The Implication of Monetary and Fiscal Policy Interactions for the Price Levels: the Fiscal Theory of the Price Level Revisited

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Abstract

This paper 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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1.1 Introduction

This paper 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 Paper 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 Paper 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 Paper 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 paper 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 Paper 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

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[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

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. (2005) with those

demand-side, see Barth and Ramey (2002). The cost channel explains that to the extent that firms must borrow to 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.

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 Paper 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 Paper 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 Paper 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 paper 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 paper 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 paper is constructed upon it.

1.2 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.

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[13] The exceptions are noted in Paper 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

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[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 Paper 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 Paper 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.

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[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 Paper 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 survey of the

[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.

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†

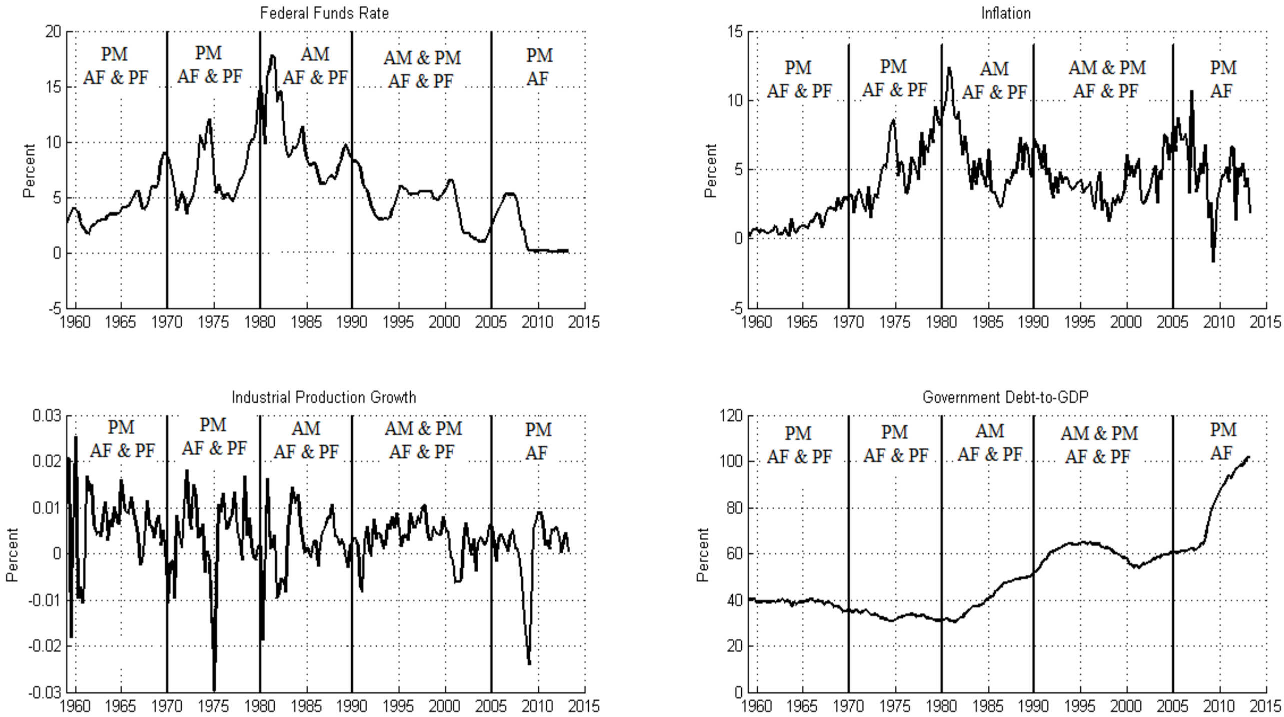
Note: This Table reports the mean and standard deviation for key indicators of the US economy under the selected representative chairmanships of the Federal Reserve. Inflation is the change in CPI. Values marked by asterisks, *, present the largest Mean, and values marked by † present the largest Standard 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.

1.3 Econometric Methodology

Recall from Paper 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.

1.3.1 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.

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

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

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

one approach over the other one, given that the two methods are different in many dimensions. 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.

$$\begin{bmatrix} X_t^1 \\ X_t^2 \\ \vdots \\ X_t^K \end{bmatrix} = \begin{bmatrix} \Lambda_1^f & 0 & \cdots & 0 \\ 0 & \Lambda_2^f & \cdots & 0 \\ \vdots & \cdots & \ddots & \vdots \\ 0 & \cdots & \cdots & \Lambda_K^f \end{bmatrix} \begin{bmatrix} F_t^1 \\ F_t^2 \\ \vdots \\ F_t^K \end{bmatrix} + e_t \tag{3. 4}$$

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.

[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.

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

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.

$$\begin{bmatrix} \hat{F}_t^1 \\ \hat{F}_t^2 \\ \vdots \\ \hat{F}_t^K \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} \hat{F}_{t-1}^1 \\ \hat{F}_{t-1}^2 \\ \vdots \\ \hat{F}_{t-1}^K \\ Y_{t-1} \end{bmatrix} + e_t \qquad (3.6)$$

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.

1.3.2 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).

[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.

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 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

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

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);

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

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;

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

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;

$$A_t \Omega_t A_t' = \Sigma_t \Sigma_t' \qquad (3.\ 14)$$

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 $\sum_t$. 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;

$$B_t = B_{t-1} + J_t^B \eta_t^B \quad (3.15)$$

$$\alpha_t = \alpha_{t-1} + J_t^\alpha \eta_t^\alpha \quad (3.16)$$

$$\log\sigma_t = \log\sigma_{t-1} + J_t^\sigma \eta_t^\sigma \quad (3.17)$$

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

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

simulation method is adopted to estimate the Time-Varying Parameters in Equations (3.15) to (3.17).

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.

1.4 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.

1.4.1 Model Specification

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

[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).

1.4.2 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

[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.

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

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.

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

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

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

[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).

