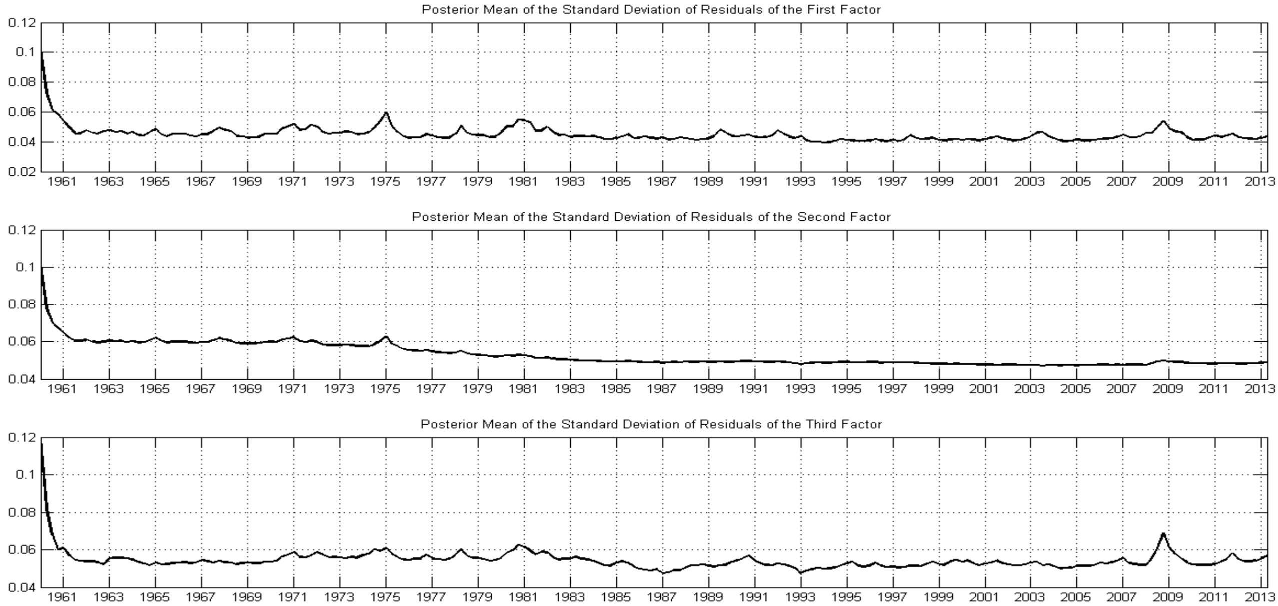
Appendix 3.B: Figures

Figure 3.B.1. US Macroeconomic Policy Regimes Probabilities



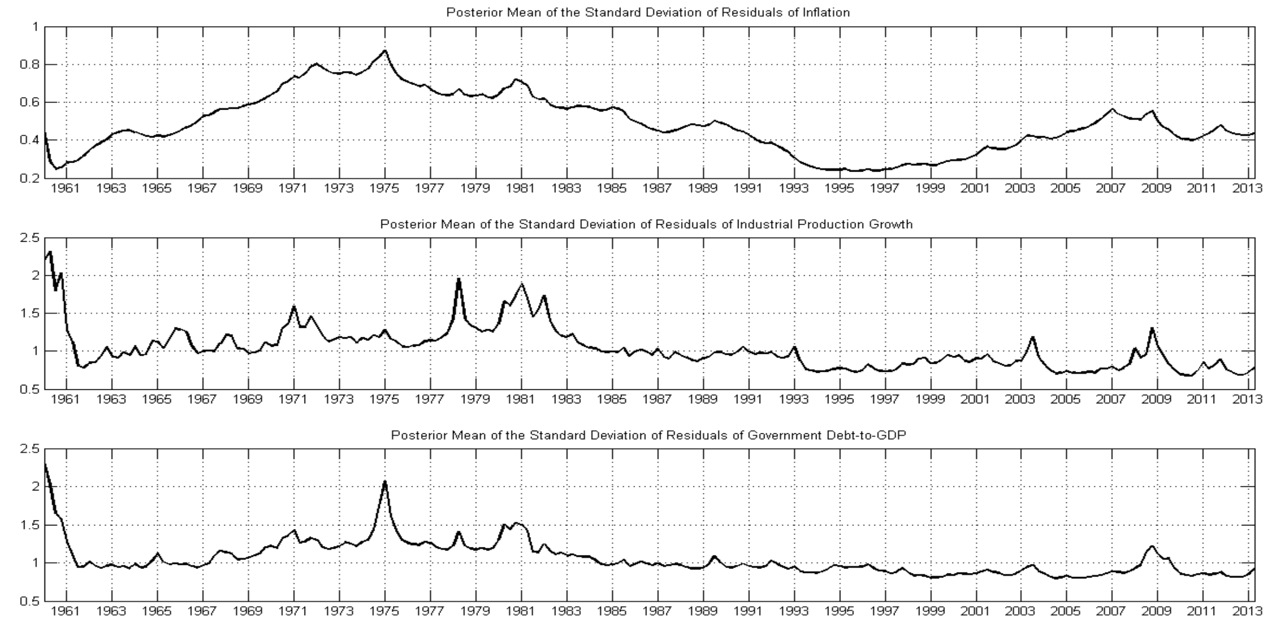
Note: This Figure illustrates different macroeconomic policy regimes estimated within a Markov-Switching model. The Figure is adopted from Davig and Leeper (2011).

Figure 3.B.2. Posterior Mean of the SD of Residuals of the Factors in the TVP-FAVAR



Note: Figure presents the Time-Varying Standard Deviations (SD) of errors within the TVP-FAVAR model with three unobserved factors over the sample 1959Q1-2013Q2. The FAVAR part of the model is estimated using the Two-Step Principal Components method based on Bernanke et al. (2005) identification approach.

Figure 3.B.3. Posterior Mean of the SD of Residuals of the Observable Variables within the TVP-FAVAR



Note: Figure presents the Time-Varying Standard Deviations (SD) of errors within the TVP-FAVAR model with three unobserved factors for the observable variables over the sample 1959Q1-2013Q2. The FAVAR part of the model is estimated using the Two-Step Principal Components method based on Bernanke et al. (2005) identification approach.

Chapter 4

The International Transmission of Monetary Policy in Presence of Government Debt: a GVAR Approach

Abstract

This chapter aims to contribute to the empirical literature on the international spillovers of US monetary policy, whilst accounting for fiscal policy. The main motivation of this chapter is to identify the way in which fiscal policy is able to influence the monetary transmission mechanism and generate international spillovers. Here we model fiscal policy using government debt levels. Moreover, the study addresses the extent to which an increase in US government debt can stimulate the real economy and generate spillovers to the other economies. When modelling fiscal policy in open economy context we account for potential import leakages by employing a Global Vector Autoregressive (GVAR) methodology, which captures trade linkages across countries. Thus, it more fully models fiscal policy implemented in a global context and accounts for policy spillovers. The Generalized Impulse Response Functions (GIRF) indicates that accounting for fiscal policy influences the impact of a monetary contraction. Given the high level of US government debt, this finding seems to be reasonable, as any changes in interest rates can change the interest expenses share of government expenditure significantly. Furthermore, the response to an expansionary fiscal policy supports the non-Ricardian view on fiscal policy within US economy that is it increases both inflation and output. This fiscal policy shock also appears to generate expansionary spillover effects on other economies. Moreover, according to the estimated Likelihood Ratio (LR) to examine the potential contribution of US government debt to long-run macroeconomic relations within the GVAR, evidence suggests that the unrestricted Fisher equation, the Term Premium, and the Uncovered Interest rate Parities (UIP) condition can be maintained for the US and other economies. Finally, the results of Persistence Profiles (PP) proposed by Pesaran and Shin (1996) suggest that government debt induces a decrease in the convergence rate to equilibrium following the policy shocks compared with alternative model specifications.

Key Words: Monetary and Fiscal Policy, International Spillovers, Government Debt, Global VAR, Generalized Impulse Response Functions, Long-Run Macroeconomic Relations

JEL classification Code: E470, H690, C510, C520, C530

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4.1 Introduction

Over the three past decades, monetary policy has received much attention as the key macroeconomic instrument. This is partly due to the small lags between its announcement, implementation, and feedback, but also due to as monetary policy focuses upon nominal variables like inflation, see Walsh (2011) and Romer (2011). In contrast, fiscal policy, which takes some time to reach its policy goal, has been deemed less efficient to affect aggregate demand. Much research has argued that fiscal policy tends to be less effective in an open economy context given import leakages. However, the prolonged and widespread recent financial crisis shows the limitation of monetary policy and a reconsideration of fiscal policy as an effective policy instrument.

The 2008 financial crisis triggered a sharp global contraction in real economic activity due partly to cross-country linkages. Many advanced economies have undertaken a range of monetary policy interventions and fiscal stimulus to counter the crisis, see Fawley and Neely (2013). The impact of these policy interventions varied among countries necessitating the reconsideration of the effectiveness of fiscal policy especially in the presence of cross-country linkages, see Blanchard et al. (2010), and Bussiere et al. (2013).

Most macroeconomists agree that a rise in the short-term interest rates induces a fall in inflation and output. While there is a widespread agreement on the effect of monetary policy, there are both theoretical and empirical-motivated disputes on the implications of fiscal policy. As noted in Chapter 2, the Ricardian interpretation of fiscal policy suggests that a fiscal expansion is impotent to stimulate aggregate demand because it indicates higher expected taxes. In contrast, the non-Ricardian view implies that this shock would increase both prices and output due to its impact on private expenditure, see Christiano and Fitzgerald (2000) for a detailed discussion. There is empirical evidence that supports both these arguments depending on the identification of fiscal policy shocks implemented and the degree of macroeconomic policy coordination. For example, Blanchard and Perotti (2002), and Fatas and Mihov (2006) find evidence to support that a positive shock to government spending induces real wages to increase which encourages private expenditure. This, in turns, would lead to an increase in aggregate demand, prices, and output. In the opposite side, Romer and Romer (1989) find evidence for a Ricardian view: a fall in the real wages and private consumption following an increase in defence expenditure in the US economy. These discrepancies mainly arises because of the different assumption on the response of taxation to the incurred government expenditure, see Canzoneri et al. (2011).[1]

Another challenge is that the Zero Lower Bound (ZLB) constraint makes Conventional Monetary Policy (CMP) less effective. The standard Keynesian resolution at the ZLB is to use fiscal policy to increase government expenditure or cut taxes in order to stimulate the economy. This policy approach can be powerful in a liquidity trap. Yet, the outcome depends on the expectation formation and most importantly, the magnitude of the policy-generated expansionary effect, see Correia et al. (2013).

Note that, the implication of liquidity trap for monetary policy may account for the role of policy commitment by the monetary authority such as keeping the interest rate near to zero for a specific period, see Krugman (1998), Enggertsson and Woodford (2004), Auerbach and Obstfeld (2005), and Farhi and Werning (2012). This policy commitment is expected to increase output and inflation in both the present and the future. However, if the real interest rates ought to be negative to stimulate the economy, the only way to attain this policy target is to generate inflation. This can be achieved by a joint and flexible fiscal and monetary policy that mitigates the ZLB constraint on nominal interest rates, see Eggertsson (2010), Christiano and Ikeda (2011), Woodford (2011), and Correia et al. (2013).

Given the important role of fiscal policy at the ZLB, however, in an open economy framework with trade linkages, it can be argued that domestic fiscal policy would create

[1] Note that as Perotti (2007) explains, fiscal policy outcome also depends upon whether government expenses include defence expenditure or not.

international spillovers and reduces the impact at home, see Auerbach and Gorodnichenko (2013). This accounts for conducting the empirical investigation of policy impact in a global framework to capture both domestic and foreign outcomes rather than solely relying on domestic implication. A global perspective can take account of global co-movements among variables and the potential connections between domestic variables and their foreign counterparts, see Ciccarelli and Mojon (2010), and Hartmann and Roestel (2013).

We identify a gap in the literature on the potential contribution of fiscal policy on the monetary transmission mechanism, in both the domestic and international levels. Thus, this Chapter aims to investigate the implication of US government debt for the monetary transmission mechanism at both the national and international level. It also attempts to address the extent to which a fiscal expansion can stimulate the economy and its ability to generate expansionary spillovers to other economies. Having considered our motivation, the construction of our benchmark model consists both domestic and cross-country relations. For this reason, this Chapter employs the Global Vector Autoregressive (GVAR) method. As Chapter 2 notes, this modelling framework is structured to facilitate cross-country analysis and explain the potential global co-movement among macro and finance variables, see Pesaran et al. (2004), Dees et al. (2007), and di Mauro and Pesaran (2013). Our motivation is to address the potential international spillovers of monetary and fiscal policy. In particular, our central contribution in this chapter is to examine the way in which the monetary transmission mechanism is influenced by a country's fiscal stance in a global framework. The GVAR methodology is ideally suited to conduct our research as it allows policy analysis, testing for long-run macro and finance relationships, and investigating the spillover effect of policy shocks. For example see, Dees et al. (2007), Bagliano and Morana, (2009), Dees and Saint-Guilhem (2007), Poirson and Weber (2011), and Nickel and Vansteenkiste (2013).[2]

[2] For a comprehensive survey of the literature on the GVAR methodology and application see di Mauro and Pesaran (2013).

For this purpose, two GVAR models have been constructed, namely the simple and the fiscal-augmented GVAR model specifications. Whilst the fiscal-augmented GVAR model includes the government debt to capture the potential impact of fiscal policy on the monetary transmission mechanism, the simple model excludes fiscal policy. We argue that although the short-term interest rate is a key policy transmission channel for both fiscal and monetary policy, however, our results suggests that an increase in government debt can counteract the policy targets. Furthermore, impulse responses indicate fiscal policy is the non-Ricardian: an increase in the government debt-to-GDP ratio can significantly stimulate the economy. This contrasts with Reinhart and Rogoff (2010). Fiscal policy also generates international spillovers to other economies. Finally, government debt appears to induce long-run macroeconomic relations to converge to equilibrium slowly.

To our knowledge, there exists limited empirical literature on the international spillovers of monetary and fiscal policy interactions.[3] We contribute to the related empirical literature in a number of ways. First, we find that real output and long-run interest rates are highly correlated across economies, whilst taking into account the government debt does not change the correlation. Second, we show that both prices and output increases in response to a monetary contraction within both the simple and the fiscal-augmented models. However, US government debt can influence the duration of responses to monetary policy shock. Given the high level of US public debt, this finding seems to be plausible as any changes in interest rates can significantly change the interest expenses share of government expenditure. Third, the impulse responses of an expansionary fiscal policy support the non-Ricardian view within the US economy. Fourth, we find that there is significant international spillovers generated by monetary and fiscal policy. Fifth, the results of Persistence Profiles (PP) test suggest that government debt

[3] As an instance, Nickel and Vansteenkiste (2013) employ the GVAR method to study the international spillovers of fiscal shocks on the both macro and financial variables including real GDP, inflation, equity prices, government and corporate bonds.

reduces the convergence rate to equilibrium following the policy shocks compared with ignoring the impact of fiscal policy.

The organization of the chapter is as follows. Section 4.2 provides a review of the related literature. Methodology issues are discussed in section 4.3. Section 4.4 presents model specification and empirical results. Dynamic analysis of the model is discussed in section 4.5. Long-run macroeconomic relations together with their Persistence Profiles results are examined in section 4.6. Section 4.7 concludes the study.

Table 4.1. Key Literature on the Domestic and International Spillovers of Macroeconomic policy

Study	Methodology	Motivation	Main Contribution
Dees, di Mauro, Pesaran, and Smith (2007)	GVAR	Developing the GVAR methodology for the analysis of global interdependencies	Equity and bond markets are more synchronous as compared to real output and inflation. In addition, a US monetary contractionary policy has limited and statistically insignificant spillover effects.
Mountford and Uhlig (2009)	Sign restrictions on the VAR Model	Quantifying the effect of a tax cut policy on the economy and whether it's source of finance matter	Comparing the IRFs from three different policy scenarios of deficit spending, deficit-financed tax cuts, and a balanced budget spending expansion, it appears that deficit-financed tax-cuts is more effective to stimulate the economy.
Ramey (2011)	the VAR and Ramey-Shapiro narrative approach	Investigating the differences between anticipated and unanticipated tax changes	The narrative approach shocks capture the timing of the news about future fiscal expansion better than VAR methods. In addition, given that the VAR approach captures the shocks too late, it misses the initial decline in consumption and real wages that occurs as soon as the news is learned. The results show that delaying the timing on the Ramey-Shapiro dates replicates the VAR results.
Corsetti and Muller (2012)	the VAR and standard Business Cycle model	Revising the potential rule of fiscal by providing new evidence on the cross-border effects of discretionary fiscal measures	Significant cross border macroeconomic effects of US fiscal policy on economic activity in the UK and the Euro Area.
Nickel and Vansteenkiste (2013)	GVAR	Examining the international spillovers of fiscal policy on the financial variables within the Euro Area	There is a strong financial market inter-linkages between corporate and the government sectors. In addition, the fiscal policy of the large risk-free government bonds issuing countries matters not only for the countries themselves but also at international level.
Dees, Holly, Pesaran, and Smith (2007)	Long-run macroeconomic relations within the GVAR model	Testing for the validity and reasonableness of the long-run macroeconomic relations	While the UIP conditions and the Fisher equation cannot be rejected, evidence has not been found to validate absolute purchasing power parity.

Note: This Table summarizes the related literature that the chapter is constructed upon it. GVAR stands for Global VAR.

4.2 Review of Literature

Over the three past decades, the main stream in monetary policy studies has not considered the effect of fiscal policy. Some studies provided evidence that fiscal policy is not as competent as monetary policy to stimulate the economy, see Barro (1983), Evans (1985,1987), and Plosser (1987). However, the zero lower bound for nominal interest rates led to a reconsideration of fiscal and monetary policy, as clearly monetary policy is constrained.[4] While nominal interest rates are close to zero, the main question here is how- if at all- policy can increase aggregate demand. Among various ways to stimulate the economy, one practical solution is to implement an expansionary fiscal policy to raise the level of current inflation and hence decrease the real interest rate, see Bodenstein et al. (2009), Devereux (2010), Eggertsson (2010), Ramey (2011), Romer (2011), Woodford (2011), and Coresetti and Muller (2012).

While there exists a consensus in the literature on the impact of monetary policy, the existing literature on the impact of fiscal policy is controversial. As discussed in Mountford and Uhlig (2009), the discrepancies among the results may depend upon different methodologies, the identification approach, and the sample period. Building up on the ZLB circumstances, some recent studies find evidence in favour of constraining monetary policy, in the form of policy commitment such as a Taylor Rule or inflation targeting, coordinated with an expansionary fiscal policy to stimulate the economy, see Woodford (2011), and Romer and Romer (2013).

In a seminal paper on monetary and fiscal policy interactions, Leeper (1991) explains how the macroeconomic impact of monetary and fiscal policy can differ depending on the assumption of which policy is constrained, or passive, while the other policy can actively respond to the shocks. As discussed in Chapter 2, there are three possible combinations of macroeconomic policy. The conventional policy outcome is achieved from an active monetary policy and a passive fiscal policy. This is referred to in the literature as the Ricardian view. In contrast, there

[4] As Cogan et al. (2010), and Woodford (2011) discuss a higher inflation expectation is required in such a circumstances to improve aggregate demand and output as in a liquidity trap insufficient demand is the major problem.

is the non-Ricardian argument, or the Fiscal Theory of the Price Level (FTPL), that holds the combination of a passive monetary policy and an active fiscal policy can produce counter intuitive results, i.e. the price puzzle. The third possible combination can be a unified monetary and fiscal policy in the form of either passive or active that generate unstable equilibrium, see Leeper (1991).

Canzoneri et al. (2002), Monacelli and Perotti (2007), Jeanne and Svensson (2007), Claeys (2008), and Eggertsson (2010) find that a debt-financed fiscal expansion coupled with a Taylor-type Rule monetary policy can lead to an increase in the interest rates.[5] It can be explained as a higher expected inflation and output gap may account for a higher interest rate. This in turns can stimulate the economy. As discussed in Eggertsson (2010), and Jeanne and Svensson (2007) when the Central Bank commit to a higher future prices by a currency depreciation, this can cause a negative capital level at the Central Bank's balance sheet that may requires borrowing from government. To avoid or control the amount of borrowing, the Central Bank would not allow its capital to fall below a certain amount. This minimum capital level provide a lower bound on the future exchange rate. To reach this minimum capital level, consistent with the desired higher future prices, the Central Bank may commit itself to a depreciation of the exchange rate.

However, there is the possibility that even an expansionary fiscal policy satisfies Ricardian equivalence and fails to change private expenditure and aggregate demand, see Barro (1979), Evans (1985-1987), Plosser (1987), and Canzoneri et al. (2011).[6] As discussed in Chapter 2, while the Keynesian view, argues that fiscal policy is an effective tool in influencing the real economy, the Ricardian view focuses on the limitation of fiscal policy, see Christiano and Fitzgerald (2000), Wickens (2008), and Romer (2011).

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[5] By constraining a fiscal expansion with a monetary commitment in the form of Taylor-Rule, the interest rate is determined based on inflation and output gap, see Taylor (1993).

[6] Bernheim (1987) provides a critical survey of the empirical literature supporting the Ricardian view on fiscal policy.

We also explain in Chapter 2 that the interest rate is the key policy transmission channel to achieve both fiscal and monetary policy goals. While standard macro theories suggest government spending and interest rates are positively correlated, in practice their relationship depends on the extent to which a change in fiscal policy would affect inflation, wealth, and private consumption, see Barro (1983), and Plosser (1987). Thus, if government spending could produce a long-lived inflation, then private consumption, interest rates, and output would increase. Otherwise, their path would remain unchanged or even would be negatively affected, see Evans (1985), Favero and Giavazzi (2007), Corsetti and Kuester (2011), and Farhi and Werning (2012).

Evans (1985,1987) concludes that the correlation between the interest rate and US government deficits is not statistically significant, providing empirical support for Ricardian equivalence.[7] According to his study, a number of factors can clarify these finding such as the Federal Reserve stabilization policy, the small size of the deficit over the sample, determination of both the deficit and the stock of money as exogenous variables, a low level of inflation expectations, capital inflows from abroad, and the existing political conflict.[8] More specifically, Evans (1985) explains that during the Second World War the Federal Reserve pegged interest rates to the Treasury securities to ensure low and stable interest rates. Thus, interest rate were unable to change in response to an increase in the government budget deficit. Similar studies for the US economy in the 1980s find little or no connection between government deficit and the interest rates, see Barro (1983), Feldstein (1985), Plosser (1987), and Ramey and Shapiro (1999) among others.

From an opposite perspective, there is empirical evidence suggesting that an expansionary fiscal policy may induce the interest rates to increase dependent upon the treatment of debt

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[7] Evans (1985) estimates both restricted and unrestricted reduced forms for the interest rate in the US and five large industrial economies. He applied a standard IS-LM framework including government expenditure, the expected inflation rate, and the real money supply variables to determine the nominal interest rate.

[8] As Wickens (2008) discusses, within an IS-LM framework, the amount of government's deficits and its financing source are the two key factors which affect the interest rate.

policy, see Reinhart and Sack (2000), Canzoneri et al. (2002), Laubach and Williams (2003), Dai and Philippon (2005), and Mountford and Uhlig (2009). For example, Dai and Philippon (2005) find evidence that a positive shock to the deficit-to-GDP ratio by one percent leads to 40-50 basis points increase in the long-term interest rates. In addition, their finding suggests that the fiscal shock, identified by a Cholesky approach, affects long-rates through expectations of future spot rates as well as risk premia.

Note that the impact of a given fiscal shock on interest rates would differ in the presence of public debt compared to otherwise, as including debt feedback in the model is associated with a larger response of interest rates, inflation, and output, see Favero and Giavazzi (2007). They argue that a rise in the stock of debt would increase future monetization or, in the extreme case, a debt default.

In addition to the potential role of public debt in changing the outcome of fiscal policy, fiscal policy can also be potent during a liquidity trap. For example, Farhi and Werning (2012), within a currency union, show that government expenditure multiplier for output is greater than one. The mechanism for their result is that government spending can stimulate inflation. With fixed nominal interest rates, this reduces real interest rates, which encourages current spending. The increase in consumption in turn leads to more inflation, creating a feedback loop. Their results suggest that the fiscal multipliers increase as the degree of price flexibility increases, which is intuitive given that the mechanism relies on the response of inflation.

In another study, Mountford and Uhlig (2009) within a sign restrictions on VAR model show that a monetary contraction can produce a counter-intuitive responses as GDP and consumption both increase, in response to a rise in short-term interest rates. To explain the outcome of fiscal policy, they present IRFs evidence from three different policy scenarios of deficit spending, deficit-financed tax cuts, and a balanced budget spending expansion. Their results suggest that a deficit-financed tax-cut succeeded more among the other alternatives to stimulate the economy through an increase in output.[9]

So far, we researched the literature on the different impact of fiscal policy on the economy, and the way that it can be influenced by the public debt. Now turning our focus from the domestic impact of fiscal policy to its potential international spillovers, it is worth investigating how fiscal and monetary policy interactions may influence the real economy in a global framework. Before globalization of the world economy, it was widely believed that fiscal expansion would increase the nominal interest rate and crowd out the effects of increased government expenditure. However, in an open economy, the Treasury has access to both domestic and foreign financial markets to finance its expenditures. Thus, with a perfect capital flows assumption, the traditional Keynesian crowding-out effect of a fiscal expansion is hard to maintain for two reasons.[10] First, perfect capital flows can decrease the crowding out effect of an expansionary fiscal policy. Second, given that the interest rates are determined at the global level, it does not seem certain that a fiscal expansion will lead to an increase in the interest rates, see Claeys et al. (2008).

Under a high degree of capital mobility, and when the fiscal deficit of a country is small relative to the world saving rate and to a mobile stock of capital, then an expansionary fiscal policy would not increase the interest rates. However, if the fiscal deficit were large by global standards, then an increase in the real interest rate would be necessary to induce the capital inflow. Conversely, rising interest rates abroad might push interest rates up, regardless of the domestic fiscal position, see Brook (2003).[11]

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[9] They applied their VAR model to US quarterly data from 1955 to 2000. Their VAR constructed on 10 variables includes GDP, private consumption, total government revenue, real wages, private non-residential investment, interest rate, adjusted reserves, the producer price index, and the GDP deflator together with the fiscal policy instrument.

[10] Note that there may be an exchange rate effect which crowds out the export sector as an increase in government spending would lead to incipient pressure upwards upon yields and capital inflow.

[11] As noted in Brook (2003) the most important factors that contribute to a fall in interest rates include business cycles, the amount of capital stock in the country, the degree of capital market integration, domestic saving and consumption rate, expectations concerning future of the economy, and the possibility of a continuing fall in the short-term rates by Central Banks.

The literature on fiscal policy multipliers in an open economy context suggests that they can be negatively correlated with the degree of openness of the economy due to import leakages as fiscal multipliers for more open and trade-dependent economies appears to be smaller, see Beetsma et al. (2006), and Cuaresma et al. (2011).

In addition to the potential role of openness on the degree by which a fiscal policy may change the interest rates, public debt also account for the magnitude of policy's international spillovers. For example, Blanchard and Perotti (2002), Canzoneri et al. (2002), Caldara and Kamps (2008), Favaro et al. (2011), and Lagana and Sgro (2011) find evidence that US government expenditure shocks generates significant international spillovers during last four decades. Corsetti and Muller (2012) within a VAR model examine the domestic effects of US government spending shock and its international spillovers to the Euro Area and the UK. They focus on the cross-border effects of a US spending expansion on economic activity in the Euro Area and UK, as well as on the US bilateral trade with these economies.[12] Their results suggest that unexpected fiscal expansions have a large impact on economic activity in the UK and Euro Area.

In another study for the Euro Area, Chin and Frankel (2003) show that the regional public debt in the Euro Area has a negative effect on the interest rate while for a country basis in the area this relations turns to be positive. Cuaresma et al. (2011) report that a fiscal policy shock implemented in Germany generate spillovers within the Euro Area.[13] Auerbach and Gorodnichenko (2013) also provide evidence that fiscal policy impacts not only the domestic economy but also generates international spillovers through the trade channel.[14]

[12] Corsetti and Muller (2012) estimate a VAR model on quarterly time series for the period 1980:Q1–2007:Q4, which do not consider the crisis period. Their VAR model includes four US time-series: government spending and output, long-term real interest rates, and public debt.
[13] Their analysis covers the Czech Republic, Hungary, Poland, Slovakia and Slovenia.
[14] In a study for OECD countries, Auerbach and Gorodnichenko (2013) find evidence of fiscal spillovers on output. Their approach for linking economies is similar to ours as policy shocks transmitted through the trade between countries. Their finding suggests that the spillover effects vary over the business cycles which have been observed to be high in recessions and modest in expansions. Also, the magnitude of spillovers highly depends on (i) the size and the state of both the source of fiscal shocks and the recipient countries, and (ii) the number of trade partners which reversely affects the spillovers.

Further to international macroeconomic spillovers, fiscal policy shocks may also be transmitted through financial variables. For example, Nickel and Vansteenkiste (2013) within a GVAR model show that fiscal shocks have significant international spillovers on financial variables.[15] Particularly, they report that a shock to government consumption results in an increase in equity prices and government bonds yield domestically and internationally. They also find that a shock to government bond yields originated in a large country can produce spillovers to the domestic and international corporate bond markets.

Finally, as regards the international macroeconomic impact of monetary policy, the literature suggests that the outcome of a monetary contraction can be counterintuitive. For example, Dees et al. (2007), within a GVAR model constructed upon monetary variables, study the international spillovers of a US monetary contraction and find that output and inflation increase in response to the policy shock, which is a counter-intuitive result.[16] Their results also show that the effect of a change in US monetary policy to the Euro Area is limited and statistically insignificant.

So far, we discuss the literature on the macroeconomic impact of fiscal policy. Our discussion concerns the non-Ricardian view on fiscal policy and the literature on both the domestic and international impact of fiscal policy. Before proceeding to the empirical analysis, it is useful to overview US macroeconomic policy indicators as is described in the next section.