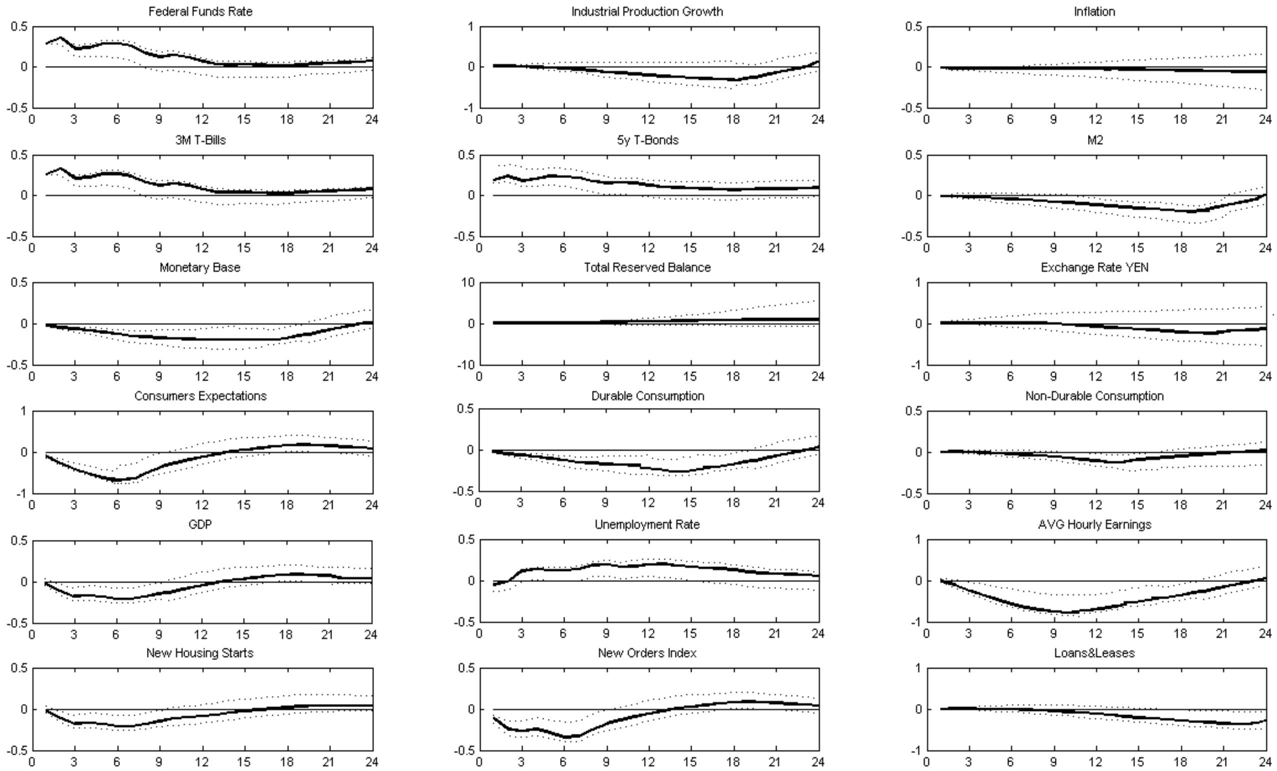
with three unobserved factors and three observed variables in the VAR. The three observed variables in the VAR section include Inflation, Industrial Production growth, and the nominal Federal Funds rate.[47] It is expected that a monetary contraction shall induce small and transitory effects on interest 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. Paper 4 explores this idea further.

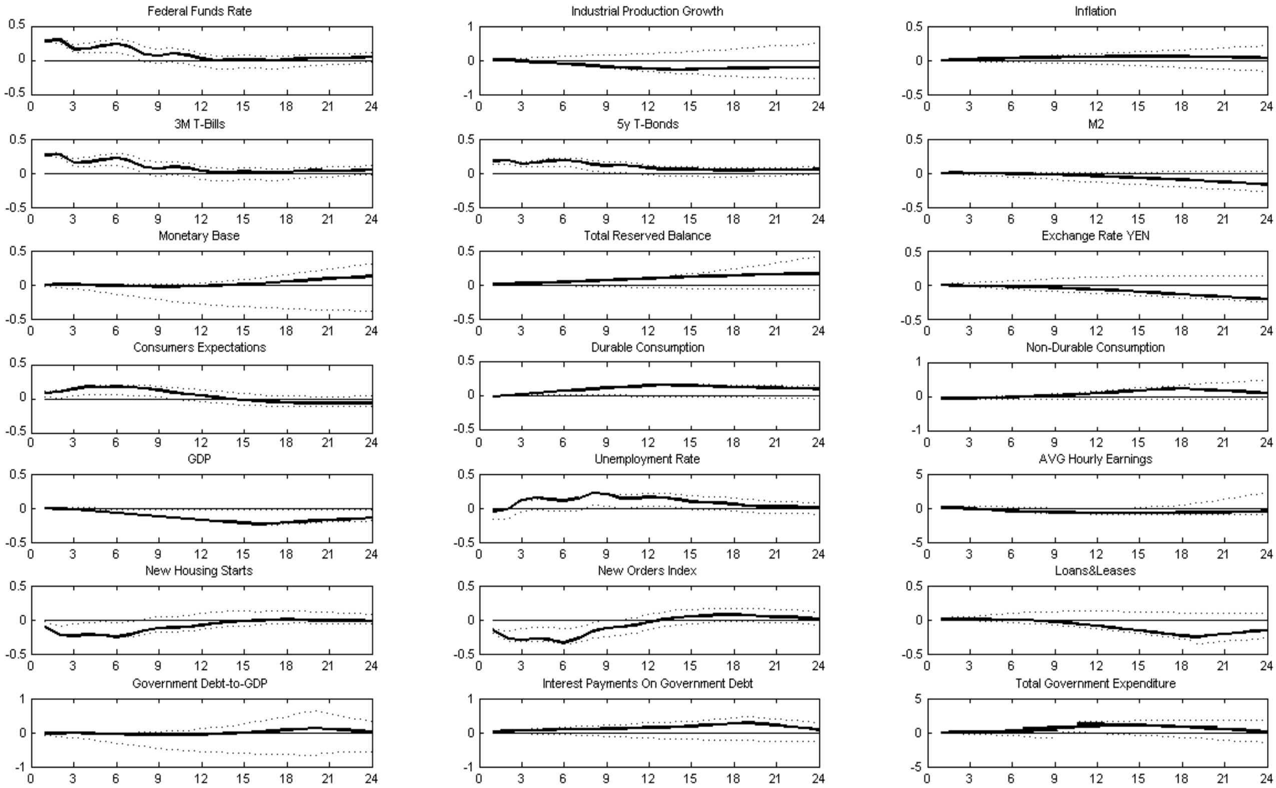
However, comparing the response of inflation from the simple model with the fiscal-FAVAR, it is evident that inflation increases in the latter model while it remains unresponsive and eventually falls within the simple model. It worthy to note that the response of both Industrial Production growth and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