Stylised Facts

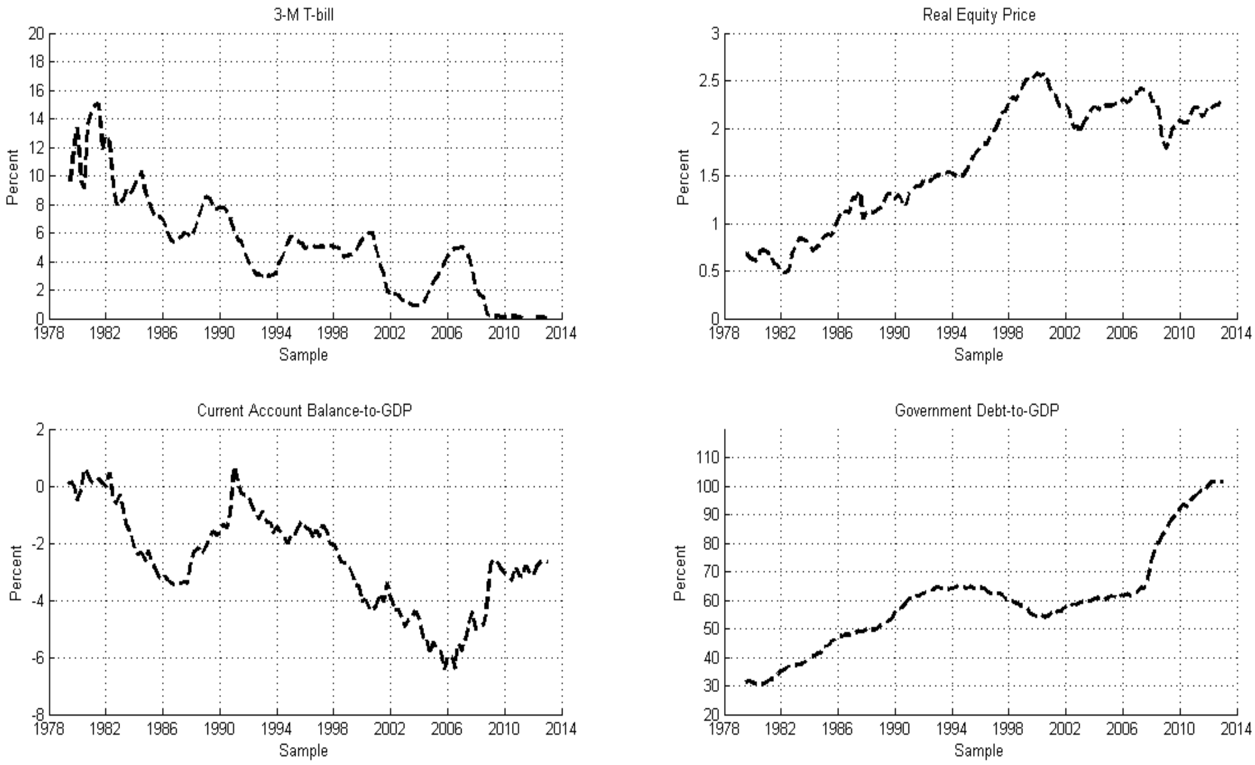
Figure 4.1 demonstrates key policy indicators of the US economy. As can be seen, the nominal short-term interest rate has significantly declined over the sample while the government debt ratio has been almost doubled. At the same time, we can see a rise in real equity prices while US current account as a share of GDP falls suggesting that during this period, imports exceeded

[15] They estimate a GVAR model on quarterly time series for the period 1980:Q1–2008:Q4 for eight countries including France, Germany, Italy, Japan, Spain, Sweden, the UK, and the US. Their constructed GVAR model includes six variables: fiscal spending, real GDP, inflation, equity prices, government bond yield, and the corporate bond yield.

[16] Their GVAR model is estimated for 26 countries over the period 1979-2003 consists of seven variables: real output, inflation, real exchange rate, real equity prices, short-term interest rate, long-term interest rate, and the price of oil.

exports. The observation suggests that there may be a positive correlation between the government debt and the current account as an increase in the public debt has been led to a higher current account deficit. This is consistent with the twin-deficit hypothesis that suggests wider fiscal deficits should usually be accompanied by wider current account deficits provided that the relationship between fiscal deficits and private consumption is positive, see Nickel and Vansteenkiste (2008).[17]

Figure 4.1. US Macroeconomic Policy Indicators



Notes: This Figure demonstrates the dynamic of short-term interest rate, real equity prices, current account balance as a share of GDP, and government debt-to-GDP ratio, using quarterly time series for the period 1979:Q2-2013:Q1 for the US. See Appendix 4.B for a detailed description of the data series.

As Chapter 2 notes, the relationship between the current account and fiscal policy changes depends upon whether consumers make their expenditure decisions in a Ricardian or non-Ricardian manner. If the debt ratio is high and the fiscal situation becomes increasingly unsustainable, then agents anticipate a tax increase. Given this expectation, consumers have an incentive to save more. In this case, a fiscal stimulus can be offset by higher private savings. Thus, under the Ricardian case, a high debt level would be associated with a stable or even

[17] This is also in line with the Keynesian view that higher fiscal deficits can encourage private consumption.

negative relationship between the fiscal deficit and the current account deficit. However, under a sustainable public debt ratio, consumers would react in a non-Ricardian manner, thus, the relationship between the current account deficit and the fiscal deficit should be positive.[18] Note that a debt-financed fiscal expansion requires an increase in either saving or the current account deficit to satisfy the equilibrium condition, see Elmendorf and Mankiw (1999).[19,20]

4.3 Structure of the Global VAR Model

The Global Vector Autoregressive (GVAR) framework is a useful econometric tool in modelling global connections. It is particularly suited to the analysis of the transmission of the shocks among the world economies. As noted in Chapter 2, the GVAR model links core domestic variables to their foreign counterparts together with globally observed variables. As detailed in Pesaran et al. (2004), and Dees et al. (2007), the construction of a GVAR model consists of the following four stages.

1. Estimating individual country/region-specific $VARX$ models,
2. Constructing a weighting matrix to link domestic variables with their foreign counterparts that also allows for the international transmission of policy innovations,
3. Linking all the estimated $VARX$ through the computed weighting matrix,
4. Solving the $GVAR$ system simultaneously.

Where $VARX(1,1)$ is denoted by $X_{it} = \Phi_i X_{i,t-1} + \Lambda_{i0} X_{it}^{*} + \Lambda_{i1} X_{i,t-1}^{*} + u_{it}$.

[18] Nickel and Vansteenkiste (2008) report three thresholds for the government debt-to-GDP ratio: low debt and medium debt countries, with a debt level of 44% of GDP, the relationship is positive, i.e. an increase in the fiscal deficit leads to a higher current account deficit, in line with the non-Ricardian view. In medium-to-high debt countries, with debt ratios between 44% and 90% of GDP, the relationship is still positive but much less so. In the very high debt countries, with debt ratios of above 90% of GDP, the relationship is negative and insignificant, suggesting that a rise in the fiscal deficit does not result in a rise in the current account deficit. Implicitly this result suggests that private consumers have become Ricardian offsetting the increase in the fiscal deficit by a fall in private consumption.

[19] The effect of government debt can be explained more clear through National Account identities. We know that at equilibrium the sum of private and public saving must be equal to the sum of investment and net exports as follows: $S+(T-G)=I+NX$. Now under a debt-financed fiscal expansion, the left side of the equation represent a budget deficit and a decrease in public saving. The equilibrium can be satisfied in three ways: (i) private saving may rise, (ii) domestic investment may fall, or (iii) net export may decline. The conventional view holds that this policy would induced private saving to increase. In contrast, the non-Ricardian view states that this policy would cause a fall in net exports that constitutes an increase in the trade deficit as the policy would encourage private expenditure rather than private saving, see Elmendorf and Mankiw (1999).

[20] One example for the positive connection between the budget deficit and the trade deficit is the Twin Deficit in the US during the 1980s.

Given the specified procedure, to estimate the $VARX$ model, suppose that there are $N+1$ countries/regions in the global economy; each one is indexed by $i=0,\ 1,\ 2,\ldots,N$ where $i=0$ represents the reference country.[21] Let X_{it} be a $K_i \times 1$ country-specific vector of domestic variables/factors and X_{it}^* be a $K_i^* \times 1$ vector of foreign variables specific to country i, where K_i and K_i^* denote the number of domestic and foreign variables for country i respectively. In the GVAR literature, the main assumption is the weak exogeneity of foreign variables. By definition, the foreign variable, X_{it}^*, is weakly exogenous to the domestic variable, X_{it}, if there is no long-run feedback from X_{it}^* to X_{it}, see Pesaran et al. (2004), and Dees et al. (2007). This property allows that foreign variables in $VARX$ models to stand as global factors.[22]

Thus, each individual $VARX\,(1,1)$ is written in the form of Equation (4.1) as follows.

$$X_{it} = a_{i0} + a_{i1t} + \Phi_i X_{i,t-1} + \Lambda_{i0} X_{it}^* + \Lambda_{i1} X_{i,t-1}^* + \varepsilon_{it} \tag{4.1}$$

Where $t=0,\ 1,\ 2,\ldots,T$, $i=0,\ 1,\ 2,\ldots,N$, a_{i0} and a_{i1t} are the coefficients of the deterministic, $\Phi_i = K_i \times K_i$ is a matrix of lagged coefficients, Λ_{i0} and Λ_{i1} are a $K_i \times K_i^*$ matrix of coefficients associated with the foreign specific variables, $\varepsilon_{it} = K_i \times 1$ is a vector of idiosyncratic country-specific shocks in which all shocks are assumed to be normally distributed as $\varepsilon_{it} \sim iid\ (0,\sigma^2)$. It is worth noting that we do not require all $VARX$ models to include the same variables for all countries. It is possible to consider zero weights for any missing variables in the country i^{th} within the $VARX$ model, see Pesaran et al. (2004).[23]

The next step is the construction of a weighting matrix to relate domestic and foreign variables together and identify potential spillovers across countries. The selection of the weighting matrix is an important matter. Given the integrated financial markets, one choice for

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[21] The Numeraire country is the country whose currency is set as the reference currency.

[22] Note that all the country-specific variables/observed factors are treated endogenously, while their foreign counterparts are treated as weakly exogenous. A detailed discussion can be found in Dees et al. (2007).

[23] As concerns our study, there are no datasets available for long-term interest rates and real equity prices variables for China. Thus, as in Dees et al. (2007) these two variables have been excluded from China's model.

linking countries together can be finance variables such as the interest rates, the exchange rates, and the equity prices to perform as the transmission channels for policy intervention. Alternatively, bilateral trade between countries can account for international spillovers since in an open economy framework, both the interest rates and the exchange rate, per se, are influenced by the trade stance, see Chudik and Fratzscher (2011).

The existing literature on the cross-countries linking channels identifies the bilateral trade between countries as one of the most significant determinants of cross-countries linkages, see Forbes and Chinn (2004), Pesaran et al. (2004), Baxter and Kouparitsas (2006), and Dees et al. (2007). Moreover, some studies find evidence of a direct link between bilateral trade and the business cycles co-movements in the way that a stronger trade relationship is associated with more similar business cycle patterns, see Pesaran et al. (2004), Dees et al. (2007), and Kappler (2009). We follow Pesaran et al. (2004), and Dees et al. (2007) to adopt bilateral trade as the international transmission channel for policy shocks.

Given bilateral trade as the weighting approach, accordingly, all domestic and foreign variables are connected via the constructed bilateral trade matrix, which allows for the world-interdependencies across countries. Let w_{ij} denotes the trade matrix between countries i, j. For each *VARX*, the vector X_{it}^{*}, which includes foreign-specific variables, can be written as follows.

$$X_{it}^{*} = \sum_{j=0}^{N} w_{ij} x_{jt}, \quad w_{ii} = 0 \quad and \quad \sum_{j=0}^{N} W_{ij} X_{jt} = 1 \tag{4.2}$$

We also follow Pesaran et al. (2004), and Dees et al. (2007) approach to employ a fixed trade weights matrix, w_{ij}. We compute the average trade flows over a three-year basis that is constructed using the current and past two years of the cross-country flows data. As has been discussed in Dees et al. (2007) the choice of using the fixed-weights is on the basis that changes in trade weights tend to be rather gradual. Thus, the foreign-specific variables computed using both the fixed and variable trade weights are often very close.

For each country, the co-integrating relations can be written as a conditional Vector Error Correction Model (VECM) for both the endogenous and weakly exogenous variables as Equation (4.3) shows.

$$\Delta X_{it} = c_{i0} - \alpha_i \beta_i' \left[\xi_{i,t-1} - \gamma_i (t-1)\right] + \Upsilon_{i0} \Delta d_t + \Lambda_{i0} \Delta X_{it}^* + \Upsilon_{i1} \Delta d_{t-1} + \Gamma_i \Delta z_{i,t-j} + u_{it} \tag{4.3}$$

Where $z_{it} = \left(X_{it}', X_{it}^{*\prime}\right)'$, $\xi_{i,t-1} = (z_{i,t-1}', d_{t-1}')'$, the matrix $\Gamma_i = \left(-\Phi_{i2}, -\Lambda_{i2}\right)$ captures the lagged coefficients of domestic and foreign variables for country i, d_i is a vector of observed global factors, and u_{it} is residuals. In addition, α_i is a $(K_i \times r_i)$ matrix of rank r_i, β_i is a $(K_i + K_i^*) \times r_i$ matrix of rank r_i ,and r_i is the number of co-integrating relations in the system. Furthermore, following Pesaran and Smith (2006) the coefficients of the linear trend in the error correction form $(\alpha_i, \beta_i, \gamma_i)$ is restricted to avoid the possibility of the quadratic trend in X_{it}. It is possible to decompose β_i as $\beta_i = (\beta_{iX}', \beta_{iX^*}', \beta_{id}')$ and $\xi_{it} = (X_{it}', X_{it}'^*, d_t')'$. Thus, rewriting the *VECM* yields Equation (4.4).

$$\beta_i'(\xi_{it} - \gamma_{it}) = \beta_{iX}' X_{it} + \beta_{iX^*}' X_{it}^* + \beta_{id}' d_t + (\beta' \gamma_i) t \tag{4.4}$$

As can be seen in Equation (4.4), it is possible to estimate co-integrating relations both within X_{it}, and between X_{it} and X_{it}^*, as well as, across X_{it} and X_{jt} for any $i \neq j$, see Dees et al. (2007). The number of co-integrating relations can be consistently estimated for each country model by treating d_t and X_{it}^* as weakly exogenous *I (1)*.[24]

After estimating all country-specific *VARX* models, we can proceed to solving all the $\sum_{i=0}^{N} k_i$ endogenous variables of the global economy collected in the $k \times 1$ vector $X_t = (X_{0t}', X_{1t}', \ldots, X_{Nt}')'$ simultaneously using the trade-weighted matrix for linking countries

[24] Note that the weak exogeneity assumption in the co-integration literature implies there is no long-run feedback from domestic variables to foreign-specific variables without ignoring lagged short-run feedback between domestic and their foreign counterparts, see Pesaran et al. (2004), and Dees et al. (2007) for a detailed discussion.

relative to each country specific weights. Thus, we need to rewrite the vector $Z_{it} = (X'_{it}, X'^{*}_{it})'$ in the form of Equation (4.5) provided that $X^{*}_{it} = \sum_{j=0}^{N} w_{ij} x_{jt}$.

$$Z_{it} = W_i X_t \ , i = 0,\ 1,\ 2, \ldots, N \tag{4.5}$$

Note that W_i is a $(k_i + k_i^{*}) \times k$ matrix that is determined by the country-specific weights, see Dees et al. (2007). Let $p = \max\ (p_0, p_1, ..., p_N, q_0, q_1, ..., q_N)$, and L be the lag-operator, the *GVAR (P)* can be formulated as Equation (4.6):

$$G\ (L, P)\ X_t = \Phi_t \tag{4.6}$$

Where

$$G(L, p) = \begin{pmatrix} A_0(L, p)W_0 \\ A_1(L, p)W_1 \\ \vdots \\ A_N(L, p)W_N \end{pmatrix} ;\ \varphi_t = \begin{pmatrix} \varphi_{0t} \\ \varphi_{1t} \\ \vdots \\ \varphi_{Nt} \end{pmatrix} \tag{4.7}$$

And $A_i(L\ , p_i, q_i) z_{it} = [\Phi_i(L\ , p_i),\ -\Lambda_i(L\ , q_i)]$, $\varphi_{it} = a_{i0} + a_{i1t} + Y_i(L\ , q_i) d_t + u_{it}$.

In order to estimate the *GVAR (P)*, Equation (4.6) must be solved recursively. This Equation is the framework of the point estimation and Generalized Impulse Response Functions (GIRF) analysis.[25] Having introduced our methodology we now proceed to set out our empirical results.

4.4 Model Specification

Given this chapter objective that is to study the international spillovers of macroeconomic policy interventions in the presence of government debt, this section presents the results of constructed GVAR. In the next section, we discuss the dynamic properties of the model. As noted earlier, to construct a GVAR model two sets of variables must be specified: domestic, X_{it}, and their foreign counterparts, X^{*}_{it}. We estimate two core models: a simple GVAR model, which excludes fiscal

[25]A detailed procedure of constructing a GVAR model and corresponding formal proof can be found in Pesaran et al. (2004), Pesaran and Smith (2006), and Dees et al. (2007).

policy variable, and a fiscal-augmented GVAR model, which includes the government debt-to-GDP ratio to examine the way that fiscal policy may influence monetary policy in a global setting. The domestic variables consists of macro and finance variables in the form of X_{it} = [real output, y_{it}, CPI inflation, π_{it}, real exchange rate, ep_{it}, real equity price, eq_{it}, short-term interest rate, sr_{it}, long-term interest rate, lr_{it}, government debt-to-GDP ratio, gdr_{it}, oil price, p_t^{oil}, raw material price, p_t^{mat}, and metal price, p_t^{metal}]. Inflation is estimated based on $\pi_{it} = P_{it} - P_{i,t-1}$ while *CPI* index is used to estimate the real values.[26] The foreign variables are presented with similar notation distinguished by an asterisk,*, as follows.

$$X_{it}^* = [y_{it}^*, \pi_{it}^*, eq_{it}^*, sr_{it}^*, lr_{it}^*, gdr_{it}^*, p_t^{oil}, p_t^{mat}, p_t^{metal}]$$

Our choice of variables is based on the standard VAR literature on the monetary policy studies, augmented with government debt to proxy fiscal variable. We decide to focus upon government debt-to-GDP ratio in our study to show the potential influence of the fiscal stance, as the debt ratio may present government expenditure dynamic over the time. There are a number of reasons that rationalize our choice. First, government debt level reduces the problem related to separating taxes and the government expenditure effects in government budget. It also can help to avoid the co-linearity problems that are highly likely to occur when both the revenue and expenditure sides of the government budget are included in the model. Most importantly, as noted in Favero and Giavazzi (2007), and Farhi and Werning (2012) by adopting the government debt ratio, it is possible to depict the dynamics of the fiscal stance rather than mapping the current budget circumstances.

Our GVAR model involves six major industrial countries: Australia, Canada, China, Japan, the UK, the US, and the Euro Area, which contribute approximately to 80 percent of the world's,

[26] As noted before, it is not required that all the country-specific *VARX* models include the same number of variables where data is not available. In our model, due to the data limitation for long-term interest rate and the equity price in China, these two variables have been excluded from the China's model.

output.[27] Given the importance of the scale of the US economy in the world, the US is set as the reference economy with the US dollar as the reference currency. The model is estimated over the period 1979:Q2- 2013:Q1. Our main sources for the data are International Monetary Fund (IMF), the OECD Statistics, and Bloomberg database as detailed in Appendix 4.B.

Before proceeding to the empirical results, it is worth noting that the GVAR results are valid only if two conditions satisfied: (i) the parameters of the individual models are stable over time, and (ii) the country-specific foreign variables are weakly exogenous, see Dees et al. (2007). The obtained results for weak exogenity and parameter stability tests imply these two conditions are satisfied for our model.

4.4.1 Trade Weights Matrix

Our approach to construct the weighting matrix is to use bilateral trade across countries. There are a number of ways to estimate the trade shares among countries.[28] We follow Dees et al. (2007) to compute bilateral trade between countries and employ Equation (4.8) for country i as follows.

$$TW_{i,j} = \frac{X_{i,j} + M_{i,j}}{TT_i} \tag{4.8}$$

Note $TW_{i,j}$ represents bilateral trade between country i and country j, $X_{i,j}$ and $M_{i,j}$ represents export and import between these two countries, and TT_i represents the total value of foreign trade in the country i with all trade partners including country j.

Table 4.2 presents the trade shares for each country. The neighbouring effects can be traced for the bilateral trade among countries. The US, the Euro Area, and Japan are the main trade partners of China, in order. The Euro Area shares bilateral trade of around 34 percent with the UK, around 30 percent with the US, and 20 percent with China. The Euro Area is the main trade

[27] The Euro Area countries include Austria, Belgium, Finland, France, Germany, Italy, Netherland, and Spain. The rationale for excluding some countries from the Euro Area is similar to that of Dees et al. (2007) justifying that building up a model as a benchmark for policy analysis required the omission of those countries facing instability or which are small in terms of economic scale.

[28] See Kappler (2009) for a detailed explanation of the alternative approaches.

partner for the UK at 68 percent, while the share of the US economy in UK foreign trade is substantially less, at 16 percent, and less than one percent for China. Canada shares of around one-third of the US foreign trade, while the Euro Area with shares of 24 percent and China with 21 percent accounting as the other major trade collaborates for the US.

As discussed in Cook and Devereux (2013), economies with a greater trade linkage may respond to policy shocks more similar. Thus, we can expect that a policy shock to any of the involved countries would generate spillovers to its trade partners. We explore this idea later in dynamic analysis of the GVAR model.

Table 4.2. Trade Weights Matrix

Country	Australia	Canada	China	Euro Area	Japan	UK	US
Australia	0.000	0.005	0.046	0.028	0.072	0.018	0.018
Canada	0.020	0.000	0.039	0.037	0.034	0.030	0.338
China	0.265	0.055	0.000	0.201	0.356	0.066	0.209
Euro Area	0.190	0.064	0.276	0.000	0.178	0.684	0.241
Japan	0.280	0.033	0.241	0.090	0.000	0.035	0.129
UK	0.067	0.028	0.043	0.340	0.034	0.000	0.065
US	0.178	0.814	0.354	0.303	0.324	0.167	0.000

Note: Trade weights are calculated based on dividing the share of bilateral trade between countries *i* and *j*, over the total amount of foreign trade of country *i*, using the IMF databases for Direction of Trade Statistics.

Having estimated the matrix of trade weights, it is also possible to estimate the trade-weighted macro variables within the GVAR model. Table 4.3 presents the weight of each country's macroeconomic variables based on its share of trade. As can be seen, macroeconomic variables in the US have the greatest weight to influence the world economies through bilateral trade channel. Thus, it is not surprising that the US economy plays a dominant role to generate international spillovers to other economies.

It can also be observed that the US long-term interest rates and real equity prices have a greater weight to generate international spillovers. Thus, these two variables can be considered as two potential channels for the transmission of policy shocks. Furthermore, the US short-term interest rates, government debt, inflation, and output seem to have equal weight to generate international spillovers across countries.

Table 4.3. Trade-Weighted Macro-Variable

Country	**Real output**	**Inflation**	**Real Exchange Rate**	**Real Equity Price**	**Long-Term Interest Rate**	**Short-Term Interest Rate**	**Government Debt-to-GDP**
Australia	0.020	0.020	0.032	0.025	0.025	0.020	0.020
Canada	0.033	0.033	0.050	0.040	0.040	0.033	0.033
China	0.182	0.182	0.281	NA	NA	0.182	0.182
Euro Area	0.247	0.247	0.382	0.302	0.302	0.247	0.247
Japan	0.110	0.110	0.170	0.134	0.134	0.110	0.110
UK	0.055	0.055	0.085	0.067	0.067	0.055	0.055
US	0.353	0.353	NA	0.431	0.431	0.353	0.353

Note: This Table presents Country-Specific variables' weights based on the constructed trade-weighted matrix. Due to data limitation, equity prices and long-term interest rate for China were not obtained and are denoted by NA. The NA cell for US exchange rate is due to denominating all countries' currencies to the US dollar.

4.4.2 Estimation of the Country-Specific Models

In order to validate the obtained results, the stationary properties of our GVAR variables must be verified. The results of unit root test is presented in Appendix 4.A. The results suggest that all domestic and foreign variables are non-stationary in level and turn to be stationery in their first difference. Given that all variables are *I(1)*, it allows us to estimate the standard co-integrating relations. Table 4.4 presents the lag order of $VARX\ (p_i, q_i)$ and the number of co-integrating relations among countries.[29] The lag order of domestic variables is determined by the Akaike Information Criteria (AIC). For foreign variables, due to the data limitation, the lag order is set to unity, while given the GVAR model structure it is not allowed to determine more than two lags for both domestic and foreign variables, see Dees et al. (2007).

[29] According to Dees et al. (2007), it is not required that the lag order of domestic variables, p_i, and foreign variables, q_i, be identical in the individual *VARX* models.

Table 4.4. Lag Order and Number of Co-Integrating Relations for VARX Models

Country	VARX Order of Individual Models p_i	q_i	Co-integrating Relations
Australia	2	1	3
Canada	2	1	3
China	2	1	1
Euro Area	2	1	3
Japan	1	1	3
UK	2	1	3
US	2	1	2

Note: This Table presents the lag order of domestic, p_i, and foreign, q_i, variables, in order. The rank of the co-integrating relations is estimated using Johansen's trace and maximum eigenvalue statistics for models with weakly exogenous regressors, in the case where unrestricted constant and restricted trend coefficients are included in the country-specific Error Correction Models (ECM). The co-integration results are based on the trace statistic and significant at 95% critical value level.

As regards co-integrating relations, let the i^{th} country-specific model consist of the following domestic and foreign variables:

$$X_{it} = \begin{pmatrix} y_{it} \\ \pi_{it} \\ sr_{it} \\ ep_{it} \\ eq_{it} \\ lr_{it} \\ gdr_{it} \end{pmatrix}, \quad X_{it}^* = \begin{pmatrix} y_{it}^* \\ \pi_{it}^* \\ sr_{it}^* \\ eq_{it}^* \\ lr_{it}^* \\ gdr_{it}^* \\ p_t^{oil} \\ p_t^{mat} \\ p_t^{metal} \end{pmatrix}$$

Now suppose that the rank obtained is $r_i = 1$. Then the corresponding co-integrating relations for the i^{th} economy can be written as follows:

$$\beta_{i,11}\, y_{it} + \beta_{i,12}\, \pi_{it} + \beta_{i,13}\, sr_{it} + \beta_{i,14}\, ep_{it} + \beta_{i,15}\, eq_{it} + \beta_{i,16}\, lr_{it} + \beta_{i,17}\, gdr_{it} + \beta_{i,18}\, y_{it}^* + \beta_{i,19}\, \pi_{it}^*$$
$$+ \beta_{i,110}\, sr_{it}^* + \beta_{i,111}\, eq_{it}^* + \beta_{i,112}\, lr_{it}^* + \beta_{i,113}\, gdr_{it}^* + \beta_{i,114}\, p_t^{oil} + \beta_{i,115}\, p_t^{mat} + \beta_{i,116}\, p_t^{metal} \sim I(0)$$

4.4.3 Weak Exogeneity Test

As noted previously, estimating a valid country-specific *VARX* model in the GVAR framework required foreign variables be weakly exogenous to their domestic counterpart, see Dees et al. (2007). Table 4.5 presents the results of weak exogenity tests.

Table 4.5. Weak Exogeneity Test

Country	**F test**	**C Value**	y_{it}^{*}	π_{it}^{*}	eq_{it}^{*}	lr_{it}^{*}	sr_{it}^{*}	gdr_{it}^{*}	p_{t}^{oil}	p_{t}^{mat}	p_{t}^{metal}
Australia	F(3,92)	***3.10***	0.10	0.18	0.15	0.30	2.12	0.89	1.62	1.13	0.62
Canada	F(3,98)	***2.46***	2.80*	3.01*	2.25	1.54	2.28	2.39	2.14	0.50	0.88
China	F(1,101)	***3.09***	0.74	1.47	1.97	1.01	1.61	1.53	1.07	0.28	0.55
Euro Area	F(3,92)	***3.10***	0.29	0.56	0.46	0.02	1.09	0.63	0.12	0.03	2.70
Japan	F(3,92)	***3.10***	0.50	0.34	0.13	2.40	1.53	0.34	1.51	2.05	1.53
UK	F(3,99)	***3.09***	2.70	0.15	1.42	0.19	0.83	1.49	0.62	2.40	2.29
US	F(2,97)	***3.09***	1.29	0.93	2.63	1.93	1.98	NA	0.65	2.48	1.25

Note: This Table contains evidence of foreign variable weak exogeneity for each country. The null hypothesis is weak exogeneity; hence, failing to reject of the null implies that weak exogeneity holds. The results are presented at 95% confidence interval. An asterisk ,*, indicates that weak exogeneity assumption is rejected for those variables of that particular country. NA indicates the variables that is not involved in the *VARX* model as weakly exogenous.

According to the results, the null hypothesis of weak exogenity is rejected for output and inflation in Canada. All other variables can be considered as weakly exogenous within the country-specific *VARX* models. As has been discussed in Dees et al. (2007) rejection of the weak exogeneity assumption would have been problematic in the case of the US given its significant impact in the global model as the reference economy. Furthermore, as foreign government debt-to-GDP ratio is not expected to affect the US economy, thus, has not been set as weakly exogenous to the US model.