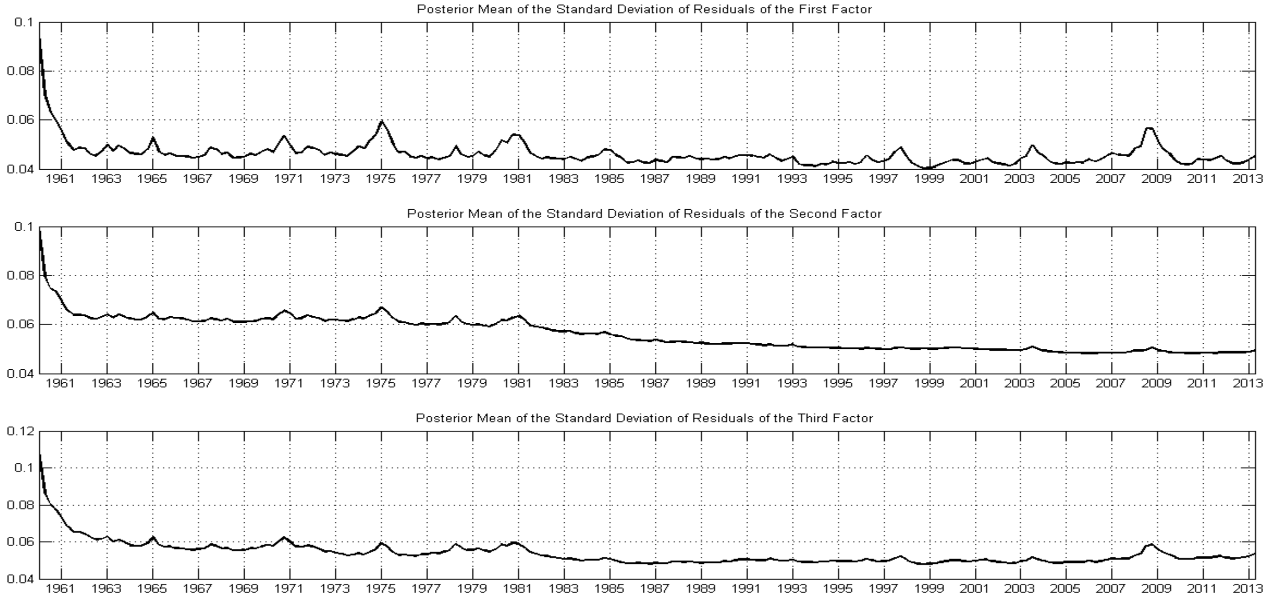
Several studies find evidence supporting that macroeconomic policy in the United States changed regimes, see Favero and Monacelli (2003), Chung et al. (2007), and Davig and Leeper (2007, 2011). Given this paper motivation, we examine the potential influence of changes in monetary and fiscal policy performance 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.

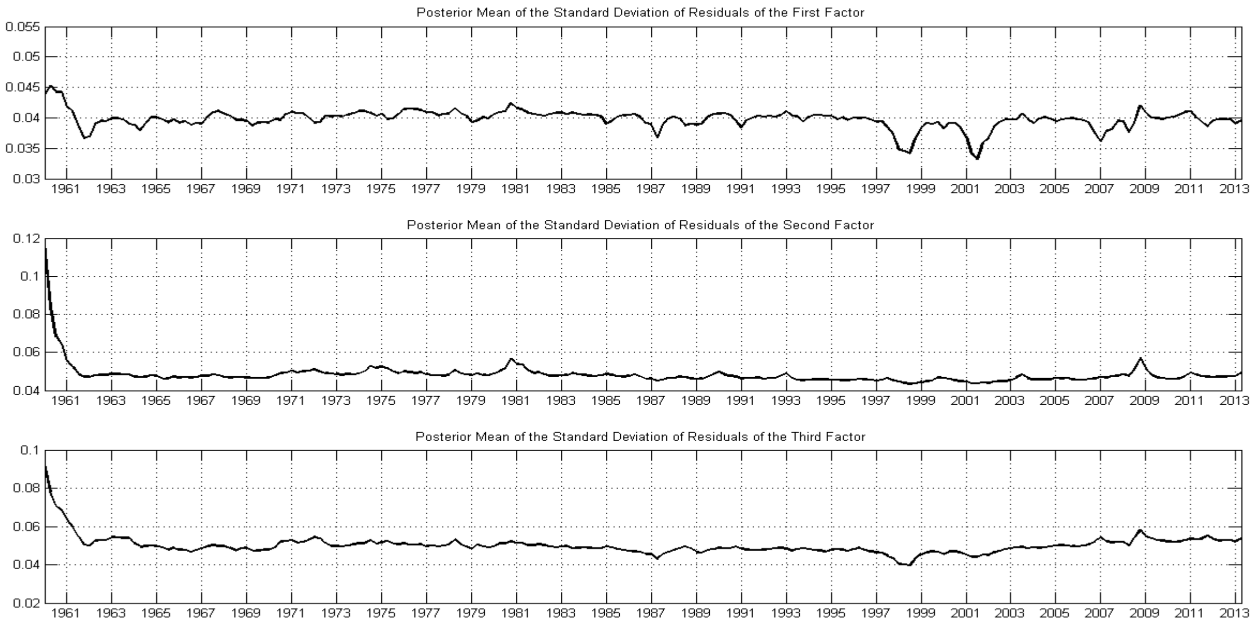
As can be observed in Figures 3.6 and 3.7, the standard deviations of the residuals of the observable variables in the VAR decrease when fiscal variables are included in the model compared with the simple TVP-FAVAR. As regards with the posterior mean of the standard deviations of inflation, mainly two 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



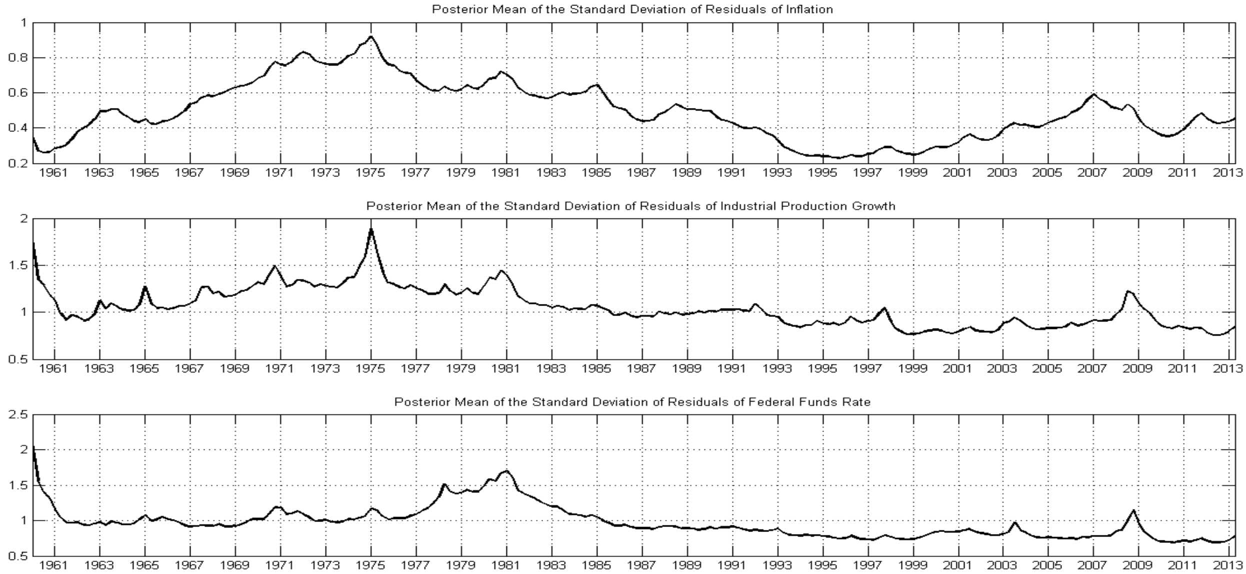
Note: Figure presents the Time-Varying Standard Deviations (SD) of the errors within the simple TVP-FAVAR model with Three Unobserved Factors over the 1959:Q1-2013:Q2 sample. The FAVAR part of the model is estimated using the Two-Step Principal Components method based on Bernanke et al. (2005) identification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

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



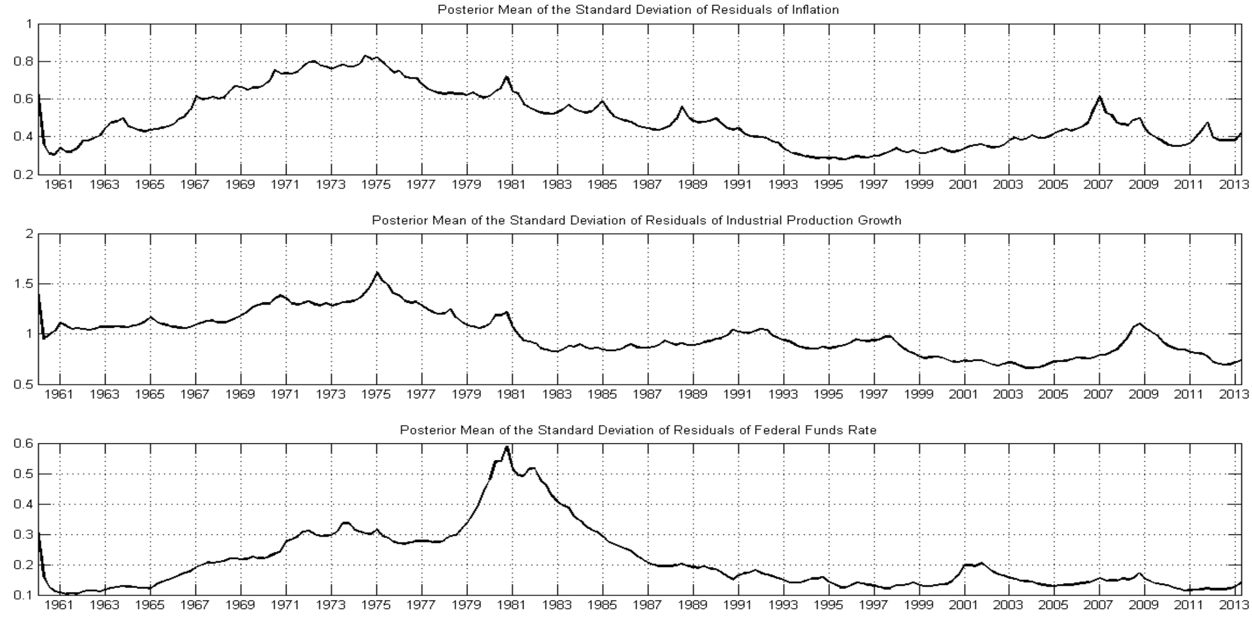
Note: Figure presents the Time-Varying Standard Deviations (SD) of errors within the fiscal-augmented TVP-FAVAR model with Three Unobserved Factors over the 1959:Q1-2013:Q2 sample. The FAVAR part of the model is estimated using the Two-Step Principal Components method based on Bernanke et al. (2005)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

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[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 3.1. US Macroeconomic Policy Regimes