4.4.4 Pair-Wise Cross-Section Correlations

One of the unique advantages of the GVAR methodology is its ability to test for Common Global Factors across countries. As stated earlier, all country-specific *VARX* models are estimated conditional upon weak exogeneity of foreign variables. This fundamental assumption is ensured when the idiosyncratic shocks of the country-specific models are cross-sectionally weakly correlated, as $\text{cov}\ (X_{it}^{*}, u_{it}) \to 0$, with $N \to \infty$. By conditioning the country-specific models on weakly exogenous foreign variables, which can be considered as proxies for the Common Global Factors, one can expect that the degree of correlation of the remaining shocks across countries/regions will be modest. As Dees et al. (2007) discuss, these residual interdependencies could represent policy and trade spillover effects.

Table 4.6. Average Pair-Wise Cross-Sectional Correlations

Country	Real Output			Inflation		
	Levels	First Differences	VARX Residuals	Levels	First Differences	VARX Residuals
Australia	0.98	0.26	0.03	0.43	0.20	-0.01
Canada	0.98	0.34	-0.03	0.55	0.23	0.00
China	0.98	0.14	-0.07	0.11	0.16	-0.10
Euro Area	0.98	0.34	-0.06	0.57	0.33	-0.03
Japan	0.93	0.23	-0.06	0.47	0.18	-0.01
UK	0.98	0.37	0.00	0.55	0.20	0.00
US	0.99	0.39	-0.06	0.55	0.34	-0.09
Average	**0.97**	**0.30**	**-0.04**	**0.46**	**0.23**	**-0.03**

Country	Long-term Interest Rate			Short-term Interest Rate		
	Levels	First Differences	VARX Residuals	Levels	First Differences	VARX Residuals
Australia	0.92	0.47	-0.02	0.73	0.27	0.03
Canada	0.96	0.58	0.02	0.82	0.27	0.04
China	NA	NA	NA	0.50	0.13	0.01
Euro Area	0.95	0.54	-0.06	0.79	0.23	-0.03
Japan	0.93	0.41	0.00	0.78	0.04	0.04
UK	0.95	0.50	-0.04	0.81	0.27	0.03
US	0.93	0.58	0.01	0.72	0.23	0.03
Average	**0.94**	**0.51**	**-0.02**	**0.74**	**0.21**	**0.02**

Country	Real Exchange Rate			Government Debt-to-GDP		
	Levels	First Differences	VARX Residuals	Levels	First Differences	VARX Residuals
Australia	0.78	0.37	0.11	0.17	0.32	0.09
Canada	0.76	0.32	0.06	0.40	0.38	0.12
China	0.19	0.10	-0.12	0.37	0.00	-0.24
Euro Area	0.77	0.41	-0.04	0.59	0.50	0.12
Japan	0.63	0.16	-0.07	0.38	0.13	0.18
UK	0.78	0.41	-0.05	0.18	0.45	0.07
US	NA	NA	NA	0.47	0.44	0.18
Average	**0.65**	**0.30**	**-0.02**	**0.37**	**0.32**	**0.07**

Note: The results present average correlation between domestic and their corresponding foreign variables among countries of interest. The *VARX* residuals are computed based on country-specific models included the foreign-specified variables. NA cells for the exchange rate in the US is due to denominating all countries' currencies to the US dollar, and for long-term interest rate in China is due to data limitation.

Average pair-wise cross-section correlations show the extent to which the country-specific foreign variables are effective in reducing the cross-section correlation of the variables in the GVAR model. Table 4.6 presents the result of this test reported in levels and first differences for the endogenous variables, also those of the *VARX* residuals. Typically, the average cross-section correlations are high in the level of the endogenous variables and low in their first differences, see Dees et al. (2007).

As can be seen in Table 4.6, real output levels have the highest degree of cross-section correlations at around of 97 percent on average. Long-term interest rate levels also shares common trends and are highly correlated across countries at around 94 percent on average. Yet, short-term interest rates show a smaller but still high degree of correlation of around 74 percent on average. Similar to short-term interest rate, we can observe a more modest degree of correlation among the real exchange rate levels across countries of about 65 percent on average. Except for China, inflation shows a degree of correlation of around 43-57 percent across countries, which are relatively smaller than the other variables. Finally, the result of cross-sectional correlation for government debt presents a low degree of co-movements across countries around of 37 percent on average.

The cross-sectional correlation of the variables in their first difference, however, is quite small compared with the level of variables, indicating that there is a limited cross-correlation between variables in their first differences. For example, the average correlations of output fall from 93-99 percent in levels to 14-39 percent in differences. In general, our results are similar to those of Dees et al. (2007), verifying our constructed GVAR specification.

Our evidence suggests that there is significant cross-country correlation for the variables in the estimated GVAR model, although its extent varies among variables.[30] Turning to the cross-section correlation of the residuals from the *VARX* models, including both domestic and foreign variables, we can observe that their correlations are very small. This indicates that the model has succeeded in capturing the common trends and trade spillover effects among variables and across countries, sees Dees et al. (2007).

4.4.5 Contemporaneous Effects of Foreign Variables

The contemporaneous effects of foreign variables on their domestic counterparts can be interpreted as the impact elasticity between domestic and foreign variables, see Dees et al. (2007). These effects can represent the international linkages between domestic and foreign variables. Table 4.7 presents results of the foreign variables impact on the domestic variables.

[30] Note that the pair-wise cross-section is not a formal statistical test for validating the estimates of global movement among variable cross-countries. However, it can be taken as an indication of such an effect, see Dees et al. (2007).

Table 4.7. Contemporaneous Effects of Foreign Variables on their Domestic Counterparts

Country	Real output	Inflation	Real Equity Price	Long-Term Interest Rate	Short-Term Interest Rate	Government Debt-to-GDP
Australia	**0.27***	**0.53***	**0.85***	**0.93***	**1.04***	**0.21***
	(2.18)	(3.54)	(6.78)	(4.50)	(4.97)	(2.87)
Canada	**0.48***	**0.65***	**0.95***	**0.98***	**0.86***	**0.26***
	(4.39)	(7.04)	(18.1)	(17.57)	(7.04)	(3.95)
China	**0.25***	**0.62***	NA	NA	0.13	0.09
	(3.71)	(2.66)	NA	NA	(1.06)	(0.07)
Euro Area	**0.31***	**0.30***	**1.04***	**0.56***	**0.37***	**0.21***
	(3.6)	(5.70)	(8.46)	(6.61)	(3.57)	(2.70)
Japan	**0.34***	-0.01	**0.70***	**0.52***	**0.17***	**0.24***
	(2.18)	(-0.18)	(6.08)	(4.84)	(2.11)	(2.95)
UK	**0.54***	**0.72***	**0.81***	**0.66***	**0.76***	**0.30***
	(4.11)	(5.50)	(15.12)	(4.55)	(3.16)	(3.39)
US	**0.52***	**0.83***	NA	NA	NA	NA
	(4.39)	(6.77)	NA	NA	NA	NA

Note: The robust *t-ratio* values are presented in parentheses computed using White's heteroscedasticity-consistent variance estimator. The null hypothesis here is the existence of correlation between domestic and foreign variables. The White's Adjusted Standard Errors criteria is based on the Heteroscedasticity-Consistent Standard Errors and allows heteroscedastic residuals. An asterisk,*, indicates that the result is statistically significant. The blank cells for the US indicate variables that are not involved in the *VARX* model as weakly exogenous. For China, blank cells are due to data limitation for long-term interest rate and equity prices.

Asterisks indicate that we typically cannot reject the null hypothesis of correlation at the 95% significance level. It can be therefore seen from the Table that with the exception of short-term interest rates and government debt in China and inflation in Japan, the other domestic specified variables are positively linked with their foreign counterparts.

The results suggests that one percent changes in foreign real output can lead to an increase of 0.5 percent on real output in the US and the UK, while the Euro Area and China real output would be less affected. In addition, CPI inflation in the US, the UK, and China are significantly affected by foreign inflation. More importantly, the results suggest that the contemporaneous elasticity of real equity price is high and above one in the case of the Euro Area. This finding has been also reported in Dees et al. (2007). They interpret this finding as an indication of the Euro Area stock markets slightly overreacting to foreign stock price changes.

Moreover, we can observe a relatively strong elasticity between long-term interest rate in both the Euro Area and the UK and foreign bond markets while the elasticity is rather less for short-term interest rates in the Euro Area. This can indicates that the Euro Area bond market is more responsive than its monetary policy reactions. In contrast, we find rather weak linkages for government debt ratio across focused countries, around of 0.25 percent, see Table 4.7. To summarize our results from this section we find that long-term interest rate and the real equity prices are highly correlated across the countries covered in our analysis. Thus, any policy-induced changes in foreign long-term interest rate and equity prices would influence the linked economies.

4.4.6 Parameter Stability Test

One of the fundamental problems facing VAR models is stability of the estimated parameters, see Bagliano and Favero (1997). It is possible that our GVAR results have been affected by this problem. As Dees et al. (2007) indicate, this problem is more pronounced for emerging economies, which are subject to significant changes. However, our constructed GVAR model includes only China in which it has gone through substantial structural changes. Nevertheless, to ensure the stability of parameters we perform the parameter stability test proposed by Nyblom (1989). The Nyblom test considers a simple linear regression model with K variables, as Equation (4.9) shows compared to the Time-Varying Parameter (TVP) alternative model, as presented in Equation (4.10).

$$y_t = x_t' \ \beta + \varepsilon_t, t = 1,\dots,n \tag{4.9}$$

$$\beta = \beta_t = \beta_{t-1} + \eta_t, \eta_t \sim (0, \sigma^2_{\eta_i}), i = 1,\dots,k \tag{4.10}$$

The objective is to test the following null and alternative hypotheses:

H_0 : β is constant $\Leftrightarrow$ $\sigma^2_{\eta_i} = 0$ for all i

H_1 : $\sigma^2_{\eta_i} > 0$ for some i

Nyblom (1989) derives a Lagrange Multiplier (LM) test statistics written as below.[31]

$LM = \frac{1}{n\hat{\sigma}^2}\sum_{t=1}^{n} S_t V^{-1} S_t$, where $S_t = \sum_{j=1}^{t} f_t$ = cumulative sums, $f_t = x_t \hat{\varepsilon}_t$, and $V = n^{-1} X'X$.

[31] Further details of the estimation of the LM statistics can be found in Nyblom (1989).

Table 4.8. Nyblom Parameter Stability Tests

LM Statistic	Real output	Inflation	Short-Term Interest Rate	Real Exchange rate	Real Equity Price	Long-Term Interest Rate	Government Debt-to-GDP
Nyblom -US	**2.57***	**2.64***	5.70	NA	**2.56***	3.79	**1.76***
	(2.96)	(2.90)	(2.99)	NA	(2.84)	(2.86)	(2.78)
Robust Nyblom -US	**3.08***	**2.58***	**3.28***	NA	**2.54***	**3.09***	**2.31***
	(3.36)	(3.32)	(3. 59)	NA	(3.12)	(3.19)	(3.22)
Nyblom -China	**2.53***	3.02	**1.60***	**1.62***	NA	NA	**2.34***
	(2.61)	(2.88)	(2.88)	(3.00)	NA	NA	(2.86)
Robust Nyblom -China	**2.73***	3.43	**1.68***	**3.06***	NA	NA	**3.51***
	(3.13)	(3.37)	(3.23)	(3.37)	NA	NA	(3.60)
Nyblom - Euro Area	**2.84***	**2.20***	3.39	4.30	**3.40***	3.46	**2.39***
	(3.53)	(3.30)	(3.17)	(3.58)	(3.65)	(3.33)	(3.65)
Robust Nyblom- Euro Area	**3.66***	**2.80***	**3.46***	4.09	**3.96***	**3.24***	**3.58***
	(3.79)	(3.90)	(3.55)	(3.95)	(4.11)	(3.87)	(4.11)
Nyblom-UK	**3.11***	**2.17***	3.43	4.21	**2.80***	**2.64***	**2.95***
	(3.32)	(3.12)	(3.38)	(3.47)	(3.19)	(3.41)	(3.63)
Robust Nyblom-UK	**3.29***	**2.95***	4.08	**3.67***	**3.37***	**3.38***	**2.80***
	(3.73)	(3.77)	(3.68)	(4.09)	(3.94)	(4.02)	(3.99)

Note: The null hypothesis is parameter stability; hence, failing to reject of the null implies parameter stability over the sample. An asterisk ,*, indicates parameter stability. Critical Values (CV) at the 5% significance level are presented in the parentheses. NA are either due to setting as reference country, i.e. the US, or data limitation, i.e. China. The robust Nyblom denotes the heteroskedasticity-robust version of the test. LM statistics abbreviates the Lagrange Multiplier statistic.

The estimated LM statistics provides a decision criteria for the rejection of the null hypothesis H_0. If $LM > CV_{0.05}$, it suggests that at 95% confidence level parameters are instable. Table 4.8 presents the results for the computed Nyblom parameter stability test and its heteroskedasiticy-robust version for the variables. The critical values of the tests are calculated based on the sieve bootstrap samples obtained from the solution of the *GVAR(P)* model.[32] The results vary across countries and variables.

According to Table 4.8, both the Nyblom test and its robust results suggest that the parameters of real output for all the countries is stable over the sample. Similar results validate parameter stability of inflation among the countries with China being the only exception. As regards the short-term interest rates, there is evidence for parameter instability for UK short-term interest rates while for the rest of countries this parameter seems to be stable over the sample. In the case of long-term rates, the robust Nyblom test results suggest parameter stability across

[32] For the technical details see Dees et al. (2007).

countries. Furthermore, as can be seen from the robust test results, parameters of government debt, real equity prices, and the exchange rate seem to be constant cross-countries over the sample except for the Euro Area real exchange rate.

Overall, according to results, there are only a few variables with unstable parameters. Given the linear GVAR modelling framework, it is not possible to completely rule out parameter instability impact from our results. However, as the test outcome changes for the robust version, except for UK's short-term interest rate, Euro Area real exchange rate, and China's inflation, it seems that these instabilities are mainly related to error variances and not the parameter coefficients. Thus, as addressed in Dees et al. (2007), a reasonable approach to deal with this problem is to use robust standard errors when examining the impact effect of foreign variables, and to use both the bootstrap means and confidence bounds along point estimates result as a foundation for the dynamic analysis.[33] Furthermore, although there is evidence of parameter changes in dynamic analysis of policy shocks, our study is concerned with past parameter variation and implicitly assumes that the policy intervention has no independent effects on parameter values, see Pesaran and Smith (2012).

4.5 Dynamic Analysis: Generalized Impulse Response Functions

The GVAR approach provides a coherent framework for modelling global interactions. The standard way of examining economic interactions in both domestic and global dimensions is through Impulse Response Function (IRF) analysis mapping the possible responses of a system to a shock imposed to the model at various future periods. In a GVAR model with $N+1$ countries/regions and K_i endogenous variables for each country/region, up to $\sum_{i=0}^{N} K_i\,(K_i - 1)$ restrictions are required for shocks to be exactly identified. In practice, however, it is very difficult to find and impose such a large number of theory-based restrictions.

[33] According to our results, there is only a small amount of evidence indicating parameter instability and is not the only one in the GVAR literature. For example, a large number of parameter instability has been reported in Dees et al. (2007) due to involving a large number of emerging economies in the GVAR model.

Given the identification problems, one possible approach is to use the Generalized Impulse Response Functions (GIRF) proposed by Koop et al. (1996) and developed by Pesaran and Shin (1998). This approach is an alternative to the Orthogonal Impulse Responses (OIR) proposed by Sims (1980). The concepts of orthogonality in impulse responses guarantees that various imposed shocks to the system are uncorrelated, implying that their corresponding covariance matrix is zero. Thus, it is possible to examine the impact of different simultaneous shocks to the model of interest. In contrast to OIR, the GIRF approach imposes shocks to individual errors and filters out the effect of other shocks using the observed distribution of all shocks.

The GIRFs depicts how changes in one variable affect other variables in the GVAR model and over time, regardless of the source of the shock. In other words, it describes the way that other variables are affected by a shock through tracing the changes to the error terms of the conditional model, u_{it}, see Equation (4.3). Moreover, since the GVAR model is conditional upon the weak exogeneity assumption, the shock correlation is not an issue here. Thus, in contrast to IRFs in structural models, GIRFs do not require that shocks to be identified. They can present dynamics in a time series model by mapping out the reaction to a one standard deviation shock to the residual in the corresponding equation, see Dees et al. (2007). Furthermore, the GIRFs are invariant to the ordering of the variables and countries in the GVAR model, which clearly is an advantage even if we had a theory-driven ordering of the variables, see Pesaran and Smith (2006), and Dees et al. (2007). These two unique properties of the GIRFs seems to overcome the identification problems concerning VAR modelling approaches.

Within the GIRFs approach, the information underlying a common global factor $(G_t\{X_t, X_{t-1},\ldots\})$ in time $t-1$ is employed to predict the value of X at time $t+n$. Then, by assuming that ε_t has a multivariate normal distribution, the effect of one standard error shock to the j^{th} Equation is tested, corresponding to the l^{th} variable in the i^{th} country, in time *t*, see Pesaran et al. (2004). The objective is to predict X_t over the period $t = T+1,\ T+2,\ldots,T+n$, where n is the forecast horizon, provided that X_t is observed in the period $t = 1, 2, \ldots, T$. Equation (4.11) shows the way that X_{T+n} is formulated for the forecasting purposes as follows.[34]

$$X_{T+n} = F^n X_T + \sum_{\tau=0}^{n-1} F^\tau [b_0 + b_1(T+n-\tau)] + \sum_{\tau=0}^{n-1} F^\tau [Y_0 d_{T+n-\tau} + Y_1 d_{T+n-\tau-1}] + \sum_{\tau=0}^{n-1} F^\tau U_{T+n-\tau} \tag{4.11}$$

Where $b_i = G^{-1} a_i$, $i = 0,1$, $F = G^{-1} H$, $Y_0 = G^{-1} \Psi_0$, and $Y_1 = G^{-1} \Psi_1$.

Consequently, the exogenous global variables can be obtained from Equation (4.12):

$$\begin{gathered} X_{T+n} = E(X_{T+n} \mid X_T, \bigcup_{\tau=1}^{n} d_{T+\tau}) = \\ F^n X_T + \sum_{\tau=0}^{n-1} F^\tau [b_0 + b_1(T+n-\tau)] + \sum_{\tau=0}^{n-1} F^\tau [Y_0 d_{T+n-\tau} + Y_1 d_{T+n-\tau-1}] + \sum_{\tau=0}^{n-1} F^\tau U_{T+n-\tau} \end{gathered} \tag{4.12}$$

Equation (4.12) shows that the point forecast of the endogenous variables, X_{T+n}, is conditional on the initial state of the system, X_T, and the exogenous global variables, $\bigcup_{\tau=1}^{n} d_{T+\tau}$. Formulating the future expected values for X_{T+n} and X^*_{T+n} enables us to calculate the GIRFs as presented in Equation (4.13).

$$\begin{gathered} G\ I_{x,\varepsilon_i l}(n, \sqrt{\sigma_{ii,ll}}, \Gamma_{t-1}) = \\ E(X_{t+n} \mid \varepsilon_{ilt} = \sqrt{\sigma_{ii,ll}}, \Gamma_{t-1}) - E(X_{t+n} \mid \Gamma_{t-1}) \end{gathered} \tag{4.13}$$

Given that $\Gamma = (X_t, X_{t-1}, \ldots)$.

Having considered the properties of GIRFs and given the motivation of the study, now we proceed to the dynamic analysis of the macro-finance responses to policy shocks. In doing so, we estimate two GVAR models: a simple GVAR and a fiscal-augmented GVAR model to address the potential impact of US fiscal policy on monetary policy and its international spillovers. Then we continue to examining both the domestic and international spillovers of US fiscal policy.

[34] A detailed explanation of formulating X_{T+n}, and formal proof can be found in Pesaran et al. (2004).

4.5.1 The Simple GVAR Model Results to Monetary Shock

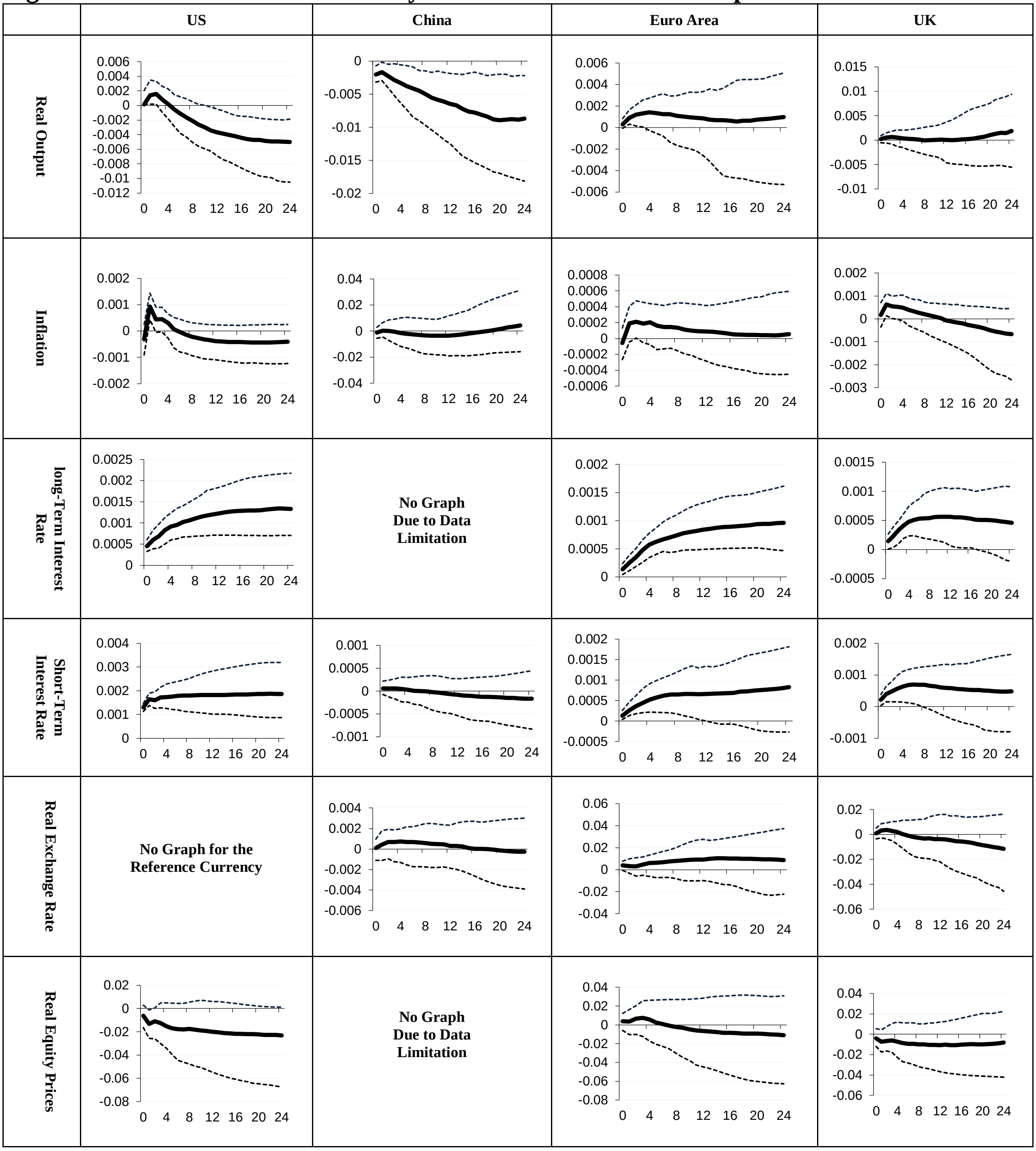
This section presents the GIRFs estimated within the simple GVAR model, which excludes government debt, to one standard error increase in the nominal short-term interest rates. Figure 4.2 plots the responses. As set out in Chapter 2, it is expected that an increase in short-term interest rates induce a fall in prices and output through the interest rates, the exchange rate, and equity prices channels.

As presented in Figure 4.2, this contractionary monetary policy shock induces US output growth to increase by 0.2 percent at peak. However, output rapidly falls and the effect is statistically significant. The same responses can be observed by inflation: a short-lived rise in inflation followed by a sharp fall up to zero. These results are counterintuitive, though they become statistically insignificant after one quarter. The same results are found in Dees et al. (2007).

This counterintuitive finding is reported in a number of studies using VAR models as reported in Hanson (2004) that is referred in the literature as the price puzzle. One popular explanation for the price puzzle relates it with the lack of information to capture the response of prices to the policy shock. The proposed solution has been the addition of extra information, most importantly commodity price indices to the model. For this reason, our model consists two commodity price indices to our model, namely metal price, and raw material price as explained in the model specification section. However, adding this extra information does not correct the response of prices. As discussed in Chapters 2 and 3, this counterintuitive responses might be better explained by taking into account different monetary and fiscal policy regimes in terms of which policy dominates the another one, see Chung et al. (2007). We explore this idea further in the next section.

As regards the long-term interest rates, the policy shock induces an increase of around 0.1 percent, which remains significant over the period. Finally, US equity prices fall in response to policy shocks, though statistically is insignificant.

Figure 4.2. The GIRFs to a Monetary Contraction within the Simple GVAR



Notes: These impulses responses are based upon a contractionary US monetary policy shock. The Figure provides quarterly GIRFs of the GVAR specified-variables after imposing a one standard error shock to US short-term interest rate without involving government debt-to-GDP variable in the model over the sample 1979:Q2-2013:Q1. The solid lines present bootstrap mean estimates with the dashed lines presenting 90% bootstrap error bands. The scale on the horizontal axis measures the number of quarters after the initial shock.

Now we turn our focus on the international spillovers induced by a US contractionary monetary policy shock. As can be seen from Figure 4.2, in the Euro Area output increase in response, though the responses are statistically insignificant at all horizons. UK real output, however, does not react to the policy shock and the associated GIRFs are not statistically significant. The policy also causes real output in China to fall, which stays significant over the period.

As regards the international spillovers of the policy shock on inflation for the economies of interest, as the GIRFs suggest China's inflation does not respond to the policy shock, while those of the Euro Area and UK shows an increase which then return back to zero. Note that all the responses remain statistically insignificant.

As regards the international impact of policy on short-term interest rates, the GIRFs presented in Figure 4.2 shows a positive and statistically significant effect for the Euro Area, and UK. This reflects a strong interdependence of short-term rate among the US, Euro Area, and UK. The effect of shock on long-term interest rates for both the Euro Area and UK tends to be positive and statistically significant; again reflecting the interdependence of the long-term rates.

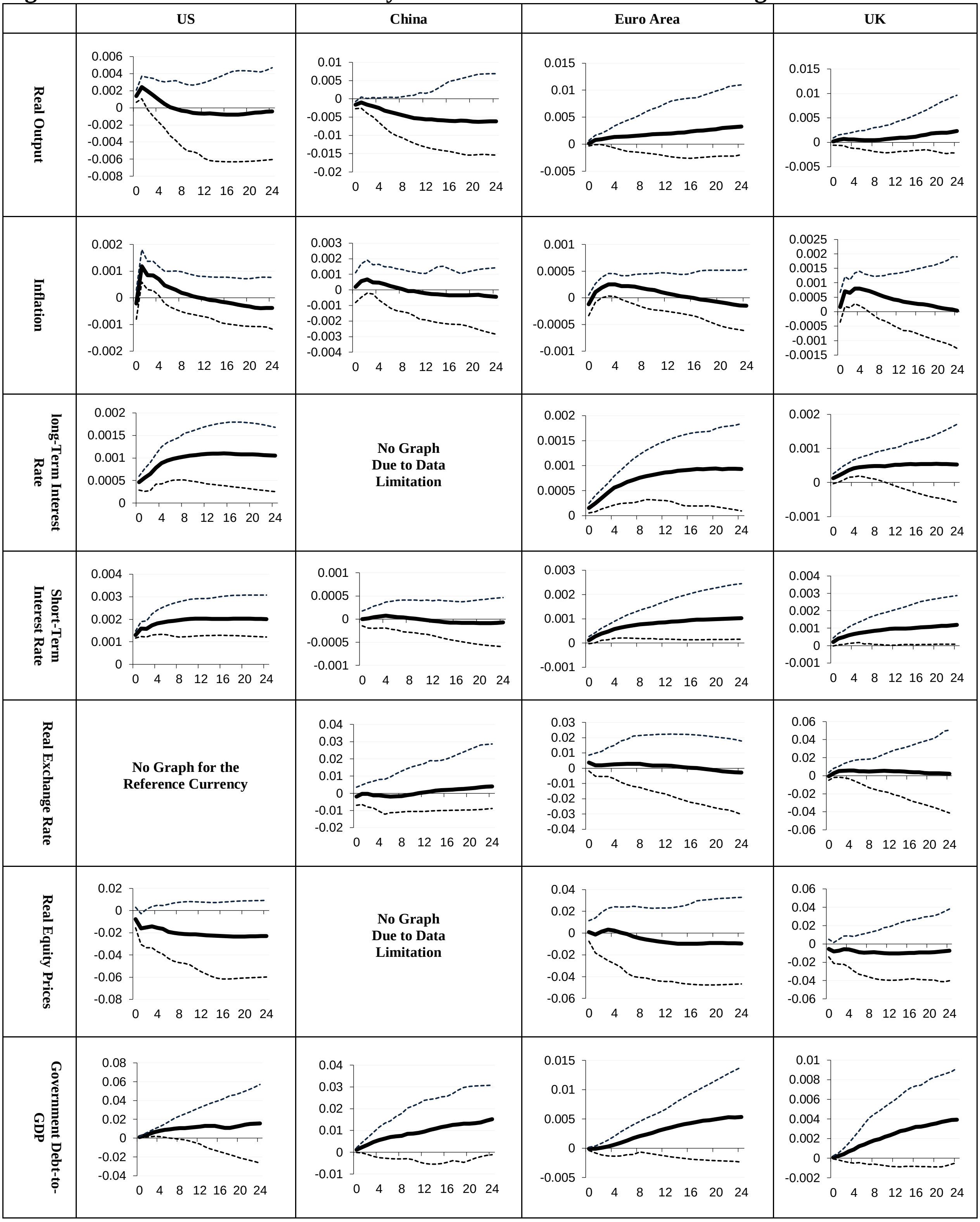
Focusing upon the international effects of US monetary contraction, the policy shock is not succeeded to significantly influence the exchange rate and equity prices in none of the economies of interest. In general, our GIRFs to this policy shock is consistent with those reported in Dees et al. (2007). Likewise, our impulse responses, suggest that a US monetary contraction has a limited international spillovers. In the next section, we consider to examine the impact of fiscal policy on the international transmission of policy shock.