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

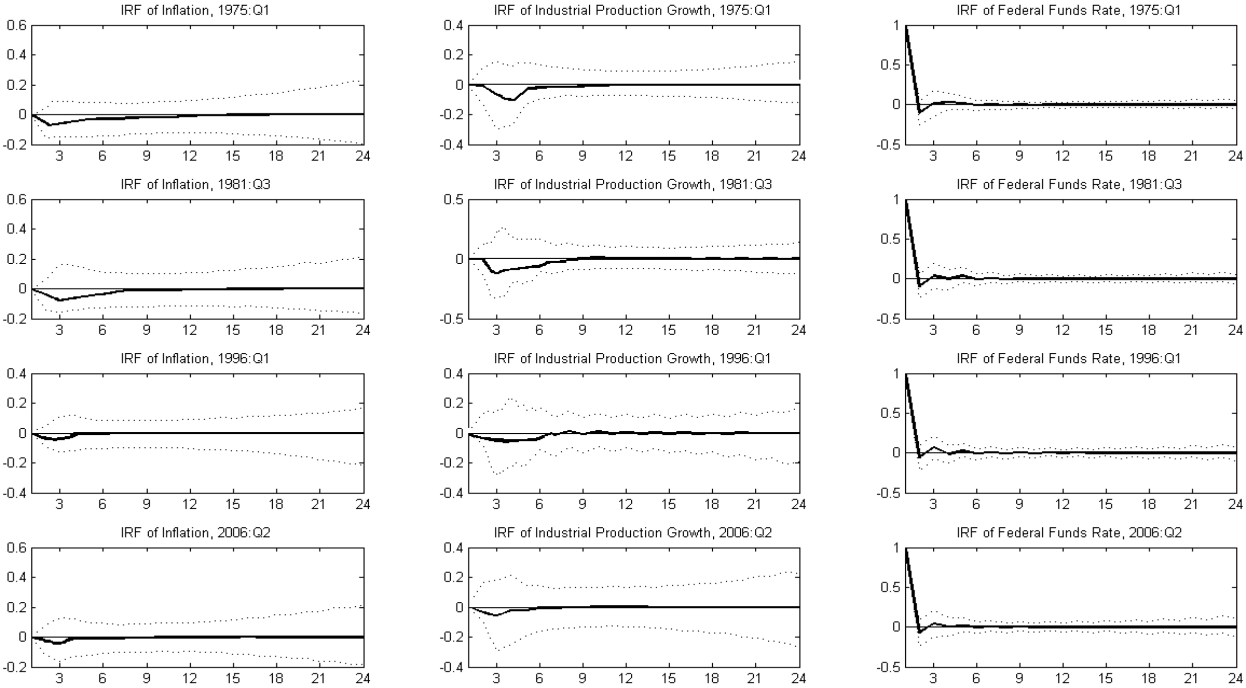
Note: This Table reports different macroeconomic policy regimes. Different fiscal policy regimes are based on Favero and Monacelli (2003), and Davig and Leeper (2007, 2011). Monetary policy regimes are based on those reported in Davig and Leeper (2007, 2011).

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.

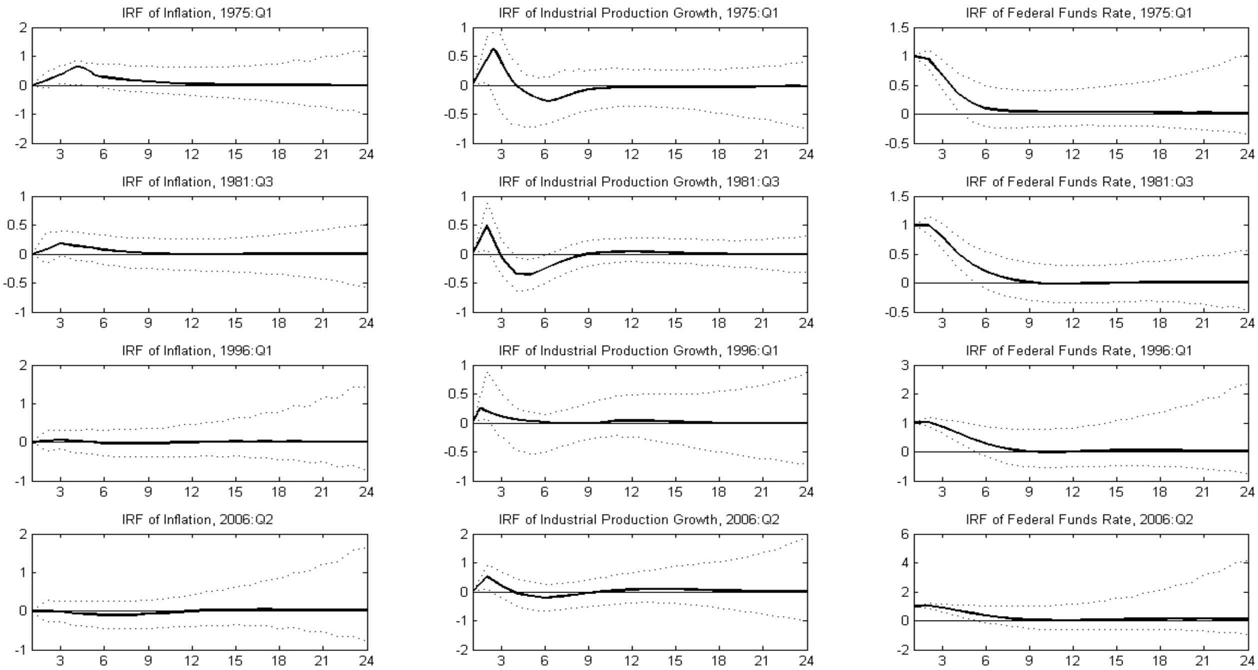
[54] Note that the results presented in Korobilis (2013) show the occurrence of the price puzzle over the 1975:Q1. His work, however, does not cover the 2006:Q2 period and is constructed upon 143 US macroeconomic time series.

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.

[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 Paper 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 taxes,

Table 3.2. 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.

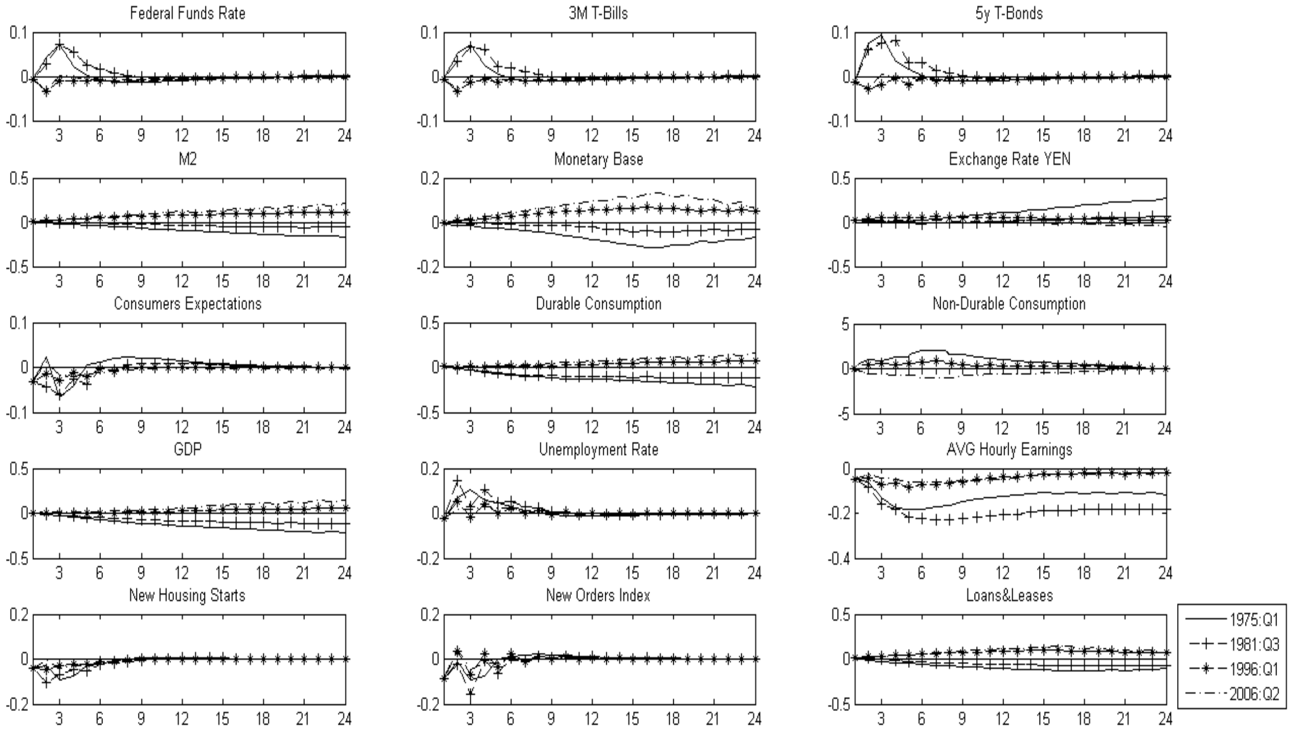
Second, during Greenspan and Bernanke periods, the Federal Funds rate has declined significantly while inflation nearly remains close to the overall sample mean value. Thus, the real rates turn to be negative. As reported in Table 3.4, the government debt continues to rise, in both sub-samples. However, 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.

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

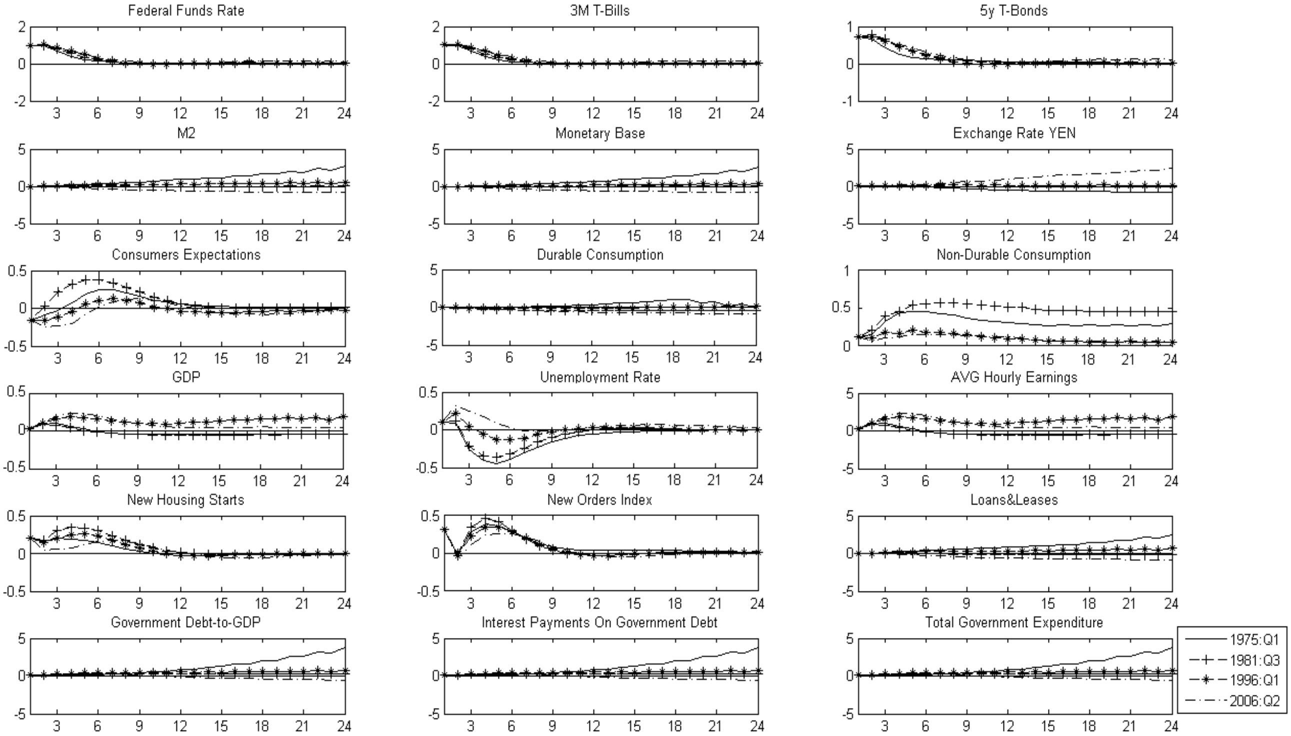
Greenspan and Bernanke periods, respectively. The IRFs results within the simple model are consistent with those presented in Korobilis (2013).

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 3.3. 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.

1.4.5 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 Paper 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 papers, 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