4.5.2 The Fiscal-GVAR Model Results to Monetary Shock

Given the increasing use of fiscal policy and the rise in US government debt, it is important to re-consider the GVAR evidence while accounting for these changes. Figure 4.3 presents the macroeconomic impact of US monetary contraction within the fiscal GVAR model. This model includes fiscal policy proxied by the government debt ratio. As presented in the graph, including the government debt-to-GDP in the model changes the GIRF results compared with the simple model. As can be seen in Figure 4.3, a monetary contraction causes US output to increase and after two quarters returns to zero, though the response is statistically significant only for a quarter. Comparing Figures 4.2 and 4.3, we can see that including government debt increase the duration of responses.

As regards the response of inflation, a price puzzle can be observed. The distinguished feature compared with the simple model is it takes longer for inflation to return to equilibrium. This implies that including government debt makes the price puzzle persist longer. This finding is in line with the results reported in Chapter 3 suggesting that the fiscal stance may contribute to the appearance of the price puzzle or its persistent. As discussed earlier, taking into account fiscal policy, a monetary contraction may lead to an increase in output and inflation. This observation can be interpreted by US unprecedented government debt level as any changes in interest rates can significantly change interest expenses components of government spending, see Favero and Giavazzi (2007), and Sims (2013).

Figure 4.3. The GIRFs to a Monetary Contraction within the Fiscal-Augmented GVAR



Notes: These impulses responses are based upon a contractionary US monetary policy shock. This Figure provides quarterly GIRFs of the GVAR specified-variables after imposing a one standard error shock to US short-term interest rate while includes government debt-to-GDP variable in the model over sample 1979:Q2-2013:Q1. The solid lines present bootstrap mean estimates with the dashed lines presenting 90% bootstrap error bands. The scale on the horizontal axis measures the number of quarters after the initial shock.

Chung et al. (2007) explains that the price puzzle can be interpreted as a normal responses of prices rather than a puzzle. The mechanism can be explained as follows. A rise in interest rates increases the interest share of government debt. To finance the payment, new government debt is required to be issued. This may generate a positive wealth effect to bond holders through either higher interest earnings or new government bond. This, in turn, can encourage private expenditure leading to an increase in output and inflation, see Chung et al. (2007), and Leeper and Walker (2012).

Likewise in the simple model, we can see from Figure 4.3 that US long-term interest rates increase by around of 0.1 percent. This effect is statistically significant for the whole period. US real equity prices also falls in response to an increase in interest rates, although this appears to be insignificant. Furthermore, government debt increases in response to a contractionary monetary policy shock, but this is statistically insignificant.

Focusing on the international transmission of a US monetary contraction, the responses appear to be relatively similar to the simple model. This policy shock increases output and prices in both the Euro Area and UK, although the responses are not statistically significant. However, a few differences can be observed in terms of magnitude and duration of the responses. For example, while the exchange rate in the Euro Area and UK increase within the simple model, the exchange rate does not respond in the debt-augmented model. The increase in foreign currencies is counterintuitive as it is expected that US contractionary monetary policy shock induce an appreciation of US dollar and depreciation of other currencies.

It can be explained as US monetary contraction has generated spillovers to both the Euro Area, and UK' interest rates. As both the short and long-term rates has been increased in these economies, the potential capital outflows has been ruled out. Thus, it can be due to this effect that real exchange rate has not changed. Moreover, this policy shock induces short-term interest rates in the Euro Area and UK to increase with both model specifications, though their response tends to be statistically significant within government debt-augmented model.

Finally, as GIRFs suggest, government debt for the countries of interest has increased in response to the policy shock, though, their responses tends to be statistically insignificant. It might be due to an increase in the interest component of the government debt caused by US contractionary monetary policy as both short and long-term interest rates are increased in the Euro Area and UK in response to the policy.

In summary, our results confirm cross-countries co-movements between short and long-term interest rates. This co-movement is not affected by US government debt. In addition, comparing the GIRFs from the simple model with those of the fiscal GVAR, it appears that US government debt influences the duration of responses to a monetary policy shock. Given that the responses of output and inflation are counterintuitive, our results are in line with those of Dees et al. (2007), although our study differs in a number of ways.[35] Having considered the high level of US government debt, this finding seems to be reasonable, as any changes in interest rates would significantly change the interest expenses share of government expenditure. Thus, US fiscal stance would affect the impact of monetary policy. This finding is consistent with the literature on the importance of debt dynamics for the real activity measures and its influence on the monetary transmission mechanism, see Chung et al. (2007), Davig and Leeper (2007, 2011), and Favero and Giavazzi (2007).

4.5.3 The GVAR Model Results to Fiscal Shock

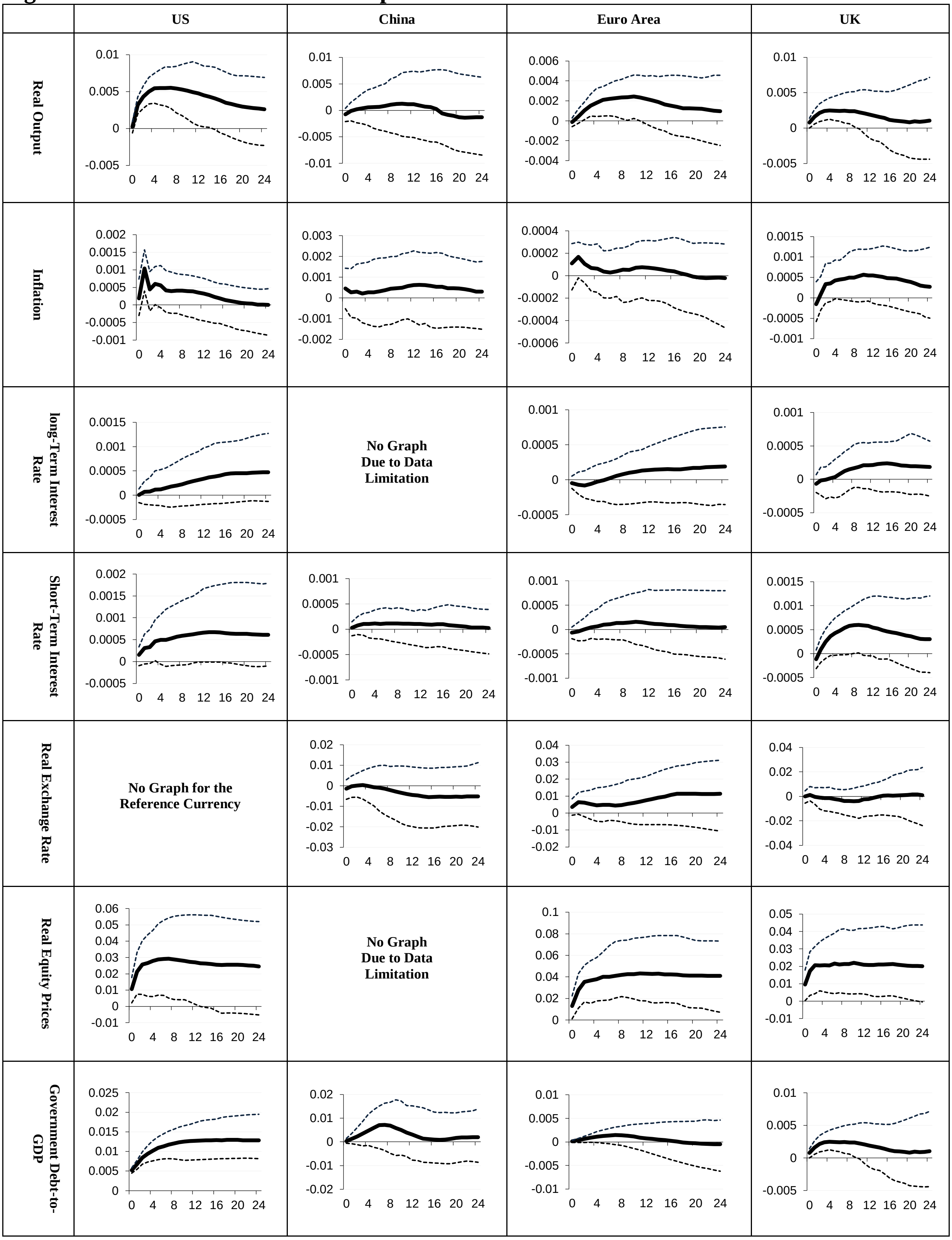
Having discussed the domestic and global impact of monetary policy shock, we now consider investigating a US fiscal policy shock. As noted earlier, there are two strands in the literature on the outcome of fiscal expansion. While the non-Ricardian find fiscal policy effective to stimulate the economy, the Ricardian view suggests the otherwise. Nevertheless, it is widely believed that at some circumstances such as the ZLB fiscal expansion may stimulate the economy. To examine

[35] Our study employs a larger sample to include the 2008 financial crisis while those of Dees et al. (2007) ends in 2003. The application of the constructed GVAR model in our study is also different in terms of using the model as framework to study the potential contribution of government debt on monetary policy. Moreover, our choice of the involved economies is more limited in terms of focusing on more homogenous economies, while those of Dees et al. (2007) includes both advanced and emerging economies.

the effectiveness of US fiscal policy and its international spillovers, this section presents the impulse responses to a US expansionary fiscal policy shock. To maintain the consistency among the Chapters, as noted in Chapter 3, we choose government debt-to-GDP as the fiscal policy instrument. Figure 4.4 presents the GIRFs to a one standard error positive shock to US government debt-to-GDP ratio. This may be expected to impact positively upon output and inflation through a demand channel and possibly to positively impact other countries through spillover effects.

As can be seen from Figure 4.4, this fiscal policy shock has a significant and positive impact on US real output. This amounts to an increase in output of 0.5 percent. This fiscal expansion shock, also, increases US inflation by around 0.1 percent at peak, although the effect is short-lived and statistically insignificant. As regards US interest rates, both short and long-term rates, it appears that a rise in government debt induces nominal interest rates to increase: while the response of the long-term rates is insignificant, short-term rates turns to be significant for a while. This feedback by short-term interest rate appears to be permanent, which amounts of around 0.05 percent. Interest rates may respond due to crowding out of borrowing and/or a Taylor Rule response of interest rates to increased output and inflation. Furthermore, this policy shock has a positive impact on US real equity prices around of two percent, which remains significant for a while.

Figure 4.4. The GIRFs to a Fiscal Expansion within the GVAR



Notes: These impulses responses are based upon an expansionary US fiscal policy shock. This Figure provides quarterly GIRFs of the GVAR specified-variables after imposing a one standard error shock to US government debt-to-GDP variable over sample 1979:Q2-2013:Q1. The solid lines present bootstrap mean estimates with the dashed lines presenting 90% bootstrap error bands. The scale on the horizontal axis measures the number of quarters after the initial shock.

Turning to the international transmission of the shock, as displayed in Figure 4.4, real output in the Euro Area and UK increase in response to the fiscal shock, then gradually returns to equilibrium. The response is statistically significant. The policy, however, cannot impact China's output significantly. As regards the impact of policy on inflation, as Figure 4.4 shows, US fiscal expansion increases inflation within the economies of interest. However, the responses are statistically insignificant.

In addition, while the fiscal shock induces China, the Euro Area, and UK short-term interest rates to increase, the response is insignificant. This policy shock also increases both the Euro Area and UK long-term rates, but insignificantly. Furthermore, both the Euro Area and UK equity prices increase in response to this policy and remain significant for the whole period. The impact on equity prices in the Euro Area is greater, around four percent. It can be seen in the graph that the real exchange rate for the Euro Area has increased in response to the shock, though again the responses are insignificant.[36] For China and the UK, overall, the real exchange rate does not respond to the fiscal expansion.

Finally, government debt in China, the Euro Area, and UK increase following the increase in US debt, which all gradually return to equilibrium. However, as Figure 4.4 shows, the responses are not statistically significant except the UK. One potential explanation is the increase in their short and long-term interest rates induced by US fiscal expansion. This in turns can increase the interest component of the government debt leading to an increase in government debt in the economies of interest.

Overall, the results of the US fiscal expansion suggests this policy is effective to increase real output. The increase in the interest rates, both short and long term, however, may crowd out this fiscal expansion. Furthermore, as US real equity prices increase following the increase in

[36] Given the appreciation of real exchange rates in the focused economies following the policy shock, this may account for the import leakages for US fiscal expansionary policy, see Baldassarri et al. (1993), and Cuaresma et al. (2011).

US government debt, it can generate a positive wealth effect, which in turn would improve aggregate demand and output by encouraging private consumption.

Thus, the impulse response results with a fiscal shock support the non-Ricardian view on fiscal policy for the US economy. From this perspective our results is consistent with those of Mountford and Uhlig (2009). They find that a deficit-financed fiscal expansion can stimulate the US economy. Furthermore, the generated expansionary effects on the economies of interest suggest that there is potential spillovers through integrated financial markets and potentially trade channel in the case of the Euro Area, i.e. import leakages, although some of the effect of the fiscal shock stays in the US.[37]

Up to now, we construct two GVAR models to examine the extent to which US fiscal policy may influence the monetary transmission mechanism in a global framework. Then we investigate the impact of a US fiscal expansion that is found to be effective in stimulating the economy and generating international spillovers. Having discussed the results, a number of features emerge. First, we find evidence of the appearance of the price puzzle in response to a contractionary monetary policy shock within a simple GVAR model. Second, the GIRFs obtained from the debt-augmented GVAR model suggest that the price puzzle tends to be more persistent in presence of government debt. The economic justification for this result can be the potential role of higher interest earnings together with the issuance of new government bonds on encouraging private expenditure and aggregate demand. Third, within the GVAR model, we find evidence for the non-Ricardian view on US fiscal policy together with significant international spillovers to the Euro Area and UK, stimulating their economies. Fourth, both short-term and long-term interest rates appear to be correlated across US and the other economies and US government debt does not change the correlation.

The next section attempts to investigate the contribution of fiscal policy to the performance of the long-run macroeconomic relations.

[37] Beetsma et al. (2006) examine fiscal policy spillovers within major economies in the Euro Area. They find evidence for import leakage in the Euro Area following a fiscal expansion.

4.6 Long-Run Macroeconomic Relations

This section examines the way in which government debt can influence the performance of long-run macroeconomic relations within the global economy. In particular, we investigate the way that long-run relations can be influenced by the US government debt. These long-run macroeconomic relations concerns the impact of policy shocks on the interest rates, inflation, and the exchange rates in the long-term.

As addressed in Dees, Holly, Pesaran, and Smith (2007), the theory-based long-run relations for country-specific models can be obtained from two sources: (i) deriving the relations from inter-temporal optimization conditions as in Dynamic Stochastic General Equilibrium (DSGE) models, or (ii) deriving the relations from arbitrage conditions. Following Dees, Holly, Pesaran, and Smith (2007), we consider a number of plausible long-run relations namely the Fisher equation, the Uncovered Interest Parities (UIP), and the Term Premium conditions between short and long-term interest rates. These hypotheses have been tested in the literature, however, they come either from single countries framework or in the case of multi-country framework, the potential role of fiscal policy has been ignored. Our choice of these long-run relations accounts for inflation and interest rates connections in the both domestic and global economies.[38]

We consider the same GVAR model specification as has been described earlier that is consistent with the Bayesian Information Criterion (BIC).[39] Recalling the co-integrating relation, the corresponding relations for the i^{th} economy can be written as below.

$$\beta_{i,r1}\ y_{it} + \beta_{i,r2}\ \pi_{it} + \beta_{i,r3}\ sr_{it} + \beta_{i,r4}\ ep_{it} + \beta_{i,r5}\ eq_{it} + \beta_{i,r6}\ lr_{it} + \beta_{i,r7}\ gdr_{it} + \beta_{i,r8}\ y_{it}^{*} + \beta_{i,r9}\ \pi_{it}^{*}$$
$$+ \beta_{i,r10}\ sr_{it}^{*} + \beta_{i,r11}\ eq_{it}^{*} + \beta_{i,r12}\ lr_{it}^{*} + \beta_{i,r13}\ gdr_{it}^{*} + \beta_{i,r14}\ p_{t}^{oil} + \beta_{i,r15}\ p_{t}^{mat} + \beta_{i,r16}\ p_{t}^{metal} \sim I(0)$$

[38] A detailed discussion of the literature on the determination of various long-run relations can be found in Dees, Holly, Pesaran, and Smith (2007).

[39] The BIC criteria suggests to choose between *VARX (2,1)* and *VARX (2,2)* given the data limitation that does not allow the lag orders of domestic and foreign variables exceeded more than two, see Dees, Holly, Pesaran, and Smith (2007).

Where r represents the number of estimated co-integrating vectors for the given country. Note that, since just one long-run economic relation can be imposed for each co-integrating vector, the number of theory-based relations must be equal to the country's rank of the co-integrating relations, see Dees, Holly, Pesaran, and Smith (2007).

We follow Dees, Holly, Pesaran, and Smith (2007) in adopting the long-run relations, which is derived from a small open economy framework as in Gali and Monacelli (2005). Thus, for the i^{th} economy these following long-run relationships have been considered as possible candidates to capture the long-run relations between the variables of interest.[40]

$$sr_{it} - \pi_{it} = a_{i3} + \xi_{i3,t} \sim I(0) \tag{4.14}$$

$$sr_{it} - sr^*_{it} - E_t(\Delta e^*_{i,t+1,}) = a_{i6} + \xi_{i6,t} \sim I(0) \tag{4.15}$$

$$sr_{it} - lr_{it} = a_{i4} + \xi_{i4,t} \sim I(0) \tag{4.16}$$

Where $E_t(\Delta e^*_{i,t+1})$ is the expected rate of depreciation of country i^{th} currency between time t and $t+1$. Note that Equation (4.14) represents the Fisher equation and suggests that the real interest rate is stationary. Equations (4.15) and (4.16) represent the UIP condition and the Term Premium, respectively. Based on the empirical result for the selected countries, $E_t(\Delta\ e^*_{i,t+1})$ is *I(0)*, therefore, the UIP condition reduces to:

$$sr_{it} - sr^*_{it} \approx I(0) \tag{4.17}$$

[40] Dees, Holly, Pesaran, and Smith (2007) present the results of testing six long-run relations to capture output growth, inflation, the interest rates, and the exchange rate. However, based on the stability and Persistent Profile tests results of the estimated GVAR, only three over-identification restrictions have been chosen in their study which have been adopted here, too.

Having considered the determined co-integrating relations across countries as presented in Table 4.4 and the specified long-run macroeconomic relationships, now we can proceed to testing these over-identification restrictions. Given our co-integrating vectors, we can impose a maximum numbers of three β_{ir} vectors as over-identification restrictions representing Equations (4.14), (4.15), and (4.16) as follows.[41]

$$\beta_{i1} = \begin{pmatrix} 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$\beta_{i2} = \begin{pmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$\beta_{i3} = \begin{pmatrix} 0 & 0 & 1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

[41] As Dees, Holly, Pesaran, and Smith (2007) explain, the choice of the possible long-term restrictions has been made upon the satisfactory performance of the GVAR model in terms of stability, persistence profiles, and IRFs. If the persistence profiles for any combination of co-integrating relations do not converge to zero as the horizon increase, then they must be disregarded as valid relations.

Table 4.9. Over-Identified Long-Run Relations-Restricted Fisher Equation

Country	r	Fisher Equation	Term Premium	UIP Conditions	LR (df)	99% CV
Australia	3	$sr_{it}-\pi_{it}$	$sr_{it}-lr_{it}$	$sr_{it}-sr_{it}^{*}$	**132.24 (36)***	151.17
Canada	3	$sr_{it}-\pi_{it}$	$sr_{it}-lr_{it}$	$sr_{it}-sr_{it}^{*}$	**142.1 (36) ***	158.60
China	1	$sr_{it}-\pi_{it}$	NA	NA	**43.97 (12) ***	53.65
Japan	3	$sr_{it}-\pi_{it}$	$sr_{it}-lr_{it}$	$sr_{it}-sr_{it}^{*}$	159.50 (36)	152.30
Euro Area	3	$sr_{it}-\pi_{it}$	$sr_{it}-lr_{it}$	$sr_{it}-sr_{it}^{*}$	**144.55 (36) ***	146.06
UK	3	$sr_{it}-\pi_{it}$	$sr_{it}-lr_{it}$	$sr_{it}-sr_{it}^{*}$	157.11 (36)	142.03
US	2	$sr_{it}-\pi_{it}$	$sr_{it}-lr_{it}$	NA	90.9 (18)	76. 50

Note: This Table reports the over-identification test results of the focused countries. r is the number of co-integration vectors. LR is the log-likelihood ratio statistic for testing the long-run restrictions, with the number of over-identifying restrictions provided in brackets. The bootstrapped upper one percent critical value of the LR statistic is provided in the last column. An Asterisk ,*, in LR results indicates that the over-identified restriction cannot be rejected by the data over the 1979:Q2-2013:Q1 sample.

Table 4.9 reports the result of testing these long-run relations within our GVAR model for the selected countries based on the log-Likelihood Ratio, *LR* statistic. The results are obtained based on restricting the inflation coefficient in the Fisher equation to unity. As can be seen in Table 4.9, the Fisher equation, Term Premium, and the UIP condition cannot be rejected for the Euro Area. In addition, based on *LR* statistic, the Fisher equation cannot be rejected in China implying that there is long-run relationship between short-term interest rates and inflation. However, in the case of the US and the UK, long-run relations are rejected.

As noted in Dees, Holly, Pesaran, and Smith (2007), the value of the inflation coefficient may represent its amount in the Central Bank policy rule. Thus, fixing the coefficient in the Fisher equation to unity can lead to inaccurate results. In fact, as the Taylor principal suggests, the coefficient of inflation should be greater than unity to ensure an accurate path for the real interest rates and output, consequently. Thus, alternative to the restricted Fisher equation, the coefficient of inflation can be allowed to be unrestricted and be estimated outside the GVAR model. Table 4.10 presents the results for the unrestricted Fisher Equation. For this purpose, we estimate β_{i1} for each country model as follows.

$$\beta_{i1}=\begin{pmatrix}0 & \beta_{i,12} & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\end{pmatrix}$$

Table 4.10. Over-Identified Long-Run Relations-Unrestricted Fisher Equation

Country	r	Fisher Equation	Term Premium	UIP Conditions	LR (df)	99% CV
Australia	3	$sr_{it} - 1.09\pi_{it}$	$sr_{it} - lr_{it}$	$sr_{it} - sr_{it}^{*}$	**132.24 (35)***	151.17
Canada	3	$sr_{it} - 1.13\pi_{it}$	$sr_{it} - lr_{it}$	$sr_{it} - sr_{it}^{*}$	**142.1 (35) ***	158.60
China	1	$sr_{it} - 0.67\pi_{it}$	NA	NA	**43.97 (13) ***	53.65
Japan	3	$sr_{it} - 2.03\pi_{it}$	$sr_{it} - lr_{it}$	$sr_{it} - sr_{it}^{*}$	152.64 (35)	148.32
Euro Area	3	$sr_{it} - 1.11\pi_{it}$	$sr_{it} - lr_{it}$	$sr_{it} - sr_{it}^{*}$	**134.25 (35) ***	136.16
UK	3	$sr_{it} - 1.67\pi_{it}$	$sr_{it} - lr_{it}$	$sr_{it} - sr_{it}^{*}$	143.18 (35)	139.43
US	2	$sr_{it} - 1.96\pi_{it}$	$sr_{it} - lr_{it}$	NA	**64.9 (17) ***	**66. 50**

Note: This Table reports the over-identification test results of the focused countries. *r* is the number of co-integration vectors. *LR* is the log-likelihood ratio statistic for testing the long-run restrictions, with the number of over-identifying restrictions provided in brackets. The bootstrapped upper one percent critical value of the *LR* statistic is provided in the last column. An Asterisk,*, in *LR* results indicates that the over-identified restriction cannot be rejected by the data over the 1979:Q2-2013:Q1 sample.

The results of unrestricted Fisher equation suggests that as the *LR* statistics in the UK and Japan are greater than their critical values, therefore, the specified long-run relations can be rejected for these two countries while for the rest of countries these relations are validated.

Given the results, while the restricted Fisher hypothesis is rejected in the US, UK, and Japan it can be supported for the other economies. In the case of the unrestricted Fisher relation that seems to be more in line with economic intuition, the results provides support that expect for Japan, and the UK, the Fisher relation holds. Likewise, based on the *LR* test results presented in Table 4.10, both the Term Premium and the UIP relations can be held for the economies of interest with the exception of the UK and Japan. Furthermore, even in the case of Japan and the UK with having LR statistic above their critical values, their Persistence Profiles, as presented in Figure 4.6, shows that these relations converge to zero over the time. We proceed to discussing Persistence Profiles of the long-run relations for both the simple and the fiscal-augmented GVAR models in the next section.

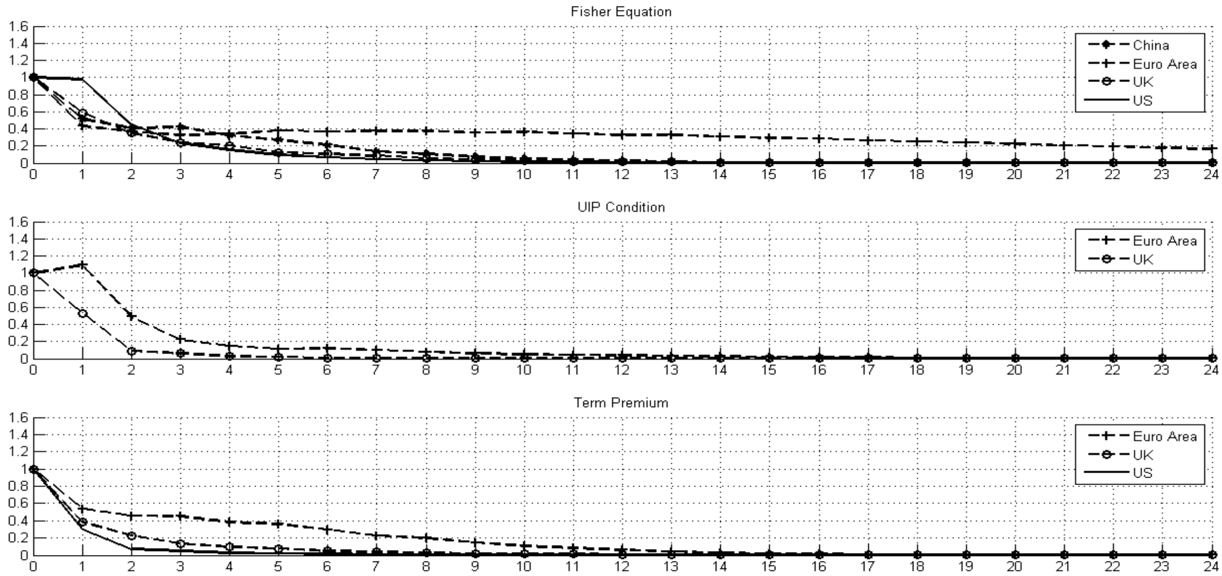
4.6.1 Persistence Profiles

Once a system of long-run co-integration relations is shocked, the speed in which the relationships return to their equilibrium is very important. As Dees, Holly, Pesaran, and Smith (2007) discuss, Persistence Profiles (PP) test, proposed by Pesaran and Shin (1996), shows the time profiles of the effects of variable-specific shocks on the co-integrating relations while the GIRFs refer to the time profile of the effects of variable-specific shocks on all the variables in the model. In other words, Persistence Profiles shows how fast the long-run relationships converge to the equilibrium following an imposed shock to the co-integrating relations within the GVAR model.

To understand the way that US government debt may influence the speed of adjustment for the long-run relationship, Figures 4.5 and 4.6 present the Persistence Profile test results corresponding to the simple and fiscal-augmented GVAR models include the long-run over-identification relations. As explained in Dees, Holly, Pesaran, and Smith (2007), the value of the PP is unity on impact, which must return back to zero as $n \to \infty$. It can be seen from Figure 4.6 that the Fisher relationship is less persistence compared with the Term Premium and the UIP conditions. For the Fisher equation, any shock is corrected in between 4 and 6 years while the fastest convergence occurs for the Euro Area, and the UK is the slowest.

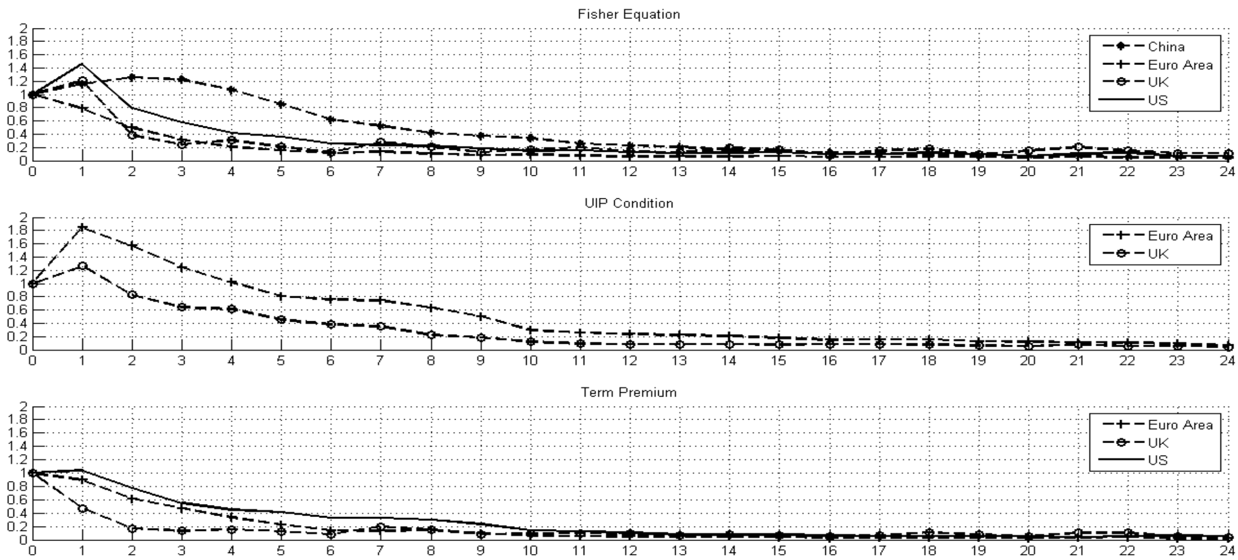
The convergence time for the UIP conditions is almost 5 years following a shock. This is consistent with the existing empirical literature as the UIP relation can diverge from equilibrium for a longer period due to the slow adjustment of expectations to any actual changes in monetary policy, see Dees, Holly, Pesaran, and Smith (2007). The Term Premium relations displays rather faster Persistence Profiles as less than four years time is required to return back to steady-state after a shock. Overall, the reasonableness of Persistence Profiles suggest that these theory-based relations appear to be valid and cannot be rejected even in the presence of government debt.