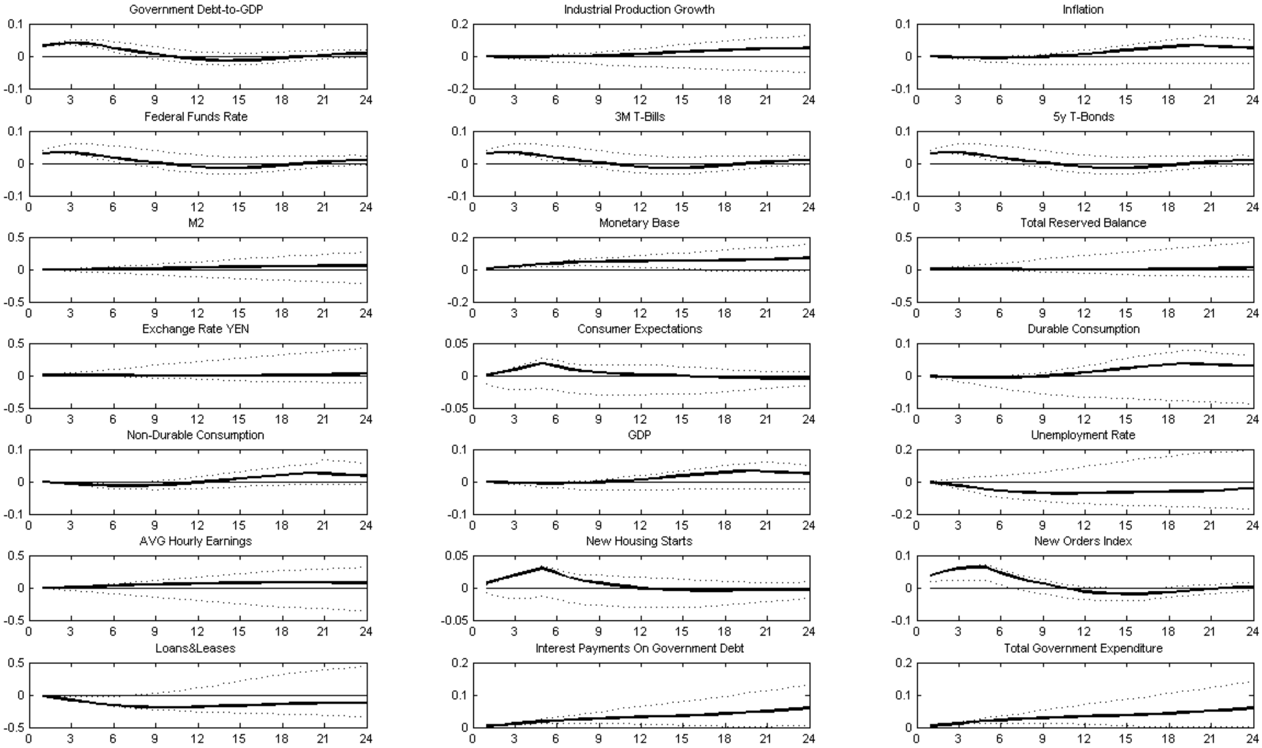
This section presents the way in which an expansionary fiscal policy shock may influence the economy within a linear FAVAR model. Likewise monetary policy, the extent to which fiscal policy can impact the economy depends on its ability to stimulate aggregate demand through private expenditure. As discussed in Paper 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.

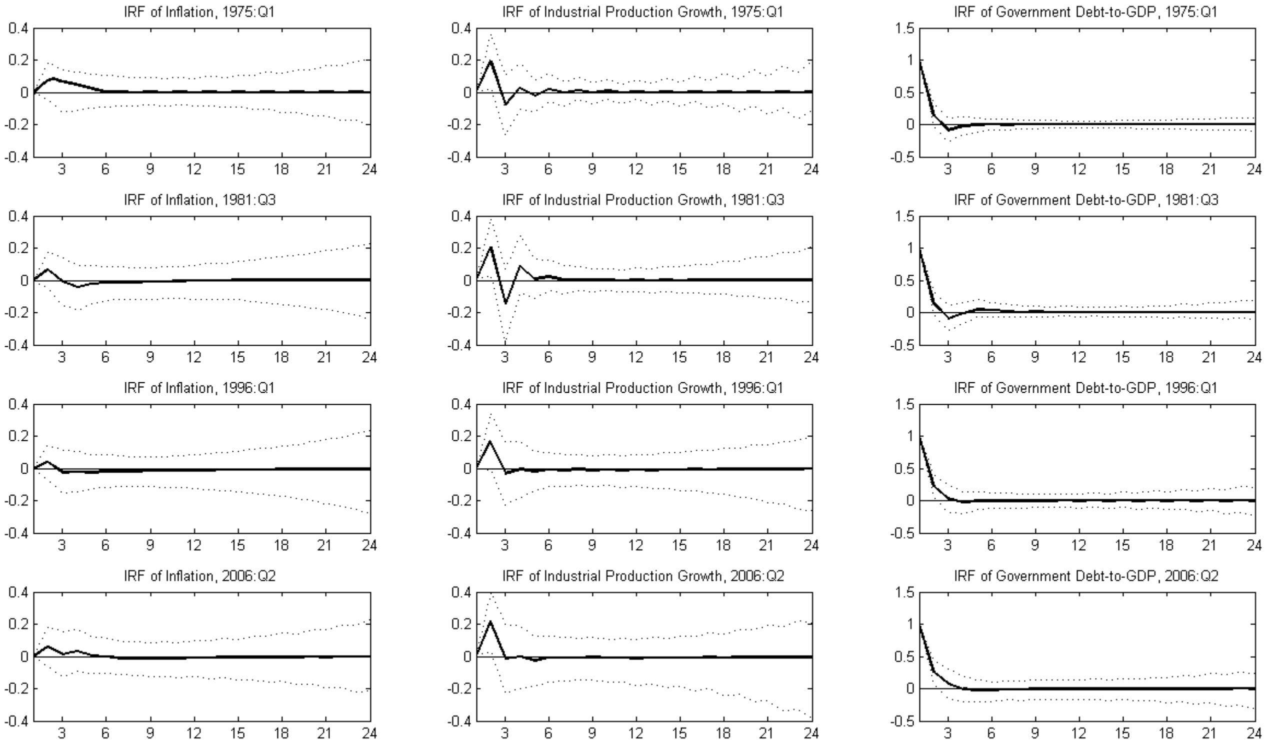
3.4.7 The TVP-FAVAR Model Specification Results to Fiscal Shock

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.