Figure 4.5. The Simple GVAR Model Persistence Profiles of the Long-Run Relations



Note: This Figure presents Persistence Profile for the US, China, the Euro Area, and the UK demonstrating co-integration relations and speed of convergence to equilibrium.

Figure 4.6. Fiscal-Augmented GVAR Model Persistence Profiles of the Long-Run Relations



Note: This Figure presents Persistence Profile for the US, China, the Euro Area, and the UK demonstrating co-integration relations and speed of convergence to equilibrium.

Comparing the results within the simple model with those obtained from the fiscal-augmented, it appears that government debt contributes to slowing the process of correction the imposed shocks to the system for the Fisher and Term Premium relations.[42] It implies that any

[42] As is presented in Dees, Holly, Pesaran, and Smith (2007), within a monetary-focused GVAR model, the Fisher equation and the Term Premium almost take two years to return to equilibrium while the time required for the UIP condition is considerably greater nearly after six years.

policy shocks would require rather longer time to return back to equilibrium when these relations are held and in presence of government debt. It can be due to the impact of fiscal policy on inflation and its persistence. As noted, we find evidence that fiscal policy may contribute to the persistence of the price puzzle. The government debt can also induce a reduction in the speed of adjustment to the equilibrium in the long-run.

4.7 Concluding Remarks

This Chapter explores the implication of government debt for the monetary policy transmission at both the domestic and international level. The study focuses on three main objectives. First, to examine the way in which the outcome of US contractionary monetary policy shock may differ in the presence of government debt. It also aims to investigate the international transmission of US monetary contraction on the economies of interest while it accounts for US government debt. Second, we examine the impact of US fiscal expansionary policy and its potential international spillovers. Third, we investigate the contribution of government debt to long-run macroeconomic relations.

Having discussed both the Ricardian and non-Ricardian arguments on the effectiveness of fiscal policy to stimulate the economy, we estimate two GVAR model specifications: a simple and a government debt-augmented GVAR model. Our overall results from the estimated GVAR model suggest that real output and long-term interest rates are highly correlated across countries, while real exchange rates, short-term interest rates and inflation show a modest correlation. As regards the contemporaneous effects of foreign variables, empirical evidence suggests that Euro Area bond market is more responsive than its monetary policy reactions. This finding is also reported in Dees et al. (2007).

The impulse responses from the estimated GVAR models also suggest a number of features. First, we can observe that both prices and output increase in response to monetary contraction within both the simple and fiscal-augmented model. However, US government debt influences the duration of responses to a monetary contraction. Given the high level of US government debt, this finding seems to be reasonable, as any changes in interest rates would significantly change the interest expenses share of government expenditure. Second, we find empirical support for the non-Ricardian view on fiscal policy within the US economy. It is shown that fiscal shocks tend to have significant domestic and international spillovers on real and financial variables. In particular, the results suggest that US expansionary fiscal policy shock influences real output and the bond markets in the Euro Area and UK. Third, according to the estimated LR test to examine the potential contribution of US government debt to long-run macroeconomic relations within the GVAR, we find that the unrestricted Fisher equation, the Term Premium, and the UIP condition hold for the US and the other economies. Finally, the results of Persistence Profiles test suggest that government debt reduces the speed of adjustment to equilibrium following policy shock. This may be due to the impact of fiscal policy on inflation and its persistence.

Given that the presented results are limited to our GVAR model, a few dimensions is emerged for further research as follows. As our results come from a linear GVAR model with constant parameters, a non-linear version of the GVAR as those of Favero (2013) that taking into account potential monetary and fiscal regime changes may capture the potential impact of the fiscal stance on the monetary transmission mechanism more accurately. It may also be insightful to construct a Time-Varying Parameter (TVP) version of the GVAR to capture the potential macroeconomic regime changes. Exploring the topic with alternative approaches for the identification of monetary and fiscal policy shocks is also left to future work.

Appendix 4.A-Unit Root Test

Table 4.A.1. Unit Root Test for Domestic-Specific Variables

Variable	WS Statistic	Australia	Canada	China	Euro Area	Japan	UK	US
y_{it} (trend)	*-3.24*	-2.82	-2.34	-1.96	-1.60	-0.98	-2.86	-2.24
y_{it} (de-trended)	*-2.55*	1.59	0.67	0.38	0.49	0.63	-0.74	0.28
Δy_{it}	*-2.55*	**-6.29***	**-4.99***	**-3.32***	**-4.69***	**-3.94***	**-2.87***	**-4.56***
π_{it} (trend)	*-3.24*	-3.07	-2.77	-3.07	-0.90	-2.47	-3.18	-1.53
π_{it} (de-trended)	*-2.55*	-2.36	-1.54	-2.01	0.79	-0.71	-0.10	-0.09
$\Delta \pi_{it}$	*-2.55*	**-9.68***	**-8.51***	**-6.79***	**-6.69***	**-8.48***	**-7.51***	**-8.37***
ep_{it} (trend)	*-3.24*	-2.60	-1.82	-1.05	-2.22	-1.86	-2.66	NA
ep_{it} (de-trended)	*-2.55*	0.12	1.02	-1.05	-0.41	0.02	-0.53	NA
Δep_{it}	*-2.55*	**-7.78***	**-7.40***	**-7.02***	**-6.85***	**-4.93***	**-7.96***	NA
eq_{it} (trend)	*-3.24*	-2.91	-2.60	NA	-2.43	-1.80	-1.53	-1.71
eq_{it} (de-trended)	*-2.55*	-1.13	-0.93	NA	-0.92	-1.65	-0.31	-0.48
Δeq_{it}	*-2.55*	**-6.99***	**-7.02***	NA	**-6.71***	**-5.01***	**-7.28***	**-6.14***
lr_{it} (trend)	*-3.24*	-2.01	-2.62	NA	-3.06	-1.90	-3.10	-3.16
lr_{it} (de-trended)	*-2.55*	-1.24	-0.49	NA	-0.60	0.01	0.24	-0.41
Δlr_{it}	*-2.55*	**-5.63***	**-7.37***	NA	**-5.52***	**-5.63***	**-7.90***	**-6.99***
sr_{it} (trend)	*-3.24*	-2.42	-3.02	-1.61	-3.02	-2.64	-2.96	-2.62
sr_{it} (de-trended)	*-2.55*	-1.95	-0.61	-1.42	-0.77	-1.03	-0.38	-0.07
Δsr_{it}	*-2.55*	**-7.27***	**-6.20***	**-6.05***	**-5.79***	**-5.21***	**-6.87***	**-4.11***
gdr_{it} (trend)	*-3.24*	-3.02	-1.77	-2.34	-3.12	-1.51	-2.50	-2.42
gdr_{it} (de-trended)	*-2.55*	-2.05	-1.31	0.75	-0.40	0.20	-2.22	-1.36
Δgdr_{it}	*-2.55*	**-3.29***	**-2.99***	**-2.81***	**-3.38***	**-3.28***	**-3.09***	**-2.80***

Note: Unit Root t-statistics is reported based on Weighted Symmetric estimation of ADF (WS) type regressions due to its superior performance compared to the standard ADF test as it exploits the time reversibility of stationary autoregressive processes. The lag length employed in the WS unit root tests is selected by the Akaike Information Criterion (AIC). An asterisk,*, indicates the rejection of the null hypothesis of unit root at the 95% significance level. The blank spaces are either due to setting as reference country, i.e. the US, or data limitation, i.e. China. All the statistics are computed over the sample 1979:Q2-2013:Q2.

Table 4.A.2. Unit Root Tests for Global Variable

Global Variable	WS Statistic	t-Statistic
p_t^{oil} (trend)	-3.24	-1.12
p_t^{oil} (de-trended)	-2.55	-0.91
Δp_t^{oil}	-2.55	**-6.46***
p_t^{mat} (trend)	-3.24	-2.43
p_t^{mat} (de-trended)	-2.55	-1.28
Δp_t^{mat}	-2.55	**-5.67***
p_t^{metal} (trend)	-3.24	-2.27
p_t^{metal} (de-trended)	-2.55	-0.95
Δp_t^{metal}	-2.55	**-5.16***

Note: Unit Root t-statistics is reported based on Weighted Symmetric estimation of ADF (WS) type regressions due to its superior performance compared to the standard ADF test as it exploits the time reversibility of stationary autoregressive processes. The lag length employed in the WS unit root tests is selected by the Akaike Information Criterion (AIC). An asterisk ,*, indicates the rejection of the null hypothesis of unit root at the 95% significance level. All the statistics are computed over the sample 1979:Q2-2013:Q2.

Table 4.A.3. Unit Root Tests for Foreign-Specific Variables

Variable	WS Statistic	Australia	Canada	China	Euro Area	Japan	UK	US
y_{it}^{*} (trend)	*-3.24*	-2.18	-2.40	-1.60	-3.08	-3.59	-1.76	-2.95
y_{it}^{*} (de-trended)	*-2.55*	1.28	0.33	0.48	0.67	-0.05	0.62	0.99
Δy_{it}^{*}	*-2.55*	**-5.37***	**-4.54***	**-4.61***	**-4.29***	**-3.48***	**-4.74***	**-5.23***
π_{it}^{*} (trend)	*-3.24*	-3.07	-1.69	-0.76	-2.41	-3.05	-1.24	-3.06
π_{it}^{*} (de-trended)	*-2.55*	-1.72	-0.05	1.20	-0.89	-2.30	0.67	-1.28
$\Delta \pi_{it}^{*}$	*-2.55*	**-7.18***	**-8.38***	**-7.74***	**-8.08***	**-7.06***	**-7.44***	**-7.35***
eq_{it}^{*} (trend)	*-3.24*	-1.96	-1.76	-2.11	-1.84	-2.16	-2.34	-3.01
eq_{it}^{*} (de-trended)	*-2.55*	-0.85	-0.49	-0.74	-0.48	-0.62	-0.81	-0.99
Δeq_{it}^{*}	*-2.55*	**-6.81***	**-6.24***	**-6.69***	**-6.74***	**-6.50***	**-6.65***	**-6.99***
lr_{it}^{*} (trend)	*-3.24*	-2.54	-2.08	-2.77	-3.02	-3.00	-2.76	-3.10
lr_{it}^{*} (de-trended)	*-2.55*	-0.05	-0.28	-0.12	0.19	-0.25	-0.34	-0.22
Δlr_{it}^{*}	*-2.55*	**-5.65***	**-6.95***	**-6.02***	**-6.81***	**-6.59***	**-5.97***	**-6.25***
sr_{it}^{*} (trend)	*-3.24*	-3.07	-2.89	-3.14	-2.26	-2.93	-2.41	-2.89
sr_{it}^{*} (de-trended)	*-2.55*	-0.60	0.06	-0.06	-0.68	-0.57	-0.43	-0.55
Δsr_{it}^{*}	*-2.55*	**-4.31***	**-4.13***	**-3.88***	**-5.13***	**-5.05***	**-5.21***	**-4.89***
gdr_{it}^{*} (trend)	*-3.24*	-1.35	-2.39	-3.00	-2.19	-1.91	-3.04	-2.96
gdr_{it}^{*} (de-trended)	*-2.55*	1.20	-0.64	0.93	0.79	0.37	0.13	0.55
Δgdr_{it}^{*}	*-2.55*	**-2.69***	**-2.70***	**-2.93***	**-3.27***	**-3.02***	**-3.13***	**-2.73***

Note: Unit Root t-statistics is reported based on Weighted Symmetric estimation of ADF (WS) type regressions due to its superior performance compared to the standard ADF test as it exploits the time reversibility of stationary autoregressive processes. The lag length employed in the WS unit root tests is selected by the Akaike Information Criterion (AIC). An asterisk ,*, indicates the rejection of the null hypothesis of unit root at the 95% significance level. All the statistics are computed over the sample 1979:Q2-2013:Q2.

Appendix 4.B-Data series

1. Real GDP

The IFS 99BVRZF series (GDP VOL) has been used for Australia, Canada, France, Germany, Italy, Japan, Netherlands, Spain, United Kingdom, and United States. For Austria, Belgium, Finland the IFS 99BVPZF series (GDP VOL) has been used. For China, as there is no quarterly real GDP index published, it is derived from a nominal GDP series released by National Bureau of Statistics (NBS) and adjusted by CPI. All these series has been seasonally adjusted using the quarterly growth rate of the adjusted IFS series from 2004Q1 to 2009Q4.[43]

2. Consumer Price Index

The IFS CPI 64zf series has been used to build the consumer price index for all selected countries excluding China in which data source is National Bureau of Statistics from Datastream data.

3. Short-term Interest Rate

The IFS is the main source of data for short-term interest rates. For China, the IFS Deposit Rate (60Lzf series) has been used. The IFS Treasury Bill Rate (60Czf series) was used for Canada, UK and US. The IFS Money Market Rate (60Bzf series) was used for Australia, Finland, Germany, Italy, Japan, and Spain. For Austria, Belgium, France, and the Netherlands no data was available for any of these series from 1999Q1 when the euro was introduced. The country specific IFS Money Market Rate (60Bzf series) was used from 1979Q1 to 1998Q4 and completed to 2009Q4 using the corresponding series (60Bzf series) for Germany as the representative euro interest rate.

4. Long-term Interest Rate

The IFS Government Bond Yield (61zf series) has been used as a measure of long-run interest rates.

5. Exchange Rates

Exchange rates series are from Bloomberg. A quarterly average of the nominal bilateral exchange rate vis-à-vis the US dollar has been computed for each country based on the closing value of the last Wednesday of each month.

6. Equity Price Index

Equity price index series are from Bloomberg using a quarterly average of the MSCI country index based on the closing value of the last Wednesday of each month. [44]

7. Government Debt-to-GDP Ratio

The IMF Government Financial Statistics is the source of data for government primary net lending/borrowing as a Percent of GDP (Code: GGXONLB_NGDP).

8. Broad Money

The broad money is downloaded from the OECD data series.

9. Trade Matrix

The IFS DOT statistics has been used to build the trade matrix choosing the c.i.f. for both exports and imports available at the annual frequency.

10. Oil Price Index

The price of oil is based on a Brent series from Bloomberg (Series: Current pipeline export quality Brent blends) using quarterly averaged of daily closing prices for all trading days.

11. Other commodities Indices

The agricultural raw material and metals price indices were both taken from the IMF's Primary Commodity Prices monthly data. Because the IMF data starts in 1980, the series were extrapolated backwards to 1979 using the growth rate of the monthly price indices (2010 = 100) from the World Bank. Monthly averages of the indices were taken for each quarter.[45]

12. PPP-GDP Data

The main source for construction of the country specific PPP-GDP weights is the World Development Indicator database of the World Bank.The Purchasing Power Parity (PPP) terms is used to construct the PPP-GDP weights obtained from the World Development Indicator database of the World Bank in current international dollars (Ticker: NY.GDP.MKTP.PP.CD).

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[43] A detailed procedure of seasonal adjustment and interpolation methods can be found in Dees et al. (2007).
[44] A detailed procedure of seasonal adjustment and interpolation methods can be found in Dees et al. (2007).
[45] See Dees et al. (2007), for further details.

Chapter 5

Domestic and International Macroeconomic Impact of US Unconventional Monetary Policy

Abstract

This chapter explores both the domestic and international macroeconomic impact of Unconventional Monetary Policy (UMP) in the US. The empirical evidence concerning the domestic effectiveness of UMP is obtained from a Factor-Augmented VAR (FAVAR) model comprises 195 US monthly time series spanning the 2007:M06-2013:M06 period. The Impulse Responses Functions (IRF) suggest that an increase in broad money can lead to an increase in economic activity and prices. A policy-induced fall in the bond yields spread within the FAVAR model also increases economic activity and prices. These findings turn out to be qualitatively similar to the literature on the effects of UMP. Taking into account the potential leakages from implementation of UMP through trade across countries, this chapter also examines the international spillovers of policy within a Global VAR (GVAR) model. The unique structure of GVAR methodology allows us to capture the international transmission of policy shocks through a trade-weighted matrix among the economies of interest. The results within the GVAR model suggests that both output and equity prices are highly correlated across countries. In addition, a fall in the US spread induces a fall in Euro Area and UK bond yield spreads as well. This implies that bond yield spreads are linked globally that is consistent with the literature as has been reported in Dees et al. (2007). Furthermore, Impulse Responses suggest that UMP, in the form of a fall in the yield spreads and increase in broad money, can significantly increase US output and generate international spillovers to the Euro Area and UK. However, changes in the bond yield spread is more effective to generate international spillovers within the Euro Area and UK, while an increase in broad money is more effective to improve the US economy. Finally, we find that there is a negative correlation between the spread and the equity prices that suggests UMP shocks are transmitted through the portfolio balance channel. Portfolio balance channel refers to lowering long-term interest rates through Open Market Operations leading to changes in portfolios.

JEL classification Code: C33, C52, E52, E58, E61

Key Words: Unconventional Monetary Policy, Portfolio Balance Channel, International Spillovers, Government Debt, Factor-Augmented VAR, Global VAR

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5.1 Introduction

This chapter contributes to the empirical literature on the macroeconomic impact of US Unconventional Monetary Policy (UMP) domestically and internationally. We also consider the potential role of government debt in the monetary transmission mechanism. In the face of the recent financial crisis, Conventional Monetary Policy (CMP) was confronted with the Zero Lower Bound (ZLB) of interests. Major Central Banks, with interest rates constrained at the ZLB, considered alternative monetary policy tools, namely UMP. However, the question regarding the effectiveness of the non-standard policy measures remains highly controversial, see Bauer and Neely (2013).

As explained in Chapter 2, UMP mainly takes one of these following forms: (i) forward guidance for future policy rates, (ii) Credit Easing (CE), and (iii) Quantitative Easing (QE), see Gagnon et al. (2011), Joyce et al. (2011), and Kapetanios et al. (2012). However, the core idea of UMP appears to focus on Central Banks' balance sheet policy by targeting either a change in the composition of the balance sheet, i.e. quantitative easing or an expansion in the size of the balance sheet, i.e. credit easing. The balance sheet policy in the form of QE has three main elements: (i) an explicit target for bank reserve, (ii) a conditional commitment to maintain high reserve levels in the future, and (iii) increased purchases of government bonds to facilitate the achievement of the target on bank reserves, see Borio and Disyatat (2010). Hence, QE as a combination of bank reserve policy and quasi-debt management policy, that is purchases of government bonds, may refer to any Central Bank's operation that results in a rise in the reserves, see Auerbach and Obstfeld (2005), Taylor and Williams (2010). The most obvious advantage of QE is to inject an excess of reserves to the market that can evade short-term interest rate volatility and keep the interest rate constant around zero, see Bowdler and Radia (2012).

The target of the proposed UMP is to lower long-term interest rates and provide more liquidity in order to stimulate the economy.[1] There are two channels for the transmission of UMP, namely the portfolio balance and signalling. Portfolio balance channel refers to lowering long-term interest rates through Open Market Operations. Within the portfolio balance channel, the LSAP increase is assumed to the price of purchased assets and their close substitutes, and to include a fall in their returns. The objective is that ultimately to stimulate aggregate demand due to a positive wealth effect. In addition, the policy-induced increase in money supply tends to depreciate the domestic currency and improve the current account, see Joyce et al. (2011), and Kapetanios et al. (2012). The announcements of LSAP will also influence government bond yields through the signalling channel. Signalling channel refers to generating expectations of lowering the future short-term interest rates. The signalling channel implies that investors consider the LSAP announcement as an indication of a lower path for future short-term interest rates. This would also affect the expectations component of long-term interest rates, see Bauer and Neely (2013).[2]

The literature on the transmission channels of UMP and the persistence of the impact suggests that Central Banks asset purchases program mainly affect bond yields and other asset prices due to a reduction in term premia through portfolio balance channel, see D'Amico and King (2013), Gagnon et al. (2011), Joyce et al. (2011), and Pesaran and Smith (2012). For example, Gagnon et al. (2011) find that the $300 billion of US bond purchases, which amount to approximately 2 percent of GDP, lowered US 10-year Treasury yields by around of 90 basis points.[3] Furthermore, the existing evidence suggests that the Federal Reserve's purchases of US Treasuries have affected yields through both the portfolio balance and signalling channels, see

[1] The Large Scale Asset Purchases (LSAP) program has been executed by purchasing bonds or assets from financial institutions financed by Central Bank's money to stimulate the economy through boosting nominal expenditure and thereby increasing domestic inflation, see Joyce et al. (2011).
[2] Note that as discussed in Woodford (2012), the announcement includes both explicit and implicit signals for the future short-term path.
[3] There are disparities among studies regards measuring the impact of US-UMP on the government's bond yields. For example, Hamilton and Wu (2012) report 13 basis points reduction following the policy, D'Amico and King (2013) report US bond yields being 45 basis points lower after UMP, while those of Fawley and Neely (2013) shows around of 107 basis points reduction in the yields.

Bauer and Neely (2013), and D'Amico and King (2013).[4] In addition, Curdia and Woodford (2011) discuss that the effectiveness of UMP depends upon the degree of substitution of the assets. For example, if Central Banks purchases assets with identical characteristic to bank reserves, agents may not consider to rebalance their portfolio, thus, the impact tends to be insignificant.[5]

Given that the signalling and portfolio balance are the main transmission channels for UMP, the existing literature on the effectiveness of UMP is controversial.[6] For example, while Friedman and Schwartz (1963) argued that the Great Recession would have been more moderate if the Federal Reserve had injected more reserves into the markets, some argue that injecting more free money should not per se affect the decisions of rational agents, see Curdia and Woodford (2009) for a detailed discussion. Recently, Woodford (2012) explains that the discrepancy between results on the effectiveness of UMP depends upon the way that agents perceive the policy intervention. For example, under an UMP in the form of policy commitment that the Central Bank commits to keep the nominal interest rate near to ZLB until achieving a certain target, say a specific level for nominal GDP, the policy impact tends to be substantial. In contrast, if UMP aims to persist until the Central Bank achieved its usual targets and then return to its usual path, the policy outcome tends to be lower. In practice, however, policy often relies on a combination of commitment to a clear target as guidance for future interest rate policy, with immediate policy actions to stimulate spending.

Having noted the literature on the impact of US-UMP in order to stimulate the economy and prevent deflation, however, the existing studies mainly concern the domestic outcome of the

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[4] Christensen et al. (2009) report that the Federal Reserve's QE program mainly worked through the signaling channel. However, their results suggest that the portfolio balance channel has been more effective to decline the yields of UK bonds yields in response to UK-UMP. Their model allows for decomposing the fall in yields into changes in the expected future policy rates and changes in term premia.

[5] As discussed in Brunner and Meltzer (1972), Central Banks can influence the pattern of yields on different assets by altering the supply of assets with different durations and liquidity, given that assets are imperfect substitutes. This implies that an important component of the portfolio balance channel is the heterogeneity across agents, as some people would consider holding different portfolios with different duration and liquidity.

[6] For a concise review of the literature on the effects of LSAP program, see Rosa (2012).

policy intervention.[7] As concerns the international macroeconomic impact of US-UMP, we identify a gap in the literature. It is important that the assessment of UMP account for the potential international spillovers of the policy and the way that the fiscal stance may influence the policy outcome. Indeed, there is little literature on exploring the UMP and its transmission mechanism in a global framework.[8] Our approach to examine the domestic macroeconomic impact of UMP is close to those of Baumeister and Benati (2013), Gagnon et al. (2011), Joyce et al. (2011,2012), Kapetanios et al. (2012), Pesaran and Smith (2012), and Gambacorta et al. (2014) as is outlined in Table 5.1. We follow this literature and focus on the portfolio balance as the main transmission channel for US-UMP.

In doing so and given the motivation of this Chapter, we employ the Factor-Augmented VAR (FAVAR), and the Global VAR (GVAR) methodologies to examine the domestic and international impact of US-UMP, respectively. By previewing the results, it is shown that UMP implemented in the US influenced the real economy within not only the US, but also China, the Euro Area, and UK. We find that US-UMP leads to a significant but temporary rise in output and prices in the US economy. This result turns out to be robust to both the FAVAR and GVAR model specifications. The output effects are qualitatively similar to the ones typically found in the literature on the effectiveness of the UMP as Table 5.1 outlines. The impact on the price level, on the other hand, seems to be less persistent and weaker. Furthermore, based on the pair-wise cross-sectional test results, we find evidence that output and equity prices are significantly correlated across countries, while the global correlation is smaller for inflation, bond yield spread, and the exchange rate. Finally, the results of the Nyblom parameter stability test provide evidence that our results are robust to potential parameter instability.

[7] See Strobebel and Taylor (2009), Fuster and willen (2010), Gagnon et al. (2011), Joyce et al. (2011), Peersman (2011), Swanson (2011), Kapetanios et al. (2012), Pesaran and Smith (2012), Baumeister and Benati (2013), and D'Amico and King (2013) among others.

[8] We can referred to Pesaran and Smith (2012), and Gambacorta et al. (2014) as a few exceptions which is described in the literature review section.

This Chapter contributes to the empirical literature on the both domestic and international spillovers of UMP within the models that account for public debt together with macro and finance variables. Our contribution to the empirical literature on the UMP is as follows. First, within a FAVAR framework we show that US-UMP can significantly increase output and inflation. Our finding is consistent with those presented in Baumeister and Benati (2013), Gambacorta et al. (2014), and Wu and Xia (2014). Second, the impulse response results within the estimated GVAR model suggest that US-UMP has generated international spillovers stimulating the Euro Area and UK economies. Third, the portfolio balance seems to be the most likely transmission channel of the policy implemented. We find that there is a negative correlation between the spread and the equity prices that suggests the policy potentially is transmitted through the portfolio balance channel.

The organization of the chapter is as follows. Section 5.2 provides a brief review of the related literature. Models specification and empirical results are presented in section 5.3 and section 5.4 concludes the study.

Table 5. 1. Key Literature on the Macroeconomic Impact of UMP

Study	Methodology	Size of the Shock	Main Contribution
Baumeister and Benati (2013)	TVP-SVAR	100 bps negative shock to the 10-year Treasury bond yield spread	US-GDP growth increased by 2.4% together with an increase in inflation by 1.6 %.
Gagnon et al. (2011)	Event-Study and Times Series Regression	NA	US-long-term interest rates is reduced by 90-110 bp.
Kapetanios et al. (2012)	BVAR, Markov-Switching SVAR, and TVP-FAVAR	100 bps negative shock to the 10-year Treasury bond yield spread	UK-GDP growth increased by 1.5 % together with an increase in inflation by 1.25 % at peak.
Joyce et al. (2011)	VAR and GARCH-M Models	NA	UK-long-term interest rates is reduced by 100 bp.
Pesaran and Smith (2012)	Autoregressive Distributed Lag (ARDL) Counterfactual	100 bps negative shock to the UK spread	UK-GDP growth increased by 0.75-1 % depending on whether foreign output is included or excluded, respectively.
Gambacorta et al. (2014)	Mean Group Panel VAR	An increase in the balance sheet around of 3%	US-output increased by 0.06 % together with an increase in inflation by 0.025 %.

Note: This Table summarizes the related literature that the chapter is constructed upon it. bp abbreviates basis points. SVAR stands for Structural VAR. BVAR stands for Bayesian VAR. TVP-FAVAR stands for Time-Varying Parameter Factor-Augmented VAR. GARCH stands for Generalized Autoregressive Conditional Heteroskedasticity.

5.2 Review of the Literature on Unconventional Monetary Policy

There exist a growing literature argues that Central Banks can influence the economy at the ZLB by implementing non-standard monetary policy measures. So far, this argument has been empirically tested twice. Once, in the early 2000s in Japan, and then after the 2008 financial crisis, a number of advanced economies pursued UMP to stimulate economic growth, see Okina and Shiratsuka (2004), Girardin and Moussa (2011), and Schenkelberg and Watzka (2013).[9]

Although UMP initially aimed to reduce financial market distress, they also targeted to stimulate the real economy. UMP measures are expected to increase the supply of money by either direct lending to commercial banks and private sector or involving purchases of long-term assets that are intended to reduce long-term interest rates, see Fawley and Neely (2013).

Early work on the impact of UMP has begun following Operation Twist in the United States in 1961. This operation involved Federal Reserve purchases of long-term bonds financed by sales of short-term Treasury Bills. The objective was to lower long-term interest rates.[10] Then in early 2000s, the Bank of Japan adopts UMP in the form of large-scale asset purchases with the objective of facilitating direct lending to banks. This policy has changed both the components and the size of the Bank of Japan's balance sheet. Although UMP implemented in Japan has prevented further recession and deflation, it has not increased output and inflation sufficiently, see Okina and Shiratsuka (2004), Girardin and Moussa (2011), and Schenkelberg and Watzka (2013).

The empirical literature on the Japan-UMP suggests that the policy impacts market expectations through signalling channel, see Ugai (2007). In addition, although there is evidence confirming that UMP caused the interest rates to remain low for some time, but the effect of UMP operations on bond yields or risk premia is mixed. For example, Bernanke et al. (2004),

[9] The Federal Reserve and the Bank of England have expanded their supply of money by purchasing a large number of targeted assets. However, the European Central Bank and the Bank of Japan chose to ease their monetary policy stance by increasing direct lending to banks and supply of loans.

[10] Note that as discussed in Chapter 2, the Operation Twist differs from the recent conduct of UMP in the sense that UMP has been financed by the creation of base money.

within a yield curve model, find that Japanese yields were roughly 50 basis points lower than expected after the conduct of UMP. In addition they report Japan-UMP is transmitted through the signalling channel, when the market learned of future declines in the net supply of longer-term Treasury securities.

As regards the transmission channels of US-UMP, in contrast to Japan, the empirical literature suggests that the policy has lowered US long-term interest rates through both signalling and portfolio balance channels, see for example Christensen et al. (2009). In another study, Bauer and Neely (2013) find evidence supporting that US-UMP has affected long-term yields through signalling channel. On the other hand, a number of studies do not allow for the signalling channel by construction and only estimate the relationship between quantities of outstanding government debt and risk premia, see for example Gagnon et al. (2011), D'Amico and King (2013), and Hamilton and Wu (2012). They find that asset purchases lowered bond yields by reducing risk premia in the US. They conclude that UMP is mainly transmitted through the portfolio balance channel.

The literature on the impact of UMP on the long-term interest rate, using event study method, suggests that unconventional policy measures mainly lower long-term yields due to a fall in risk premium and the announcement that short-term interest rates would remain low for an extended horizon, see Gagnon et al. (2011), and Fawley and Neely (2013).[11] The same results, using a cross-section analysis approach, have been reported in D'Amico and King (2013). They find that the bond yields of the purchased securities have been lowered more compared to the other assets. They conclude that the program substantially reduced US long-term Treasury yields which appears to be persistent. Furthermore, Gagnon et al. (2011) employ both event-study and time-series approaches to analyse the impact of UMP on long-term yield spreads in the US.[12] Their results indicate that UMP has led to a long-lasting reductions in long-term interest rates on

[11] Cecioni et al. (2011) provide a comprehensive survey of the evidence on the effectiveness of the various UMP measures adopted by the Federal Reserve and the European Central Bank.
[12] The bond yield spread is defined as the difference between long and short-term interest rate, which is the 10-year government bond yield minus the 3-month Treasury bill.

a range of securities, including securities that were not included in the purchase programs. They show that the primary transmission mechanism is the portfolio balance channel by reducing the risk premium of the assets being purchased and their close substitutes. This would increase the price of assets and hence lower their yields, leading to portfolio rebalancing. This in turns will increase the wealth and reduce the cost of borrowing.[13]

Having discussed the transmission mechanism of UMP, now we consider discussing the macroeconomic impact of the policy. A number of studies find evidence that US unconventional monetary strategy adverted significant risk of both deflation and output collapse. For example, Baumeister and Benati (2013) estimate a Time-Varying Parameter Structural VAR (TVP-SVAR) model to investigate the macroeconomic impact of US-UMP. They find that a reduction in the long-term yield spread increases both output growth and inflation. Their counterfactual simulations also indicate that UMP actions in the US prevents further reduction in output and prices. They use US quarterly data for 1954:Q3–2008:Q4 and find that in the absence of UMP, output growth would have fallen by 10 percent compared to an actual fall of 3 percent and that inflation would have been negative. Their simulation results under conventional monetary policy suggest that the real GDP in US would have been 0.9 percent lower and the inflation rate would have been reached as low as -1 percent in the absence of UMP.

In another study on the effectiveness of US-UMP, Chung et al. (2012) find that this policy intervention raises the level of real GDP by around of 3 percent. They also report that the inflation is 1 percent lower than if the Federal Reserve had not implement UMP. This confirms the effectiveness of the policy to prevent deflation. Their simulations results come from a model that a 50 basis points reduction in long-term interest rates is transmitted through a portfolio balance channel. In addition, they find that the Federal Reserve's asset purchases have an effects equivalent to a cut in the federal funds rate of around 300 basis points from early 2009 to 2012.

[13] The same findings have been reported in Swanson (2011), Hamilton and Wu (2012) suggesting that US-UMP has lowered the long-term interest rates.

As regards the impact of UK-UMP, and having examined the empirical literature, it appears that UK-UMP has been also effective to stimulate the economy and prevent deflation. For example, Baumeister and Benati (2013) examine UK quarterly data spans the 1955:Q1-2008:Q4. They find that in the absent of UK-UMP, in the form of a reduction in long-term interest rates, inflation and output growth would have fallen significantly. In addition, their counterfactual results suggests that the reduction in the long-term interest rate induced by UMP in the UK have prevented deflation and further reduction in output.

In another study, Joyce et al. (2011) using event studies and portfolio balance models find that UK-UMP affects the real economy mainly through the portfolio balance channel and in two stages: an initial impact phases and an adjustment phase. First, asset purchases affect the composition of the portfolios by an increase in the holdings of broad money and a decline in proportion of assets. Then, provided that money and assets are imperfect substitutions, the policy shock causes a portfolio rebalancing leading to an upward pressure on current asset prices and hence a decline in asset returns.

Kapetanios et al. (2012) also find evidence for the effectiveness of UK-UMP. They assumed that UK-UMP has lowered the 10-year government bond yield by 100 basis points. They employed three different approaches to investigate the UMP impact including Bayesian VAR (BVAR), Markov-Switching Structural VAR (MS-SVAR), and a Time-Varying Parameter VAR (TVP-VAR).[14] Their results suggest that UK-UMP had a peak effect on the level of real GDP and inflation of around 1.5 and 1.25 percent respectively, while the reported results vary across the different model specifications. Furthermore, their counterfactual analysis suggests that

[14] They estimate three VAR models in a way that each model incorporate structural change in different ways to produce counterfactual forecasts. They use a large BVAR, estimated over rolling windows, to allow for structural change; an MS-SVAR, where parameters are allowed to change at a particular time to capture regime changes; and a TVP-SVAR, which allows assessing general time variation in parameters. The policy shocks in these models are identified through restrictions on the impulse responses. They assume that UMP acted to reduce bonds spreads. They use monthly data from 1993 to 2011. The BVAR model comprises 43 variables, reflecting real activity, prices, and policy rates in the UK, US, and Euro Area. They employed MS-SVAR model in a switching VAR with four regimes. The VAR part of their model consists of six variables: output growth, inflation, M4 growth, the 3-month Treasury Bill rate, the spread between the 10-year bond rate and the 3-month Treasury Bill rate, and growth in the FTSE all share index.

without UMP the decline in output and inflation would have been larger during 2009. They conclude that unconventional policy implemented in the UK has prevented a deeper recession and deflation.

Similar qualitative finding is reported in Pesaran and Smith (2012) indicating that UMP has been effective in the UK economy. Their results are based on a counterfactual analysis using the bivariate Autoregressive Distributed Lag (ARDL) method. Their model consists of UK domestic output growth, US and Euro Area output growth, and the spread between long and short-term interest rates. They follow the Bank of England assumption that UMP caused a permanent 100 basis points reduction in the UK spread. Their justification for taking the spread as a proxy of UMP is that when Central Banks purchase assets, which are mainly government bonds, it involves exchanging one governmental liability for another in the Central Bank's balance sheet. This change in the quantities of the two assets would cause a rise in the price of government bond and a decline in their yields. This in turns is expected to encourage aggregate demand by increasing wealth and reducing companies cost of borrowing. It also may increases banks' liquidity and may prompt more lending. Pesaran and Smith (2012) provide **e**mpirical support that this unconventional policy induced a temporary increase in UK's output growth by about one percent. Their findings also indicate that including foreign output growth in the model can lower the effect of the policy on UK's output.

Finally, as regards the international macroeconomic impact of UMP, Gambacorta et al. (2014) present results from a panel VAR using monthly data from eight advanced economies.[15] They find that an exogenous increase in Central Bank balance sheets at the ZLB leads to a temporary rise in economic activity and consumer prices. The estimated output effects turn out to be qualitatively similar to the ones reported in the literature on the effects of conventional

[15] The economies included in the panel analysis are Canada, the Euro Area, Japan, Norway, Sweden, Switzerland, the United Kingdom, and the United States. The time-series sample spans January 2008 until June 2011. They do not allow for cross-country spillover effects of UMP measures because the sample period is too small to extend the empirical model in this direction. It implies that they focus on the domestic effects of UMP measures. An UMP shock is identified as an exogenous innovation to the Central Bank balance sheet in the form of a mixture of zero and sign restrictions.

monetary policy and hence indicates that UMP measures have been effective in stimulating the economy. However, the impact on the price level is weaker and less persistent. Their individual country results suggest that there are no major differences in the macroeconomic effects of UMP across countries, despite the heterogeneity of the measures that were taken. Furthermore, they estimate an extended model augmented with the outstanding debt of the central government. They report that public debt falls significantly in response to the Central Bank balance sheet policy. This probably reflects positive feedback effects of the shock-induced increase in output on public finances.

Having reviewed the related literature, the next section proceeds to examining the impact of US Unconventional Monetary Policy within both FAVAR and GVAR frameworks.

5.3 Empirical Results

This section presents the empirical findings of the study. The objective is to examine the domestic and international effect of UMP in the US. We adopt the FAVAR and GVAR methodologies as our econometrics framework. Our choice of the applied methodology is rationalized given the unique properties of these two approaches. While within the FAVAR, the large dataset comprises macro and financial variables to capture the domestic impact of the conducted policy more accurately, the GVAR method enables us to investigate the potential international spillovers of the policy.

As discussed, the empirical literature on UMP suggest that the conduct of unconventional policy has caused a permanent reduction in long-term yields.[16] The policy also increased the size of Central Banks' balance sheet through increasing broad money. The policy potentially works through the portfolio balance and/or signalling channels. On this ground, we investigate macroeconomic impact of US unconventional policy through two policy experiments: (i) a fall in bond yield spread, and (ii) a rise in broad money.[17] Following Kapetanios et al. (2012), and

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[16] See Gagnon et al. (2011), Joyce et al. (2011), Kapetanios et al. (2012), Pesaran and Smith (2012), Baumeister and Benati (2013), Fawley and Neely (2013), and Schenkelberg and Watzka (2013).

[17] Both bond yield spread and broad money have been employed in the literature to proxy the effect of UMP. For example, Kapetanious et al. (2012), and Pesaran and Smith (2012) adopt bond yield spread as UMP instrument

Pesaran and Smith, (2012), the bond yield spread is defined as the difference between long and short-term interest rate. That is the 10-year government bond yield minus the 3-month Treasury bill to capture the term structure of interest rates. In accord with the emprirical literature, we assume that US-UMP caused a 100 basis points reduction in the spread, see Gagnon et al. (2011), Joyce et al. (2011), Kapetanios et al. (2012), Pesaran and Smith (2012), Baumeister and Benati (2013), Fawley and Neely (2013), and Schenkelberg and Watzka (2013). For the second experiment, we examine the impact of one standard error increase in broad money while both interventions are assumed to be permanent.[18]

In so doing, first we estimate a FAVAR model within a two-step Principal Component (PC) method to investigate the impact of a fall in bond yields spread together with an increase in the broad money shocks on the US economy. Second, we estimate a GVAR model to examine the potential international spillovers generated by these two policy shocks. In addition, both models investigate the transmission mechanism of policy shocks.

5.3.1 Estimation of the FAVAR Model

This section investigate the domestic impact of UMP within a FAVAR. We follow the same procedure as addressed in Chapter 3 to construct the FAVAR model. In so doing, following Bernanke et al. (2005), the Factor-Augmented VAR model takes the form as follows.

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi\ (L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + u_t \tag{5.1}$$

Note that $\Phi\ (L)$ is a lag polynomial of finite order d, and u_i is error term vector with $(K+M)\times 1$ dimension that $u_t \sim i.i.d,\ N(0,Q)$. However, this Equation cannot be estimated directly because the factors, F_t, are unobservable. Given that these factors are representing forces

which is considered to capture the effect of asset purchases on lowering long-term interest rates. As regards adopting broad money as another UMP instrument, we follow Woodford (2012) who argues that changes in the size of balance sheet may reflect UMP. We assume that the liquidity provision policy of Central Banks will change the supply of money in the economy, captured by broad money. Note that Gambacota et al. (2014) adopt both an increase in the size of Central Bank's balance sheet and an increase in base money, as the two UMP instruments, and report the same results.

[18] As discussed in Pesaran and Smith (2012), and Woodford (2012) this assumption can be interpreted as a policy commitment, though, it allows limited conclusion.

that potentially affect many economic variables, it is possible to infer some information about the factors from observation of large number of economic time series as explained in Bernanke et al. (2005). Assuming that X_t represents the informational time series with the dimension of $N \times 1$, while $K + M \leq N$, and are related to both the unobservable factors F_t and the observed variables Y_t. Thus, the unobservable components summarized in F_t can be estimated as formulated in Equation (5.2).

$$X_{it} = \Lambda_i^f F_t + \Lambda_i^y Y_t + e_t \tag{5.2}$$

Where Λ^f is an $N \times K$ matrix of factor loadings, Λ^y is an $N \times M$ matrix of observable variables, and e_t is the vector of error terms with $N \times 1$ dimension, which are mean zero and assumed to be either normal and uncorrelated or weakly cross-correlated depending on the model estimation method.[19] Furthermore, it is assumed that the error terms of Equations (5.1) and (5.2) are independent of each other. Thus, X_t measures the unobservable factors conditional on Y_t, see Bernanke et al. (2005).

Our FAVAR model is estimated using monthly data over 2007:M06-2013:M06 sample. The dataset consists of 195 US macroeconomic time series collected from the St Louis Fed FRED database.[20] Following common practice in this literature, all variables are transformed to be stationary as described in Appendix 3.A.[21] All the time series are seasonally adjusted were this is applicable.[22] Consistent with the Factor Modelling literature, macroeconomic time series is selected to represent the following categories: Real Output and Income, Employment and Hours, Consumption, Housing Starts and Sales, Real Inventories and Orders Indices, Exchange Rates,

[19] As is discussed in Bernanke et al. (2005) the Principal Components method allows for some cross-correlation in e_t that disappears as $N \to \infty$.
[20] A detailed description of database and the list of involved variables are provided in Appendix 3.A.
[21] We follow Bernanke et al. (2005), and Korobilis (2013) procedure to ensure stationary properties of the time series.
[22] The time series are seasonally adjusted using the Demetra+ package developed by Eurostat. To seasonally adjust the time series, the TRAMOSEATS method has been employed. This method can be divided into two main parts: a pre-adjustment step, which removes the deterministic component of the series by means of a regression model with Arima noises and the decomposition part itself. See Grudkowska (2013) for a detailed explanation.

Interest Rates, Money and Credit Quantity Aggregates, Price Indexes, Average Hourly Earnings, the Fiscal Stance, and Consumers Expectations.

As regards determining the number of factors involved in the FAVAR model, we follow Bernanke et al. (2005) approach that is based on the sensitivity of the results to the alternative number of factors. As have been reported in Bernanke et al. (2005) and Korobilis (2013) the qualitative results are not altered when the number of factors increased from three to five factors. We estimate our specified FAVAR model with three and five factors. As the obtained results appear to be quite the same, the FAVAR model is constructed with three factors to maintain parsimony.[23]

The lag length of the state Equation (5.2) is another important specification to be determined. The lag lengths are selected in the VAR literature based on statistical criterion such as AIC, BIC, or SIC. In the FAVAR literature, however, no specific criterion is used, to our knowledge. Bernanke et al. (2005) employ 13 lags in order to allow sufficient dynamics in their model. While Stock and Watson (2005) estimate a 2-lag model. We follow Bernanke et al. (2005) approach and construct our model using 13 lags.

With reference to the observable variables required to be isolated in the VAR part, Y_t , our VAR includes inflation, Industrial Production growth, and the Bond Yield Spread.[24] Thus, our FAVAR is a trivariate VAR augmented with three unobservable factors, F_t , which are extracted from the large set of time series macroeconomic variables as is addressed in Appendix 3.A. We use the PC approach to extract the factors. The use of PC method ensures identification of the model since it normalizes all factors to have zero mean and unit variance, see Korobilis (2013).

Following Bernanke et al. (2005), the identification approach is a recursive method to identify unconventional monetary policy shock, see section 3.4.2 for more details. This approach

[23] As discussed in Bernanke et al. (2005) increasing the number of factors does not appear to improve the results.

[24] We followed Bernanke et al. (2005) approach to put Industrial Production growth as observable variable in the VAR to proxy output. As Bernanke et al. (2005) explain: "Output in the theoretical model may correspond more closely to a latent measure of economic activity than to a specific data series such as real GDP". Thus, we include GDP as a time series in our information to extract the unobserved factors. We, then, present the IRFs of GDP to the policy shock within the FAVAR model.

assumes that the monetary authority reacts simultaneously to macroeconomic shocks. The recursive approach orders the policy instrument, R_t, last and its innovations are treated as the policy shocks while the unobservable factors and macroeconomic variables respond to the policy shock with time lags. Thus, monetary policy actions influence inflation and Industrial Production growth with at least one period of lag, while the time lag for UMP tool is zero by ordering it last in the VAR part.[25] Furthermore, it treats inflation as predetermined, which is consistent with the estimation of Taylor Rule that regress the nominal interest rate on inflation, see Bernanke et al. (2005), and Chung et al. (2007).

As discussed in Bernanke et al. (2005) two blocks of information variables can be defined: (i) the slow-moving variables, and (ii) the fast-moving variables. The slow-moving block of variables are set to respond to monetary policy shocks with a month lag while the fast-moving block of variables reacts instantly to the policy shocks.[26]

Having established model specification and the identification of monetary policy shock, the next section presents the impulse response analysis.

5.3.2 IRFs Results of US Bond Yield Spread Shock

This section presents the empirical results obtained from a FAVAR model estimated by the two-step PC approach. The objective is to investigate the impact of an expansionary Unconventional Monetary Policy on the US economy. Furthermore, we consider examining the way in which US fiscal stance may influence the transmission of policy shock.

Figure 5.1 presents the Impulse Response Functions to an expansionary UMP in the form of a fall in US bond yield spread.[27] This means a decrease in the spread between long and short-term interest rates.

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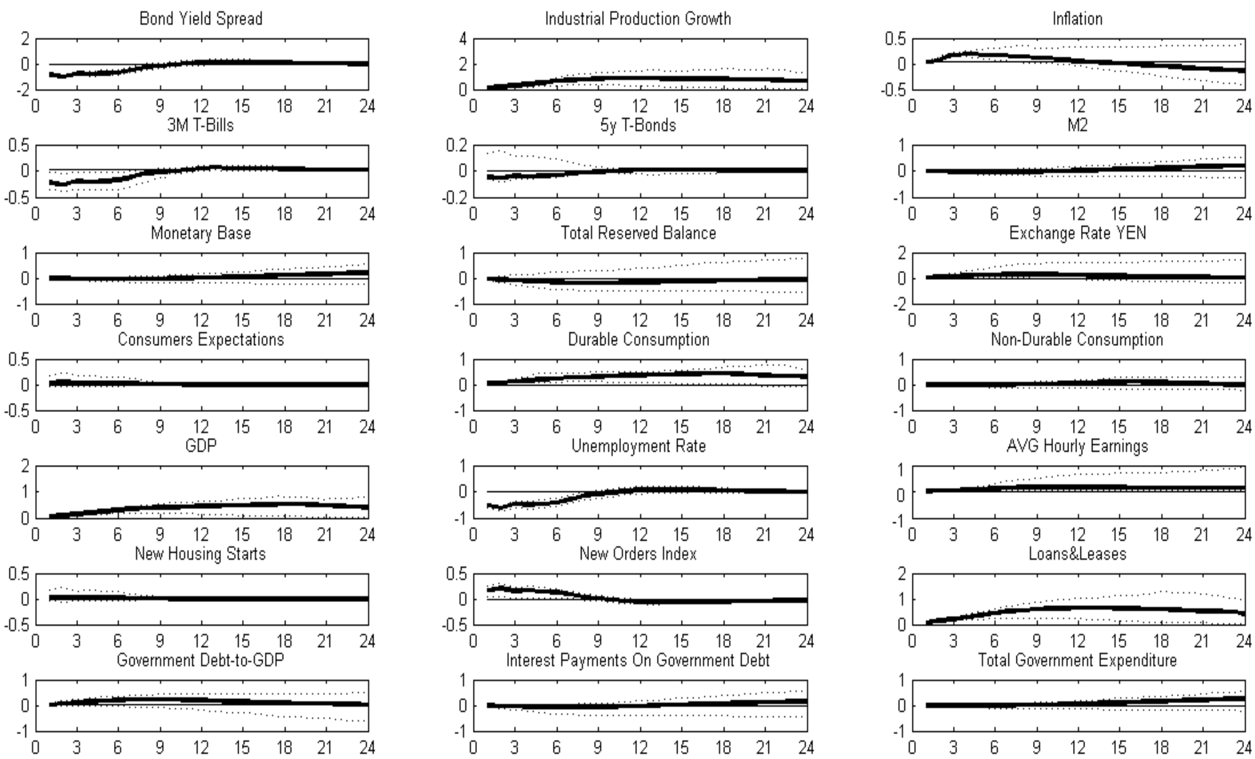
[25] As explained in Primiceri (2005), ordering monetary policy tool last in the VAR is not simply an ordering issue, but an identification condition that is essential for isolating monetary policy shock.

[26] The slow-moving block of variables includes Real Output and Income, Employment and Hours, Consumption, Price Indexes, Average Hourly Earnings, the Fiscal Stance, and Consumers Expectations. The fast-moving block of variables includes Housing Starts and Sales, Real Inventories and Orders Indices, Exchange Rates, Interest Rates, and Money and Credit Quantity Aggregates, see Appendix 3.A for more details.

[27] As noted, the bond yield spread is defined as the difference between long and short-term interest rate, which is the 10-year government bond yield minus the 3-month Treasury bill.

Figure 5. 1.The IRFs to a Bond Yield Spread Shock



Notes: This Figure illustrates the IRFs to an expansionary UMP shock within a FAVAR model. The VAR part of the model includes the bond yield spread, Industrial Production growth, and Inflation on top panel. The IRFs of other key variables in the monetary transmission mechanism is estimated based on three unobserved factors. The Impulse Responses together with their confidence intervals (10^{th}, 50^{th}, and 90^{th}) are generated based on Bernanke et al. (2005) FAVAR model specification corresponds to a one standard deviation fall in the Bond Yield Spread. The FAVAR model is estimated using a Two-Step Principal Components approach over monthly data spans 2007:M06-2013:M06 sample.

The IRFs are generated within the FAVAR model consists of three unobserved factors and three observed variables in the VAR. The three observed variables in the VAR part of the model includes inflation, Industrial Production growth, and the bond yield spread. As can be seen, an expansionary UMP shock leads to a significant rise in Industrial Production growth and inflation. However, the expansionary effect on inflation is temporary, while the impact on Industrial Production growth persists for the whole period. This is consistent with the literature as a fall in the spread is expected to generate an expansionary effect on output, see Gagnon et al. (2011), Kapetanios et al. (2012), Pesaran and Smith (2012), Baumeister and Benati (2013), and Wu and Xia (2014). In particular, Wu and Xia (2014) within a FAVAR model, find similar qualitative responses for Industrial Production index, inflation, and unemployment.

As regards the other real activity measures, the IRFs show intuitive responses. It can be seen from Figure 5.1 that following UMP expansion, consumption, GDP, and new orders index increase, while unemployment declines. The responses are statistically significant.

The responses of monetary aggregate measures such as broad money, the monetary base, and loans are consistent with the literature. As Figure 5.1 shows, monetary aggregate measures increase, although all the responses are statistically insignificant, except of loans. Finally, as the IRFs suggest, a fall in the spread seems to be unable to significantly influence the fiscal stance.

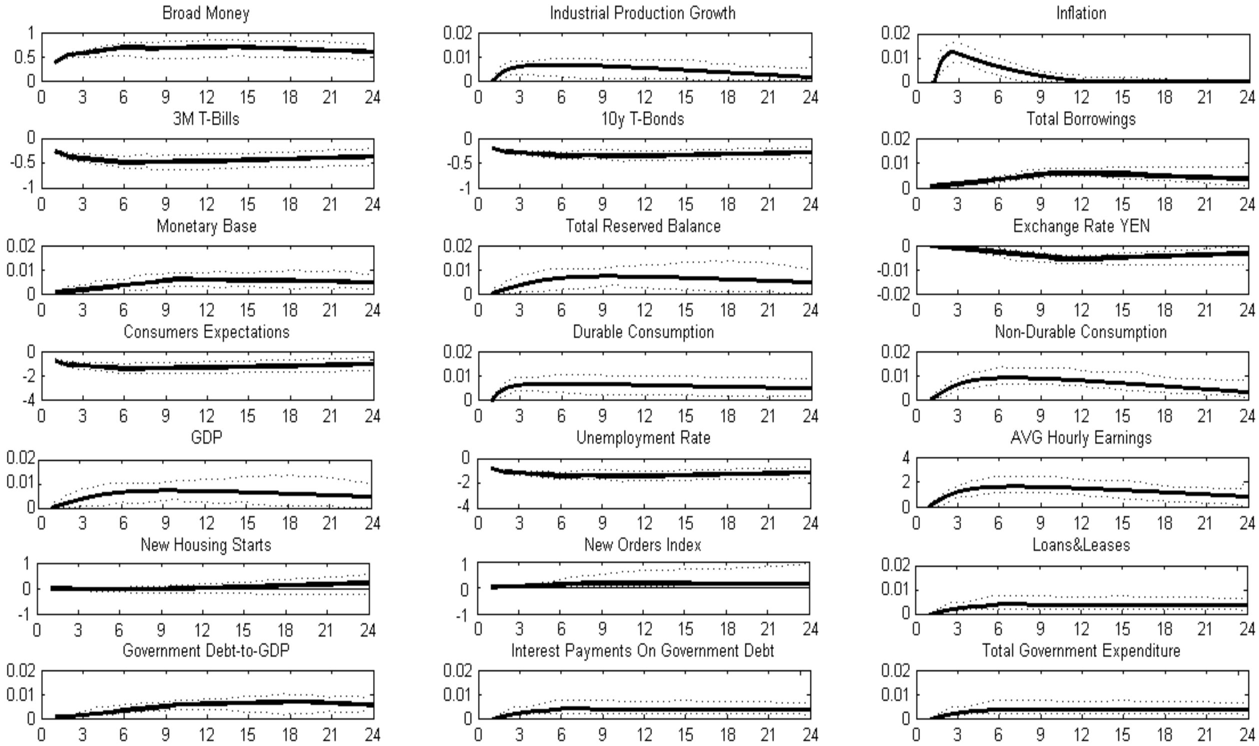
In order to examine the robustness of our results to UMP shock, we consider replicating our analysis using a different quantitative policy instrument. That is an increase in broad money. The next section presents the impulse responses.

5.3.3 IRFs Results of US Broad Money Shock

Now we present the impulse responses to an increase in US broad money. Figure 5.2 shows the results generated within a FAVAR model consists of three unobserved factors and three observed variables. The VAR section of the model includes inflation, Industrial Production growth, and broad money.

Overall, the IRFs results suggest the following common findings. An increase in broad money induces inflation and industrial production index to increase which statistically are significant. Other real activity measures such as consumption, GDP, and average hourly earnings also increase. This finding suggest that an increase in US broad money can succeed to stimulate the economy. As expected, the policy shock also is associated with a reduction in unemployment. New housing starts and new orders remain irresponsive following the shock. The increase in consumption, inflation, and GDP in response to this UMP shock may indicates that the policy shock generates a positive wealth effect encouraging private expenditure and aggregate demand.

Figure 5. 2.The IRFs to a Broad Money Shock



Notes: This Figure illustrates the IRFs to an expansionary UMP shock within a FAVAR model. The VAR part of the model includes the broad money, Industrial Production growth, and Inflation on top panel. The IRFs of other key variables in the monetary transmission mechanism is estimated based on three unobserved factors. The Impulse Responses together with their confidence intervals (10^{th}, 50^{th}, and 90^{th}) are generated based on Bernanke et al. (2005) FAVAR model specification corresponds to a 1 standard deviation increase in Broad Money. The FAVAR model is estimated using a Two-Step Principal Components approach from Bernanke et al. (2005) over monthly data spans 2007:M06-2013:M06 sample.

As regards the response of monetary aggregate, our results are consistent with the intuition. We can see that the policy shock increases the base money, borrowing, and loans, which are statistically significant. However, total reserve balance increased that is a counterintuitive response. Turning to interest rate response, we can see that an increase in US broad money caused both short and long-term interest rates to fall. This finding is consistent with the literature on the impact of UMP on lowering ling-term bond yields, see Gagnon et al. (2011), Joyce et al. (2012), Kapetanios et al. (2012), and Pesaran and Smith (2012). Finally, government debt and expenditure both increase in response to the shock. Although it is expected that an expansionary UMP increases economic activity and reduces debt, but our results can be justified as the interest share of public debt increase. This might be due to the conduct of UMP that can be associated with issuing new government bonds to finance the program.

Given that the policy-induced increase in broad money increases consumption and loans, it may indicate the portfolio balance as the policy transmission channel. This can support the view that the UMP program may generate positive wealth effect, which in turn would improve aggregate demand.

Comparing the impulse responses obtained from these two expansionary UMP shocks, we can see that the both shocks significantly increase prices and real activity measures. Nevertheless, the IRFs of a fall in the spread seems to generate more expansionary effect rather increasing broad money. Having discussed the domestic impact of these policy shocks, the next section proceeds to examining their international spillovers.

5.3.4 Estimation of the GVAR Model

Here we employ the GVAR framework to examine the international spillovers of US-UMP. The same procedure as addressed in Chapter 4 is used to construct the GVAR model. Thus, the country-specific $VARX\,(1,1)$ model will take the general form as presented in Equation (5.3).[28]

$$X_{it} = a_{i0} + a_{i1t} + \Phi_{i1} X_{i,t-1} + \Lambda_{i0} X^{*}_{it} + \Lambda_{i1} X^{*}_{i,t-1} + \varepsilon_{it} \tag{5.3}$$

Note that a_{i0} and a_{i1t} are the coefficients of the deterministic, $\Phi_i = K_i \times K_i$ is a matrix of lagged coefficients, Λ_{i0} and Λ_{i1} are $K_i \times K_i^*$ matrix of coefficients associated with the foreign specific variables, $\varepsilon_{it} = K_i \times 1$ is a vector of idiosyncratic country-specific shocks in which all shocks are assumed to be normally distributed as $\varepsilon_{it} \sim iid\,(0, \sigma^2)$. It is worth nothing that it is not necessary that all $VARX^*$ be the same across all countries in terms of the included variables due to the fact that we consider zero weights for any missing variables in the country $\boldsymbol{i}^{th}$ within the $VARX^*$ model, see Pesaran et al. (2004).[29]

[28] Note that all the country-specific variables/observed factors are treated endogenously, while their foreign counterparts are treated as weakly exogenous. For a detailed discussion on this subject, see Dees et al. (2007).

[29] As concerns our study, there are no datasets available for long-term interest rates and real equity prices variables for China.

As has been explained in Chapter 4, we follow Pesaran et al. (2004), Pesaran and Smith (2006), and Dees et al. (2007) approach to construct the weighting matrix. We choose the bilateral trade as the international transmission channel of policy innovation.[30] Thus, all foreign variables are linked through a bilateral trade matrix. Assuming that w_{ij} indicates the trade matrix between countries *i* and *j*, the corresponding foreign variables will influence country-specific *VARX* models as follows.

$$X_{it}^{*} = \sum_{j=0}^{N} w_{ij} x_{jt}, \quad w_{ii} = 0 \quad and \quad \sum_{j=0}^{N} w_{ij} x_{jt} = 1$$

Likewise Chapter 4, we follow Pesaran et al. (2004), and Dees et al. (2007) to employ a fixed trade weights matrix by using the average trade flows computed over a three year basis.[31] The computed bilateral trade-weighted matrix is presented in Appendix 5.A.

We use the same procedure as explained in Chapter 4 to estimate the *GVAR(P)* as formulated in Equation (5.4).

$$G\ (L,P)\ X_t = \Phi_t \tag{5.4}$$

And

$$G(L,p) = \begin{pmatrix} A_0(L,p)W_0 \\ A_1(L,p)W_1 \\ \vdots \\ A_N(L,p)W_N \end{pmatrix} ;\ \varphi_t = \begin{pmatrix} \varphi_{0t} \\ \varphi_{1t} \\ \vdots \\ \varphi_{Nt} \end{pmatrix} \tag{5.5}$$

Where $A_i(L\ ,p_i,q_i)z_{it} = [\Phi_i(L\ ,p_i),\ -\Lambda_i(L\ ,q_i)]$, $\varphi_{it} = a_{i0} + a_{i1t} + Y_i(L\ ,q_i)d_t + u_{it}$.

The next step is to estimate the *GVAR (P)* from Equation (5.4). This equation is our framework for the point estimation and Generalized Impulse Response Functions (GIRF) analysis.[32]

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[30] As discussed in Forbes and Chinn (2004), and Baxter and Kouparitsas (2006), bilateral trade between countries is one of the most important determinants of cross-countries linkages.

[31] As has been discussed in Dees et al. (2007) the choice of using fixed-weights is on the basis that changes in trade weights tend to be rather gradual. Thus, the foreign-specific variables computed using either fixed or variable trade weights are often very close.

[32] A detailed procedure of constructing a GVAR model and formal proof can be found in Pesaran et al. (2004), Pesaran and Smith (2006), and Dees et al. (2007).

5.3.5 GVAR Model Specification

This section explains the preliminary analysis required prior to estimating the model. Given this chapter's motivation, our GVAR model includes these variables: real output, y_{it}, CPI inflation, π_{it}, bond yield spread, bys_{it}, real exchange rate, ep_{it}, real equity price, eq_{it}, broad money, M_{2it} ,government debt-to-GDP ratio, gdr_{it}, price of oil, p_t^{oil}, raw material price, p_t^{mat}, and price of metal, p_t^{metal}, where data are available. Inflation is estimated using this definition: $\pi_{it} = p_{it} - p_{i,t-1}$, where CPI index is used for estimating the real values.[33]

The foreign-specific variables are presented with similar notation, but are distinguished by an asterisk,*, as follows.

$$X_{it} = [y_{it}, \pi_{it}, ep_{it}, eq_{it}, bys_{it}, M_{2it}, gdr_{it}, p_t^{oil}, p_t^{mat}, p_t^{metal}]$$

$$X_{it}^* = [y_{it}^*, \pi_{it}^*, eq_{it}^*, bys_{it}^*, M_{2it}^*, gdr_{it}^*, p_t^{oil}, p_t^{mat}, p_t^{metal}]$$

Our GVAR model involves 14 economies, which contribute approximately to 80 percent of the world's output.[34] We estimate our model using monthly data covering the period 2007:M06-2013:M06. The main sources for the data are International Finance Statistics (IFS), the OECD Statistics, and Bloomberg database as detailed in Appendices 3.A and 4.B. Given the importance to the scale of US economy in the world, the US is set as the reference economy with the US dollar as the reference currency.

5.3.6 Model Testing

Prior to proceed with the estimation of the specified GVAR, a number of tests must be performed to ensure the validity of the results. This section presents the results of weak exogenity, parameter

[33] As noted before, it is not required that all the country-specific *VARX* models include the same number of variables where data is not available. In our model, due to the data limitation for long-term interest rate and equity price in China, these two variables have been excluded from the *VARX* model for China.
[34] The economies covered by our study include Australia, Canada, China, Japan, the UK, the US, and the Euro Area. The Euro Area economies include Austria, Belgium, Finland, France, Germany, Italy, Netherland, and Spain. The rationale for excluding some countries from the Euro Area is similar to that of Dees et al. (2007) justifying that building up a model as a benchmark for policy analysis required the omission of those countries facing instability or which are small in terms of economic scale.

stability, and unit root tests. We start by performing unit root tests to determine the order of integration of both the endogenous and exogenous variables. Tables 5.A.2 and 5.A.3 present the results of unit root tests using the weighted symmetric estimation of Augmented Dickey Fuller (WS-ADF) statistics for the levels and the first differences of variables. The results confirm that all domestic and foreign variables are stationary in their first difference. The results of unit root show that all variables are $I(1)$ across all countries allowing the use of standard co-integration and Error Correction Model (ECM) estimation. Thus, we use the level series for both endogenous and our weakly exogenous variables in the country-specific models.

Next, we estimate country-specific co-integrating VAR models and determine the rank of the co-integrating relations. Table 5.A.4 presents the results. The lag order for the domestic variables are determined based on the Akaike Information Criteria (AIC). For foreign variables, the lag order is set to unity due to the data limitation.[35]

Finally, according to the literature on the GVAR modelling, the weak exogeneity of the country-specific foreign variables is a key assumption for estimating the individual *VARX*. Table 5.2 presents the results of the weak exogenity tests. According to the results, with the exception of Australian inflation, all other variables are weakly exogenouce within the country-specific *VARX* models. Furthermore, the foreign bond yield spread, bys_{it}^{*}, foreign government debt ratio, gdr_{it}^{*}, and foreign broad money, M_{2it}^{*}, are not expected to affect the US economy substantially. Thus, they are not considered as weakly exogenous within the US model.

[35] Note that as Dees et al. (2007) explain, it is not possible to determine more than two lags for both the domestic and foreign variables.

Table 5. 2. Weak Exogeneity Test

Country	F test	C Value	y^*_{it}	π^*_{it}	eq^*_{it}	bys^*_{it}	M^*_{2it}	gdr^*_{it}	p^{oil}_t	p^{mat}_t	p^{metal}_t
Australia	F(2,98)	***3.10***	0.41	4.26*	0.38	0.51	0.88	1.08	1.62	1.13	0.62
Canada	F(3,104)	***2.70***	1.29	1.48	0.56	2.03	0.62	2.42	2.14	0.50	0.88
China	F(2,106)	***3.10***	0.21	1.42	0.80	1.73	0.69	0.69	1.07	0.28	0.55
Euro Area	F(2,98)	***3.10***	1.81	0.85	0.09	0.65	0.34	1.34	0.12	0.03	2.70
Japan	F(2,98)	***3.10***	1.03	0.03	0.55	0.48	0.76	0.96	1.51	2.05	1.53
UK	F(2,105)	***3.10***	2.72	0.54	1.30	0.92	0.38	1.38	0.62	2.40	2.29
US	F(2,102)	***3.10***	1.72	1.80	0.63	NA	NA	NA	0.65	2.48	1.25

Note: The null hypothesis is weak exogeneity; hence, failing to reject of the null implies that weak exogeneity is held. The results are presented at 95% confidence level. An asterisk,*, indicates that weak exogeneity assumption cannot be held for those variables/country. NA indicates the variables that are not involved in the *VARX* model as weakly exogenous.

Now we continue to perform another important test to validate the estimated GVAR model that is parameter stability. To ensure the estimated parameters within the GVAR model are stable, the same procedure as Chapter 4 details is followed to perform the parameter stability test of Nyblom (1989). Table 5.3 presents the results for the computed Nyblom parameter stability test. The critical values of the tests are calculated based on the sieve bootstrap samples obtained from the solution of the GVAR model.

According to the Nyblom test results, all the parameters are stable in their robust version with the exception of UK bond yield spread. Note that there is a few number of parameter instability according to Nyblom statistics that includes Euro Area exchange rate and inflation, and US bond yield spread. It is worth noting that given the limitation of the GVAR methodology, we cannot completely rule out the potential parameter instability among the estimated variables.

Taking into account some potential parameter changes associated with policy shocks, our study, however, is concerned with past parameter variations and implicitly assumes that the policy intervention has no independent effects on parameter values, see Pesaran and Smith (2012). Nevertheless, to take cautious, we follow Dees et al. (2007) to use both the bootstrap means and confidence bounds rather than point estimate results.

Table 5. 3. Nyblom Parameter Stability Tests

LM Statistic	Real Output	Inflation	Bond Yields Spread	Real Exchange Rate	Real Equity Prices	Broad Money	Government Debt-to-GDP
Nyblom -US	**3.56***	**2.60***	5.33	NA	**2.70***	**3.34***	**1.76***
	(3.70)	(3.33)	(3.52)	NA	(3.36)	(3.38)	(2.78)
Robust Nyblom -US	**3.19***	**2.50***	**3.03***	NA	**2.86***	**3.12***	**2.31***
	(3.59)	(3.18)	(3.82)	NA	(3.74)	(3.28)	(3.22)
Nyblom -China	**2.67***	**2.20***	NA	**2.47***	NA	**2.34***	**2.34***
	(3.58)	(3.53)	NA	(3.82)	NA	(3.86)	(2.86)
Robust Nyblom -China	**2.94***	**3.67***	NA	**4.20***	NA	**3.51***	**3.51***
	(3.93)	(4.11)	NA	(4.21)	NA	(4.60)	(3.60)
Nyblom - Euro Area	**2.96***	8.62	**3.39***	**2.63***	5.26	**2.63***	**2.39***
	(3.78)	(3.49)	(3.94)	(3.72)	(4.20)	(4.08)	(3.65)
Robust Nyblom- Euro Area	**3.78***	**3.83***	**3.60***	**3.48***	**3.45***	**4.29***	**3.58***
	(4.18)	(4.10)	(4.24)	(4.35)	(4.33)	(4.43)	(4.11)
Nyblom-UK	**3.16***	**2.10***	**2.93***	**3.50***	**2.66***	**3.20***	**2.95***
	(3.62)	(4.25)	(3.85)	(3.83)	(3.71)	(3.41)	(3.63)
Robust Nyblom-UK	**3.50***	**2.52***	4.69	**3.26***	**2.90***	**3.73***	**2.80***
	(4.62)	(4.38)	(4.43)	(4.51)	(4.37)	(3.92)	(3.99)

Note: The null hypothesis is parameter stability; hence, failing to reject of the null implies parameter stability over the sample. An asterisk, *, indicates parameter stability for those variables/countries. Critical Values at the 95% significance level are presented in the parentheses. NA are either indicating variables for the reference country, i.e. the US, or due to data limitation, i.e. China. The robust Nyblom denotes the heteroskedasticity-robust version of the test. LM statistics abbreviates the Lagrange Multiplier.

5.3.7 Average Pair-Wise Cross-Section Correlation

This section investigates whether there is a Common Global Factor among countries within the estimated GVAR model. Having considered that all country-specific *VARX* models are estimated conditional upon the weak exogeneity of foreign variables, it implies that $\text{cov}(X_{it}^{*}, u_{it}) \rightarrow 0, \ \ with\ N \rightarrow \infty$. This allows the foreign variables to be considered as proxies of the common global factors, see Pesaran et al. (2004), and Dees et al. (2007). When the degree of correlation of the remaining shocks across countries is small, it suggests that there are interdependencies among the residuals. As Dees et al. (2007) explain it could be interpreted as a sign implying that the estimated model captures the effects of policy shocks.

Table 5.4 presents the result of average pair-wise cross-sectional correlation of the variables. The results are reported for levels and the first differences of the endogenous variables together with those of the $VARX^{*}$ residuals.

Table 5. 4. Average Pair-Wise Cross-Section Correlations

Country	Real Output			Inflation		
	Levels	First Difference	VARX Residuals	Levels	First Difference	VARX Residuals
Australia	0.98	0.25	0.02	0.70	0.39	-0.01
Canada	0.98	0.33	-0.07	0.76	0.44	-0.02
China	0.97	0.13	-0.1	0.38	0.30	-0.13
Euro Area	0.98	0.33	-0.03	0.79	0.58	-0.07
Japan	0.93	0.22	-0.05	0.77	0.47	-0.03
UK	0.98	0.37	-0.01	0.77	0.43	-0.03
US	0.98	0.37	-0.10	0.79	0.50	-0.11

Country	Bond yield Spread			Real Equity Price		
	Levels	First Difference	VARX Residuals	Levels	First Difference	VARX Residuals
Australia	0.79	0.67	-0.02	0.34	0.22	0.02
Canada	0.74	0.73	-0.04	0.40	0.18	-0.01
China	NA	NA	NA	-0.19	-0.14	-0.09
Euro Area	0.84	0.72	-0.22	0.26	0.25	0.00
Japan	0.32	0.55	-0.17	0.18	0.12	0.00
UK	0.82	0.74	-0.04	0.43	0.19	-0.09
US	0.81	0.74	-0.16	0.28	0.22	0.03

Country	Real Exchange Rate			Broad Money		
	Levels	First Difference	VARX Residuals	Levels	First Difference	VARX Residuals
Australia	0.40	0.38	0.06	-0.02	0.00	0.03
Canada	0.45	0.35	0.05	0.08	0.06	0.01
China	-0.01	0.10	-0.14	-0.05	-0.03	0.03
Euro Area	0.42	0.42	-0.03	-0.01	-0.02	-0.02
Japan	-0.11	0.18	-0.07	-0.07	-0.09	-0.03
UK	0.38	0.42	-0.06	0.03	-0.01	-0.03
US	NA	NA	NA	-0.02	0.03	0.02

Note: The results present average correlation between domestic and their corresponding foreign variables among countries of interest. The *VARX* residuals are computed based on country-specific models included the foreign-specified variables. NA for the exchange rate in the US is due to denominating all countries' currencies to the US dollar, and for long-term interest rate in China is due to data limitation.

Typically, the average cross-section correlations are high in the level of the endogenous variables and low in their first differences, see Dees et al. (2007). According to the results, the real output shows the highest degree of cross correlation ranging between 93-98 percent for the countries of interest. This implies that any changes in output of each country may influence other countries output as well. As regards inflation, with China being the only exception, there is a moderate degree of correlation ranging between 70-79 percent.

In addition, we can see a considerable degree of cross-correlation of around 74-84 percent for bond yield spread, with Japan being the exception. This indicates that a policy-induced changes in each country's spread can impact bond yield spread within the other economies of interest. As regards the real equality price cross-correlation, the results suggest a low degree of correlation across countries. A modest degree of cross-correlation, also, can be observed for the real exchange rate among the countries. Finally, for broad money, as Table 5.5 presents, we can see a very low degree of cross-correlation.

The cross-section correlation of the variables in their first difference, however, is quiet small compared with level of the variables suggests a limited cross-correlation between variables in their first differences. For example, the average cross-section correlations of output fall from 93-98 percent to13-37 percent by moving from level to the first differences. In general, our result is consistent with those of Dees et al. (2007) which can indicate that our constructed GVAR specification is accurate.

It can be inferred from the results that there is a significant cross-correlation among the key policy indicator variables in our constructed GVAR model, although its extent varies among variables. Turning to the cross-section correlation of the residuals from the $VARX^*$ models, we can observe that the cross-correlations are very small due to the residual independencies. As Dees et al. (2007) explain this confirms that the model effectively can capture the global trends and spillover effects among variables and across countries.

5.3.8 Contemporaneous Effects of Foreign Variables

Having examined the cross-correlation among variables, now we continue to discuss the contemporaneous effect of the foreign variables on their counterparts. Table 5.5 presents the results together with their robust t-ratio values. These results indicate impact elasticity between the domestic and foreign variables.

We can see that most of the values are significant with a positive sign. The exceptions are inflation for Japan, and broad money and government debt for China. These results are informative as regards the cross-countries linkages. For example, a one percent change in the other countries' weighted output can increase US output around of half percent. We can see that China's output has the least output elasticity among countries while those of the UK show the highest amount.

Table 5. 5. Contemporaneous Effects of Foreign Variables on their Domestic Counterparts

Country	Real output	Inflation	Real Equity Price	Bond Yield Spread	Broad Money	Government Debt-to-GDP
Australia	**0.53***	**0.62***	**0.83***	**0.93***	**0.24***	**0.25***
	(2.18)	(3.54)	(6.78)	(4.50)	(4.97)	(2.87)
Canada	**0.61***	**0.67***	**0.95***	**0.78***	**0.36***	**0.28***
	(4.39)	(7.04)	(18.1)	(17.57)	(7.04)	(3.95)
China	**0.33***	**0.62***	NA	NA	0.13	0.15
	(3.71)	(2.66)	NA	NA	(1.06)	(0.07)
Euro Area	**0.42***	**0.65***	**1.04***	**0.76***	**0.27***	**0.22***
	(3.6)	(5.70)	(8.46)	(6.61)	(3.57)	(2.70)
Japan	**0.40***	-0.01	**0.73***	**0.52***	**0.17***	**0.23***
	(2.18)	(-0.18)	(6.08)	(4.84)	(2.11)	(2.95)
UK	**0.74***	**0.79***	**0.85***	**0.76***	**0.26***	**0.31***
	(4.11)	(5.50)	(15.12)	(4.55)	(3.16)	(3.39)
US	**0.54***	**0.88***	NA	NA	NA	NA
	(4.39)	(6.77)	NA	NA	NA	NA

Note: The robust *t-ratio* values are presented in parentheses computed using White's heteroscedasticity-consistent variance estimator. An asterisk, *, indicates that the result is statistically significant. NA for the US indicate variables that are not involved in the *VARX* model as weakly exogenous. For China, NA is due to data limitation for long-term interest rate and equity prices.

The highest elasticity can be observed for the real equity prices whereby the domestic counterpart variables react more than proportionally to the foreign variables that is above one in the case of the Euro Area. Our results are similar to those reported in Dees et al. (2007). They interpret this finding as an indication that the Euro Area stock markets is slightly overreacting to foreign stock price changes. We can also observe relatively strong elasticity between bond yields spread across counties while the elasticity is rather weak for broad money and government debt, see Table 5.5.

Up to this point, we explain the construction of our GVAR model and perform the preliminary test to validate the model. In the next section, we proceed to the dynamic analysis of the model.

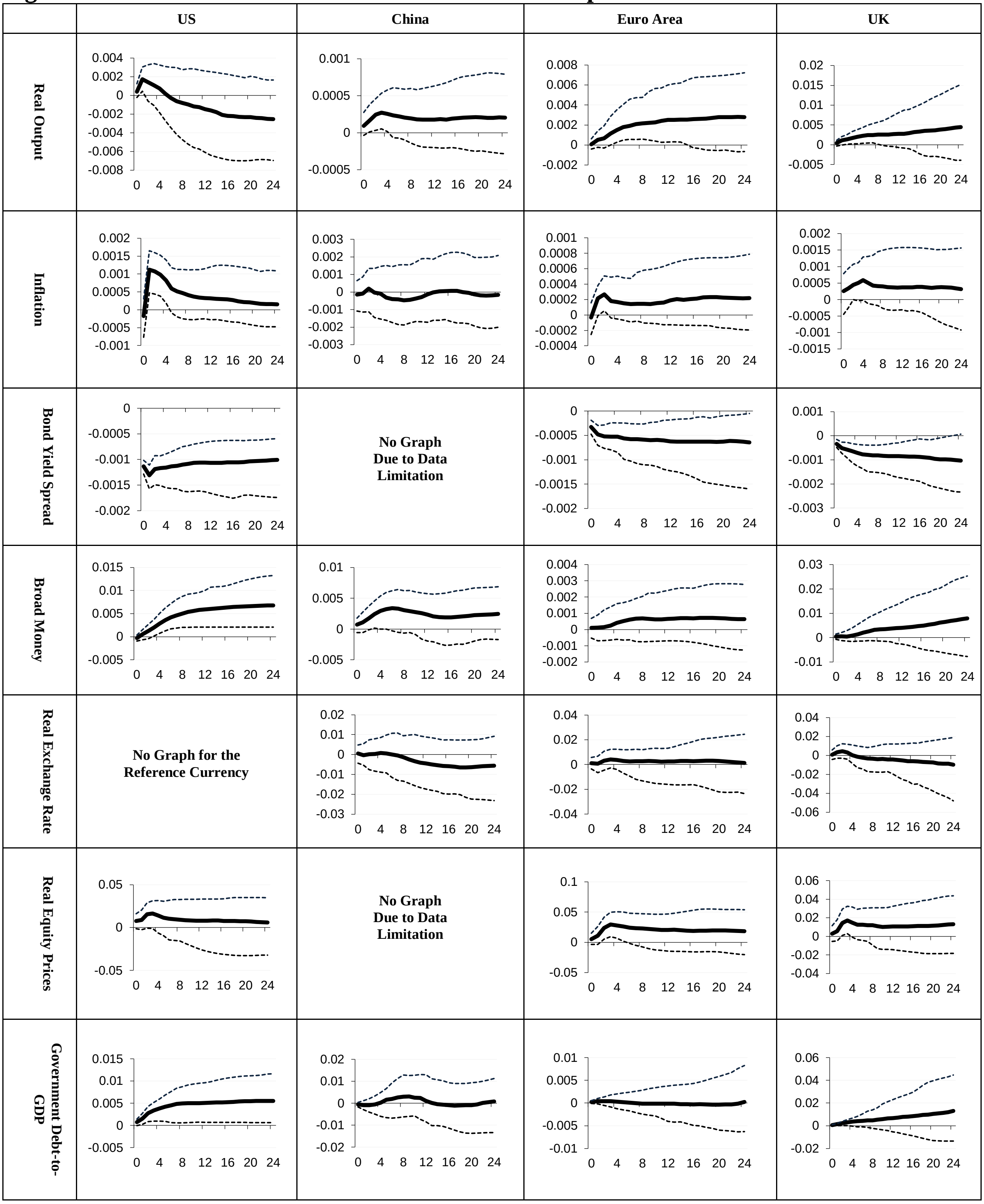
5.3.9 The GIRF Results of US Bond Yield Spread Shock

As noted in Chapter 2, the Generalized Impulse Response Functions (GIRF) is an alternative to the Orthogonal Impulse Responses (OIR) to study the effects of different policy experiments. The concepts of orthogonality in impulse responses is discussed in Chapter 4. It must be emphasized that OIR guarantees that different shocks are uncorrelated implying that their corresponding covariance matrix is zero. Thus, it is possible to examine the impact of different shocks to the model, simultaneously. Furthermore, the OIR is sensitive to the ordering of the variables in the VAR. However, the GIRF approach imposes shocks to individual errors and filters out the effect of other shocks using the observed distribution of all shocks. It is also invariant to the ordering of the variables and countries in the GVAR model, which clearly is an advantage even if we had a theory-driven ordering of the variables, see Pesarn and Smith (2006), and Dees et al. (2007). These two unique properties of the GIRFs make it much suitable to deal with identification problems concerning VAR models. We follow the same procedure to estimate the GIRFs as addressed in Chapter 4.

Now we can proceed to examining the international macroeconomic impact of US-UMP. It is expected that an expansionary UMP in the form of asset purchases program would lower return of the assets and increase broad money through signalling and the portfolio balance channels. The policy's target is to stimulate private expenditure by lowering borrowing costs and generating a positive wealth effect, see Baumeister and Benati (2010), Gagnon et al. (2011), Joyce et al. (2011,2012), and Kapetanios et al. (2012), and Pesaran and Smith (2012). To assess the impact of US-UMP, we consider two policy experiments: (i) a fall in US bond yield spread, and (ii) an increase in US broad money.

We first present the macroeconomic impact of a fall in US bond yield spread and its potential international spillovers. Figure 5.3 presents the GIRFs to a one standard error fall in the bond yield spread within the GVAR model. We can see that a fall in the spread induces US output to increase by 0.2 percent that sharply returns to zero. The response is statistically significant only for a short while. In addition, the policy shock increases US inflation at around 0.1 percent at peak which becomes statistically significant over the first 4 months of the simulation period. The responses of both output and inflation are conventional and consistent with the literature. For example, see Gagnon et al. (2011), Baumeister and Benati (2013), and Gambacorta et al. (2014).

Figure 5. 3. The GIRFs to a fall in the US Bond Yield Spread



Notes: This Figure provides GIRFs of the GVAR specified-variables after a one standard error fall in US bond yield spread over the monthly observations spans 2007:M06-2013:M06. The solid lines present bootstrap mean estimates with the dotted lines presenting 90% bootstrap error bands. The scale on the horizontal axis measures the number of months after the initial shock.

Their simulation result for the US economy suggest that in the absence of UMP, real output would have been 0.75-2.4 percent lower and economy would have faced deflation. Comparing our results with those of Baumeister and Benati (2010), our model suggests less expansionary effect for US output. It could be due to the fact that our GVAR model captures the international spillovers of US-UMP.

Furthermore, this policy-induced fall in the spread by -0.1 percent appears to be persistent. As regards the response of broad money, the GIRFs suggests that the policy shock increases broad money by around 0.5 percent, which is statistically significant over the period. This is an important finding. Having considered that a policy-induced reduction in the spread caused broad money to increase, it may indicate that the policy is transmitted through portfolio balance channel as the asset holders rebalance their portfolio. This also implies that US expansionary UMP, in the form of LSAP that would cause the spread to fall, can raise broad money leading to an expansion in the size of balance sheet.

As regards the impact of US-UMP on the asset prices, Figure 5.3 illustrates that real equity prices increases by one percent in average, although the response is significant for a short while. This finding also can account for portfolio balance as the transmission channel. It suggests that a policy-induced fall in the spread is associated with an increase in equity prices implying that US UMP may improve asset trading, hence, inducing an increase in the price of equities. This portfolio rebalancing, in turn, would generate a positive wealth effect increasing aggregate demand.

Note that, prior to the 2008 financial crisis, the impact of the short-term rates on equity prices was widely acknowledged, see Bernanke and Kuttner (2005), and Gurkaynak, Sack and Swanson (2005). As noted in Chen et al. (2012), and Kiley (2013), the negative correlation between the spread and the equity prices caused by an expansionary UMP may validate portfolio balance as the monetary transmission channel. Finally, as can be seen, government debt-to-GDP increases in response to this policy shock, by 0.5 percent, which is statistically significant over the period. It may be due to either an increase in the interest share of public debt or the issuance of new government bonds to finance UMP program.

Turning our focus to the international macroeconomic impact of a fall in US bond yield spread, Figure 5.3 illustrates its international spillovers. We can see that US-UMP has increased output in China, the Euro Area, and UK, which are statistically significant for a while. In addition, this policy shock increases inflation within both the Euro Area, and UK, although the responses are statistically insignificant.

As regards Euro Area and UK bond yields spread, a fall in US spread causes a fall in their spread as well. This implies that bond yields spread are linked globally. Our results from the cross-section correlation indicate that bond yield spread are highly correlated among the countries. This finding is also consistent with the literature on the global interdependence of short-term and long-term interest rates, see Dees et al. (2007).

We can also observe that US-UMP shock increases real equity prices within both the Euro Area and UK, although their responses are statistically significant only for a few months, see Figure 5.3. It implies that US unconventional monetary measures may generate international spillovers into equity markets in the Euro Area and UK. Thus, it can be argued that portfolio balance channel may be the international transmission channel of the policy. Finally, the GIRFs suggest that US-UMP shock has no significant impact on the real exchange rate and government debt in the economies of interest, see Figure 5.3.

5.3.10 The GIRF Results of US Broad Money Shock

An alternative approach to examine the macroeconomic impact of US-UMP is through a one standard error positive shock to broad money. This can be justified as UMP may contribute to an expansion in the size of Central Bank balance sheet, particularly, an increase in liabilities column of the balance sheet, see Woodford (2012).[36]

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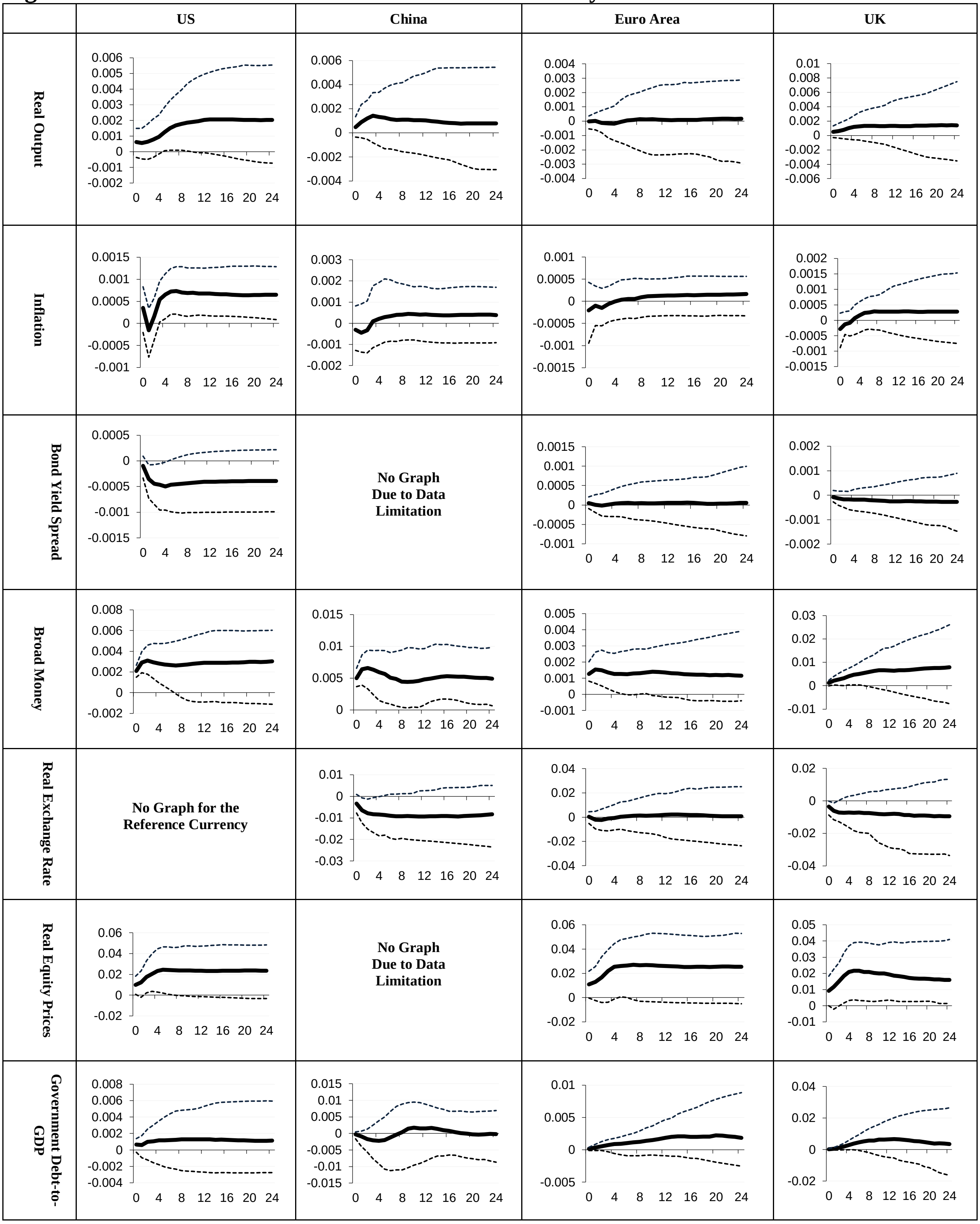
[36] The increase in broad money assumption can be interpreted by agents as the Fed intention to continue with further asset purchases program until achieving the policy target.

Figure 5.4 presents the GIRFs results to this expansionary UMP shock. As illustrated, the policy succeeds to increase US output by 0.2 percent, which is statistically significant for a while. Comparing the response of output to a rise in broad money with those of a fall in the spread, it can be observed that a shock to US broad money seems to be more effective in stimulating the domestic economy. Inflation also increases in response to the policy by around of 0.05 percent, which is significant over the period. Thus, the GIRFs suggest that an increase in broad money can generate a more persistent increase in domestic inflation and output within the US economy. This finding is also reported in Gambacorta et al. (2014). Their finding suggest that US output and inflation are increased by 0.06 percent and 0.025 percent, respectively.

As regards the response of the spread, it can be seen that the policy induces a small reduction in the spread that sharply turns to be insignificant for the whole period. Furthermore, real equity prices increases in response to the shock by 2 percent, which is significant for a while. This again implies that US unconventional monetary measures may be transmitted through portfolio balance channel leading to an increase in output and inflation. Finally, the policy shock induces government debt to increase, though the response appears to be statistically insignificant.

Turning to policy international spillovers, we can see that there is not a strong evidence of international spillovers. For example, output and inflation increase in China and the UK, however, the responses appears to be insignificant. For the Euro Area, Figure 5.4 shows that the policy shock has no impact on output and inflation. As GIRFs suggests, a policy-induced increase in US broad money is associated with an increase in broad money in China, the Euro Area, and UK that the responses turn to be significant. Furthermore, the policy shock induces real equity prices in the Euro Area and UK to increase which is significant for the UK. This finding may suggest that the portfolio balance can be the international transmission channel of the policy shock within the Euro Area and UK, however, the impulse responses of their bond yield spread does not make it a strong influence. Finally, government debt in China, the Euro Area, and UK increase in response to the shock, although, the responses appears to be insignificant.

Figure 5. 4. The GIRFs to a Rise in the US Broad Money



Notes: This Figure provides GIRFs of the GVAR specified-variables after a one standard error shock to US broad money over the monthly observations spans 2007:M06-2013:M06. The solid lines present bootstrap mean estimates with the dotted lines presenting 90% bootstrap error bands. The scale on the horizontal axis measures the number of months after the initial shock.

Table 5. 6. Comparing the Point Estimate Result for US-UMP

	Policy Shock/Econometrics Approach	US	China	Euro Area	UK
			at Peak		
Output	The Spread-FAVAR	**0. 5***	NA	NA	NA
	The Spread-GVAR	**0.2***	**0.02***	**0.2***	**0.2***
	Broad Money-FAVAR	**0.01***	NA	NA	NA
	Broad Money-GVAR	**0.2***	0.15	0	0.1
Inflation	The Spread-FAVAR	**0. 5***	NA	NA	NA
	The Spread-GVAR	**0.1***	0	0.02	0.05
	Broad Money-FAVAR	**0.01***	NA	NA	NA
	Broad Money-GVAR	**0.05***	0.1	0.01	0.02

Note: The Table presents the point estimate results of a one standard error fall in US bond yields spread together with those of a one standard error increase in US broad money. Values are presented in percentage. An asterisk,*, superscripts indicates that the results are statistically significant.

Table 5.6 compares the point estimate outcome of a policy-induced fall in the spread with those of an increase in broad money within both the FAVAR and the GVAR models. As reported in the Table, it seems that US-UMP, proxied by both a fall in the spread and an increase in broad money, can stimulate the US economy. However, the GIRFs suggest that changes in the spread is a more effective way to generate international spillovers within China, the Euro Area, and UK, while an increase in broad money is more effective to improve the US economy, see Table 5.6. Given that the bond yield spreads are correlated across countries, a fall in US spread can cause the spread to fall in the economies covered in our analysis. This in turns may stimulate their economies through portfolio balance channel.

In contrast, the impact of US-UMP in the form of an increase in broad money tends to significantly improve US output with weak international spillovers to the selected economies. Overall, our estimated GIRFs suggests that US-UMP can stimulate the US economy and generate international spillovers to China, the Euro Area, and UK. Our results are consistent with the empirical literature on the effectiveness of US unconventional monetary measures. For example, Baumeister and Benati (2010), Gagnon et al. (2011), Gambacorta et al. (2014), and Wu and Xia (2014) find that UMP has been effective to increase US output and inflation. However, we find less expansionary effect for US-UMP compared with the literature. This finding is also reported in Pesaran and Smith (2012). They examine UK-UMP and find that including foreign output can reduce the expansionary effects of the policy due to the potential international spillovers.

5.4 Concluding Remarks

This chapter explores the domestic and international impact of US expansionary UMP using the FAVAR and GVAR methods. The study pursues two objectives. First, to examine the way that an expansionary Unconventional Monetary Policy may influence the US economy. Second, to investigate whether and by which means US Unconventional Monetary Policy can generate international spillovers to other economies. Despite the growing literature on the macroeconomic impact of UMP, there is little empirical literature with the focus on the policy outcome in a global framework.

Given our motivation, we first construct a FAVAR model to account for the domestic impact of US-UMP shocks. Then we construct a GVAR model that connects all the country-specific models by bilateral trade and allows a large degree of interdependencies among the economies. This enables our investigation to capture the international spillover of US expansionary UMP. We model US-UMP shocks using two methods: a fall in the bond yield spread, and an increase in broad money. Our overall results from both the FAVAR and GVAR model suggest that US-UMP has significant domestic and international spillover effects on the macro and financial variables.

Having examined impulse responses, a number of features emerge, although qualitatively the IRFs to US-UMP shocks are very similar to those of GIRFs. First, the results from our FAVAR model suggest that US expansionary UMP has a significant domestic impact on the economy increasing output and inflation. The impulse responses from a fall in the US spread seems to generate more inflationary impact on the US economy compared with those of an increase in US broad money. Second, the results within the GVAR model suggest that both output and bond yield spread are highly correlated across countries, while the correlation for real equity prices are relatively modest. This finding is consistent with those of Dees et al. (2007). We also find that there is a negative correlation between the spread and the equity prices, which validates portfolio balance as the transmission channel. In addition, bond yield spread are globally linked between the US, Euro Area, and UK.

As regards the impulse responses to policy shocks, within the GVAR model, we find that a fall in US spread may generate strong international spillovers. The presented results also show that this expansionary UMP contribute to increasing output and prices both in the US economy and within the Euro Area and UK. In addition, a fall in US spread is associated with a fall in the spread within both the Euro Area and UK, while the real equity prices increased. This finding suggests that the policy shock is transmitted through portfolio balance channel.

Third, our results within the GVAR model are robust to a policy-induced increase in US broad money as this UMP shock can also significantly increase the output within the US economy and generate international spillovers to the Euro Area and UK. In addition, the increase in real equity prices within both the Euro Area and UK indicates that the portfolio balance is the international transmission channel for this policy shock. Fourth, Comparing the GIRFs of UMP shocks suggest that changes in the bond yield spread are more effective in generating international spillovers within the Euro Area and UK, while an increase in broad money is more effective in improving the US economy.

Finally, our results suggest that US-UMP may be transmitted through the portfolio balance channel both in the domestic and international levels, given that the policy shocks cause a reduction in the spread while the real equity prices increased. This is consistent with the finding reported in Joyce et al. (2011, 2012) who identify portfolio balance as the main transmission channel.

Our results are generally consistent with those presented in Gagnon et al. (2011), Joyce et al. (2011, 2012), Kapetanios et al. (2012), Baumeister and Benati (2013), Gambacorta et al. (2014), and Wu and Xia (2014). However, our finding suggests slightly less expansionary effect generated by the policy shocks compared with the literature. It might be due to our approach, which focus on the crisis period. Also, it can be justified as our GVAR model allows for potential international spillovers of the policy interventions. This finding also is reported in Pesaran and Smith (2012). Their model includes foreign output growth to investigate the effectiveness of UK UMP. They argue that the comparison of the results from a simple model with those of foreign output-augmented one, indicates that including foreign variables can reduce the expansionary effect of UMP shock.

It is worth noting that our empirical results only allow limited conclusion given the limitation of the applied econometrics approaches. Further research is required to examine the macroeconomic impact of policy, which allows alternative potential channels for transmission of UMP. It can also enhance our results if we can discriminate between temporary and permanent shocks. Another avenue for further research in line with our study is that to evaluate the effectiveness of UMP with Conditional Modelling techniques that allows counterfactual analysis as in Pesaran and Smith (2012). Furthermore, although, the models used in this study are the variants of VAR models that capture different aspects of the overall evolution in macroeconomic variables, a structural DSGE-type model may provide some further insights.

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Appendix 5.A

Table 5.A.1. Trade Weights Matrix

Country	Australia	Canada	China	Euro Area	Japan	UK	US
Australia	0.000	0.005	0.053	0.028	0.079	0.018	0.019
Canada	0.018	0.000	0.039	0.037	0.034	0.030	0.328
China	0.301	0.063	0.000	0.222	0.380	0.076	0.224
Euro Area	0.179	0.067	0.283	0.000	0.176	0.676	0.244
Japan	0.274	0.033	0.235	0.087	0.000	0.033	0.120
UK	0.062	0.029	0.045	0.326	0.032	0.000	0.065
US	0.166	0.803	0.344	0.300	0.299	0.166	0.000

Note: Trade weights are calculated based on dividing the share of bilateral trade between countries i and j, over the total amount of foreign trade of country i, using the IMF databases for Bilateral Trade. The sample spans 2007-2013.

Table 5.A.2. Unit Root Test for the Domestic Variables

Variable	WS Statistic	Australia	Canada	China	Euro Area	Japan	UK	US
y_{it} (trend)	*-3.24*	-2.702	-2.254	-2.009	-1.924	-0.648	-2.391	-1.595
y_{it} (de-trended)	*-2.55*	1.551	0.692	0.239	0.761	0.633	-0.631	0.195
Δy_{it}	*-2.55*	**-6.407***	**-5.097***	**-3.444***	**-4.882***	**-4.433***	**-3.020***	**-4.189***
π_{it} (trend)	*-3.24*	-2.209	-1.924	-2.991	-0.899	-1.356	-1.459	-1.783
π_{it} (de-trended)	*-2.55*	-2.299	-2.004	-3.020	-0.991	-1.326	-1.447	-1.786
$\Delta \pi_{it}$	*-2.55*	**-11.069***	**-9.732***	**-6.437***	**-8.238***	**-9.547***	**-6.634***	**-9.868***
ep_{it} (trend)	*-3.24*	-0.841	-1.150	0.093	-1.631	-2.467	-2.252	NA
ep_{it} (de-trended)	*-2.55*	-1.306	-1.053	0.713	-1.680	-0.390	-1.854	NA
Δep_{it}	*-2.55*	**-7.795***	**-7.721***	**-7.020***	**-5.138***	**-5.082***	**-8.208***	NA
eq_{it} (trend)	*-3.24*	-3.206	-2.663	NA	-2.259	-1.737	-1.571	-1.879
eq_{it} (de-trended)	*-2.55*	-1.234	-0.842	NA	-0.919	-1.656	-0.242	-0.360
Δeq_{it}	*-2.55*	**-7.328***	**-7.239***	NA	**-6.986***	**-5.101***	**-7.62***	**-6.443***
bys_{it} (trend)	*-3.24*	-3.156	-3.014	NA	-3.047	-2.596	-3.060	-2.703
bys_{it} (de-trended)	*-2.55*	-2.048	-0.670	NA	-1.081	-1.010	-0.411	-0.057
Δbys_{it}	*-2.55*	**-7.425***	**-6.344***	NA	**-5.858***	**-5.343***	**-7.032***	**-4.281***
M_{2it} (trend)	*-3.24*	-1.682	-1.187	0.009	-2.758	-0.145	-1.449	-1.887
M_{2it} (de-trended)	*-2.55*	-1.281	-1.256	-0.065	-2.048	0.088	-0.470	-1.814
ΔM_{2it}	*-2.55*	**-7.746***	**-6.173***	**-8.118***	**-8.054***	**-7.138***	**-6.94***	**-6.832***
gdr_{it} (trend)	*-3.24*	-3.02	-1.77	-2.34	-3.12	-1.51	-2.50	-2.42
gdr_{it} (de-trended)	*-2.55*	-2.05	-1.31	0.75	-0.40	0.20	-2.22	-1.36
Δgdr_{it}	*-2.55*	**-3.29***	**-2.99***	**-2.81***	**-3.38***	**-3.28***	**-3.09***	**-2.80***

Note: Unit Root t-statistics is reported based on Weighted Symmetric estimation of ADF (WS) type regressions due to its superior performance compared to the standard ADF test as it exploits the time reversibility of stationary autoregressive processes. The lag length employed in the WS unit root tests is selected by the Akaike Information Criterion (AIC). An asterisk ,*, indicates the rejection of the null hypothesis of unit root at the 5% significance level. The blank spaces are either due to setting as reference country, i.e. the US, or data limitation, i.e. China. All the statistics are computed over the sample 2007:M06-2013:M06.

Table 5.A.3. Unit Root Test for the Foreign Variables

Variable	WS Statistic	Australia	Canada	China	Euro Area	Japan	UK	US
y_{it}^* (trend)	*-3.24*	-2.736	-1.729	-1.263	-3.053	-3.105	-1.816	-2.831
y_{it}^* (de-trended)	*-2.55*	1.287	0.230	0.477	0.723	-0.025	0.767	0.958
Δy_{it}^*	*-2.55*	**-3.952***	**-4.523***	**-4.529***	**-4.541***	**-3.433***	**-4.897***	**-5.392***
π_{it}^* (trend)	*-3.24*	-1.772	-1.987	-0.924	-1.783	-3.189	-1.043	-1.570
π_{it}^* (de-trended)	*-2.55*	-2.064	-1.996	-1.650	-2.056	-2.204	-1.119	-1.653
$\Delta \pi_{it}^*$	*-2.55*	**-6.433***	**-9.237***	**-6.115***	**-6.600***	**-6.541***	**-6.155***	**-6.243***
ep_{it}^* (trend)	*-3.24*	-0.452	-0.300	-2.340	-0.417	0.486	-1.298	NA
ep_{it}^* (de-trended)	*-2.55*	-0.346	0.045	-1.508	0.198	0.829	-1.312	NA
Δep_{it}^*	*-2.55*	**-7.654***	**-7.373***	**-5.178***	**-7.865***	**-6.896***	**-5.162***	NA
eq_{it}^* (trend)	*-3.24*	-1.874	-1.886	-2.046	-1.874	-2.150	-2.208	-2.906
eq_{it}^* (de-trended)	*-2.55*	-0.858	-0.387	-0.721	-0.409	-0.569	-0.796	-0.963
Δeq_{it}^*	*-2.55*	**-7.041***	**-6.550***	**-6.953***	**-7.041***	**-6.837***	**-6.937***	**-7.224***
bys_{it}^* (trend)	*-3.24*	-3.050	-3.009	-3.034	-2.391	-3.019	-3.013	-3.051
bys_{it}^* (de-trended)	*-2.55*	-0.835	0.046	-0.151	-0.778	-0.832	-0.680	-0.737
Δbys_{it}^*	*-2.55*	**-4.409***	**-4.324***	**-5.162***	**-5.185***	**-5.047***	**-5.268***	**-4.961***
M_{2it}^* (trend)	*-3.24*	-1.709	-2.418	-2.728	-1.149	-1.879	-2.729	-1.653
M_{2it}^* (de-trended)	*-2.55*	-0.883	-1.649	-1.698	-0.399	-1.005	-1.911	-1.104
ΔM_{2it}^*	*-2.55*	**-8.214***	**-7.807***	**-8.078***	**-7.781***	**-8.186***	**-8.085***	**-8.124***
gdr_{it}^* (trend)	*-3.24*	-1.35	-2.39	-3.00	-2.19	-1.91	-3.04	-2.96
gdr_{it}^* (de-trended)	*-2.55*	1.20	-0.64	0.93	0.79	0.37	0.13	0.55
Δgdr_{it}^*	*-2.55*	**-2.69***	**-2.70***	**-2.93***	**-3.27***	**-3.02***	**-3.13***	**-2.73***

Note: Unit Root t-statistics is reported based on Weighted Symmetric estimation of ADF (WS) type regressions due to its superior performance compared to the standard ADF test as it exploits the time reversibility of stationary autoregressive processes. The lag length employed in the WS unit root tests is selected by the Akaike Information Criterion (AIC). An asterisk,*, indicates the rejection of the null hypothesis of unit root at the 5% significance level. All the statistics are computed over the sample 2007:M06-2013:M06.

Table 5.A.4. Lag Order and Number of Co-Integrating Relationships for VARX Models

Country	VARX Order of Individual Models		Co-integrating Relations
	p_i	q_i	
Australia	2	1	2
Canada	2	1	3
China	2	1	2
Euro Area	2	1	2
Japan	2	1	2
UK	2	1	2
US	2	1	2

Note: This Table presents the lag order of domestic, p_i, and foreign, q_i, variables in order. The rank of the co-integrating relations is estimated using Johansen`s trace and maximum eigenvalue statistics for models with weakly exogenous regressors, in the case where unrestricted constant and restricted trend coefficients are included in the country-specific Error Correction Models (ECM). The Co-Integration results are based on the trace statistic and significant at 95% critical value level.

Chapter 6

Concluding Remarks

This thesis sheds light on topical issues relating to the conduct of monetary and fiscal policy. Two features of the macroeconomic policies received less attention despite being central to the impact of the policy actions. First, monetary and fiscal policy interacts and influences the real activity measures jointly. A number of studies emphasize that separating monetary and fiscal policies undermines policy interactions that are important for the determination of prices, see Davig and Leeper (2007,2011), Sims (2011), and Woodford (2011). Second, monetary and fiscal policy interactions may have important international spillovers that may influence or even weaken the domestic impact of the policy shocks, see Pesaran et al. (2004), Dees et al. (2007), Gali (2008), and Pesaran and Smith (2012). Indeed, adopting a global approach might be useful to uncover common dynamic relationship that might otherwise be ignored by idiosyncratic effects at the individual country level, see Pesaran and Smith (2006, 2011).

Given our motivation, we examined thesis subject matter in three stand-alone empirical chapters. This Chapter summarise the main findings and elaborates on the shortcoming of our analysis to identify directions for further work as follows.

6.1 Main Results and Contribution to the Literature

Chapter 3 focused on the conduct of US monetary policy and its transmission mechanism in the presence of government debt over different time intervals. The study contributes to the empirical literature on monetary and fiscal policy interactions in three ways. First, we find that a monetary contraction in a linear FAVAR reduces output growth as expected. This is irrespective of whether the fiscal stance is included or not. However, while inflation falls in response to a monetary contraction within the simple model, it increases in the fiscal-augmented model. This response can be interpreted through the potential positive wealth effects generated by a monetary contraction. Second, the impulse responses from a fiscal-augmented TVP-FAVAR model suggest that fiscal policy may contribute to producing a price puzzle. The price puzzle is more accentuated in the case of an active fiscal policy and a passive monetary policy. This is the case during the 1970s. This influences the monetary transmission mechanism through generating a positive wealth effect and increasing consumption.

The positive response of inflation and output growth to monetary contraction, which is more accentuated under active fiscal policy and passive monetary policy coordination, is consistent with the results presented in Favero and Monacelli (2003), Chung et al. (2007), Davig and Leeper (2007, 2011), Sims (2011), and Leeper and Walker (2012). Chung et al. (2007) argue that the price puzzle can be a normal outcome of periods when monetary policy fails to follow a Taylor Rule and taxes fail to respond to the state of debt. In addition, this result is consistent with Hanson's (2004) explanation of the price puzzle that it cannot be solved by the conventional method of adding extra information and it tends to be severe under an active fiscal policy and a passive monetary policy regime.

Thirdly, the impulse responses within both the linear and TVP-FAVAR model specifications show that fiscal policy has an inflationary impact on the economy. This finding provides empirical support for the non-Ricardian view on US fiscal policy. That is an expansionary fiscal policy stimulates prices and output. This finding is consistent with the results reported in Favero and Monacelli (2003), Davig and Leeper (2007, 2011), and Reade (2011).

In Chapter 4, we examined the international spillovers of US monetary contraction in the presence of government debt. We contribute to the literature on international spillovers of monetary and fiscal policy interactions in a number of ways. First, according to the estimated GVAR model, we find evidence that real output and long-term interest rates are highly correlated across major economies, while real exchange rates, short-term interest rates and inflation show a modest correlation. As regards the contemporaneous effects of foreign variables, empirical evidence suggests that Euro Area bond market is more responsive than its monetary policy reactions. This finding is also reported in Dees et al. (2007).

In addition, the impulse responses obtained from the estimated GVAR models suggest a number of features. First, we show that US government debt influences the duration of responses to a monetary contraction. Given the high level of US government debt, this finding seems to be plausible, as any changes in interest rates can significantly change the interest expenses share of government expenditure. Second, we find empirical evidence to support the non-Ricardian view on fiscal policy within the US economy. The results from a linear government debt-augmented GVAR model show that an expansionary fiscal policy shock may have significant domestic and international spillovers on real and financial variables. In particular, the results suggest that US expansionary fiscal policy shock influences real output and the bond markets in the Euro Area and UK. Third, according to the results of Persistence Profiles test, we provide evidence suggesting that US government debt reduces the speed of adjustment to equilibrium following a contractionary monetary policy shock. This may be due to the impact of fiscal policy on inflation and its persistence.

In Chapter 5, we explored both the domestic and international impact of US Unconventional Monetary Policy (UMP). We adopted the FAVAR and GVAR methods as our policy analysis frameworks. Our results add further evidence to the empirical literature on UMP to support the effectiveness of US-UMP. Our contributions in this chapter are as follows. First, our results from a FAVAR model suggest that US expansionary UMP may have inflationary impact on the economy. Nevertheless, the impulse responses from a fall in the bond yield spread seems to generate more expansionary effect compared with those of an increase in broad money. Our finding overall is consistent with the literature on the effectiveness of US-UMP, see Baumeister and Benati (2010), Gagnon et al. (2011), Gambacorta et al. (2014), and Wu and Xia (2014).

Second, we show that a fall in US spread may generate strong international spillovers. Our results from a GVAR model suggest that US-UMP, in the form of a fall in the spread, contribute to increasing output in US economy and within both the Euro Area and UK. In addition, a fall in US spread is associated with a fall in the spread within the Euro Area and UK, while the real equity prices increased. This finding suggests that the policy shock is transmitted through portfolio balance channel. Third, our results within the GVAR model are robust to a policy-induced increase in broad money. We find that an increase in US broad money can significantly increase US output and generate international spillovers to the Euro Area and UK. In addition, the increase in real equity prices within both the Euro Area and UK indicates that the portfolio balance is the international transmission channel for this policy shock. This is consistent with the finding reported in Joyce et al. (2011, 2012) who identify portfolio balance as the main transmission channel.

Finally, our results suggest that changes in the bond yield spread are more effective in generating international spillovers within the Euro Area and UK, while an increase in broad money is more effective in improving the US economy. Our results are generally consistent with the literature as presented in Baumeister and Benati (2010), Gagnon et al. (2011), Joyce et al. (2011, 2012), Kapetanios et al. (2012), Gambacorta et al. (2014), and Wu and Xia (2014). However, our finding suggests slightly less expansionary effect generated by the policy shocks compared with the literature. It might be due to our approach, which focus on the crisis period. In addition, it can be justified as our GVAR model allows for potential international spillovers of the policy interventions. This finding also is reported in Pesaran and Smith (2012). They argue that including foreign variables can reduce the expansionary effect of UMP shock.

6.2 Policy Implications of the Research

This section outlines some policy lessons that can be drawn from our empirical finding. Overall, our results have important implications for macroeconomic policy management and suggest that a reconsideration of certain popular approaches in measuring the impact of monetary policy is required. Clearly fiscal policy has important impact on the conduct of monetary policy, in particular for inflation and output. This is the case as inflation is the key variable that monetary policy aims to control. However according to the Fiscal Theory of the Price Level, fiscal policy also can significantly influence prices. This implies that the monetary authorities can no longer ignore the fiscal stance.

Thus, the central policy implication arises from our analysis counteracts the monetarist view that inflation is always and everywhere a monetary phenomenon. We find the opposite: monetary aggregates are not the main determinant of inflation. Fiscal policy may also play a substantial role in the determination of the price level, see Bradley (1984), Woodford (1998, 2011), Cochrane (2009), Favero and Monacelli (2003), Chung et al. (2007), Davig and Leeper (2007, 2011), Sims (2011), Leeper and Walker (2012), and Leeper (2013).

In addition, we find empirical evidence that price puzzle can be the outcome of active fiscal policy and passive monetary policy. It implies that an active fiscal policy may contradict the policy-targeted deflationary impact of monetary contraction. This has an important policy implication for the macroeconomic policy management. It suggests that the omission of the fiscal stance from models intended to evaluate monetary policy may produce implausible results. Furthermore, our results show that US government debt may reduce the speed of adjustment to equilibrium following monetary policy shocks due to the impact of fiscal policy on inflation and its persistence. This finding also suggests that the monetary authorities should consider adopting econometrics model that explicitly account for the fiscal stance.

Finally, we find that an increase in broad money is more effective to stimulate the domestic economy, while lowering the bond yield spread can generate more international spillovers. This implies that the monetary authorities should examine the use of unconventional monetary policy measures in a global framework that accounts for both the domestic and international impact of policy implementation.

6.3 Limitations of the Study and Direction for Further Research

Having outlined the main findings of our thesis, there are a number of caveats concerns our analysis. We note these limitations together with some directions for further research as follows.

First, our results from Chapter 3 are limited to the constructed FAVAR models, both the linear and non-linear model specifications, which only allow very limited scope of macroeconomic policy interactions to be traced. As concerns the results from the linear FAVAR model, it worth exploring the experiment within the Block of Factors framework as in Korobilis (2013). As regards the results obtained from the Time-Varying Parameter FAVAR model, our model does not explicitly allows for monetary and fiscal policy regime switching as in Davig and Leeper (2011). Thus, this experiment is left to future work. Finally, it may be useful to further investigate our research questions adopting a Time-Varying Factor loadings as in Del Negro and Otrok (2008).

Second, we employ a linear GVAR model with constant parameters in Chapter 4. Given the existing evidence on significant macroeconomic regime changes over the past decades, it appears plausible to explore the research questions using a non-linear version of the GVAR. For example, the non-linear GVAR model as in Favero (2013) may account for different monetary and fiscal policy regimes to analyse global policy shocks. Adopting alternatives identification approaches for monetary and fiscal policy shocks also is left to future work.

Third, as concerns the findings presented in Chapter 5, a few dimensions is emerged in line with this study is to discriminate between temporary and permanent shocks. It may be also useful to evaluate the effectiveness of UMP with Conditional Modelling techniques that allows counterfactual analysis as in Pesaran and Smith (2012). Furthermore, although, the models used in this study are the variants of VAR models that capture different aspects of the evolution in macroeconomic variables, a structural DSGE-type model could potentially provide some further insights.

Finally, the usual caveats concerning the econometric specification, estimation and validation of our models apply. However, our use of state of the art econometric techniques hopefully minimizes the effects of such issues.

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