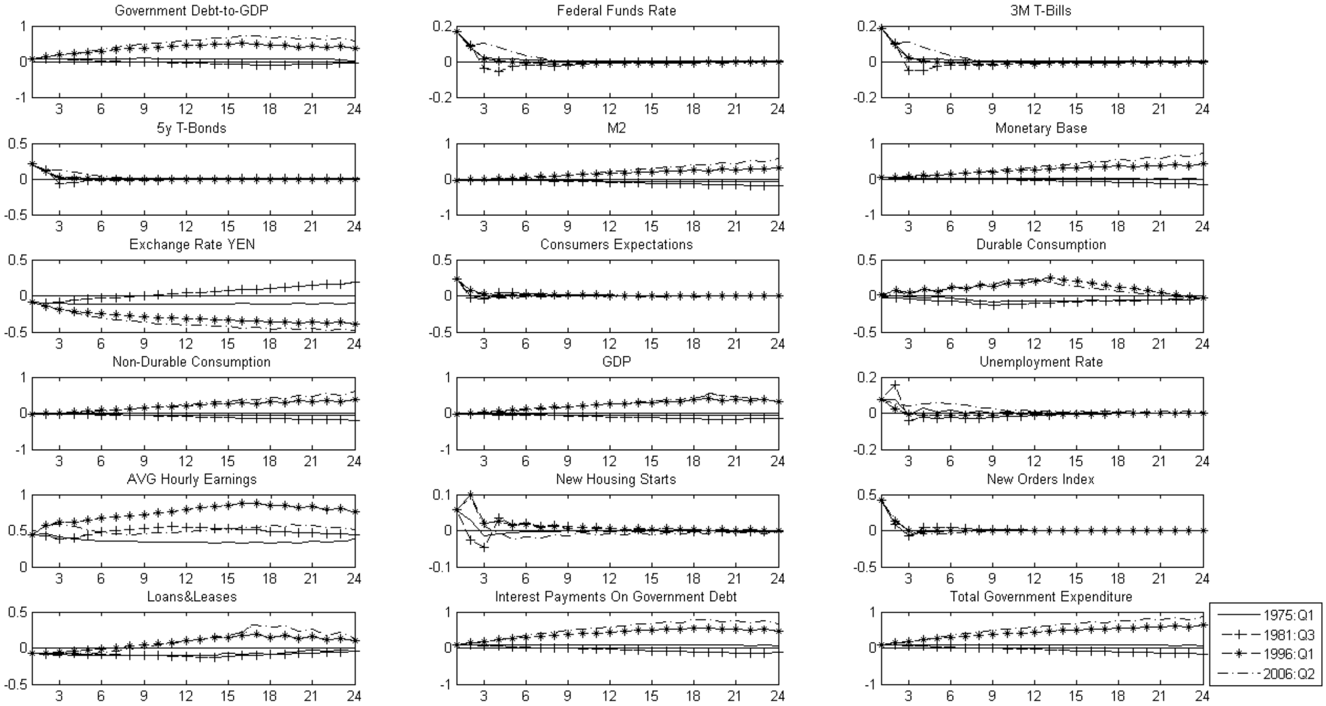
Figure 3.13. IRFs of the Observable Variables within the TVP-FAVAR



Note: The Figure shows IRFs to a US fiscal Expansion. The Impulse Responses (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 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.

1.5 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 3.4. 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 3.5. 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.

1.6 Concluding Remarks

This paper 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
32	UEMP5TO14	Civilians Unemployed for 5-14 Weeks	5	1
33	UEMP15T26	Civilians Unemployed for 15-26 Weeks	5	1

	Mnemonic	Description	T code	Slow Code
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
71	TB6MS	6-Month Treasury Bill: Secondary Market Rate	1	0
72	GS1	1-Year Treasury Constant Maturity Rate	1	0

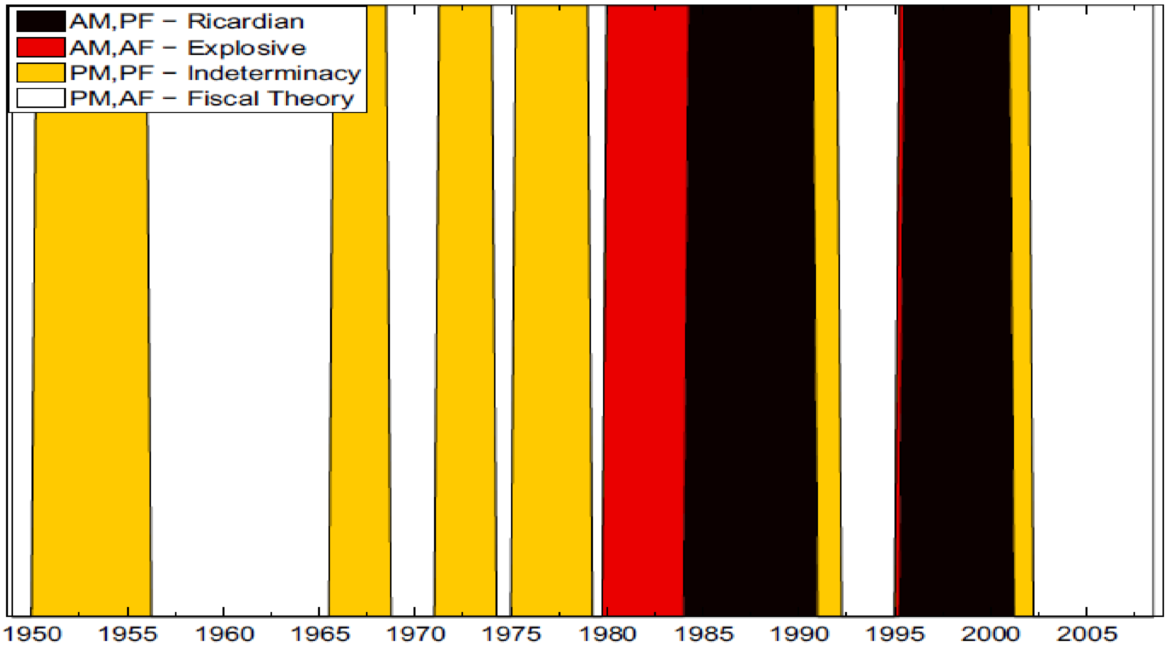
	Mnemonic	Description	T code	Slow Code
73	GS3	3-Year Treasury Constant Maturity Rate	1	0
74	GS5	5-Year Treasury Constant Maturity Rate	1	0
75	GS10	10-Year Treasury Constant Maturity Rate	1	0
76	INTGSBUSM19N	Interest Rates- Government Bonds for United States	1	0
77	IRLTLT01USQ1N	Long-Term Government Bond 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
114	USGSEC	US Government Treasury and Securities at All Commercial Banks	5	0
115	OTHSEC	Other Securities at All Commercial Banks	5	0

	Mnemonic	Description	T code	Slow Code
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
157	COMPRNFB	Nonfarm Business Sector: Real Compensation Per Hour	5	1
158	ALWASPQ027S	All sectors; wages and salaries paid (IMA)	5	1

	Mnemonic	Description	T code	Slow Code
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

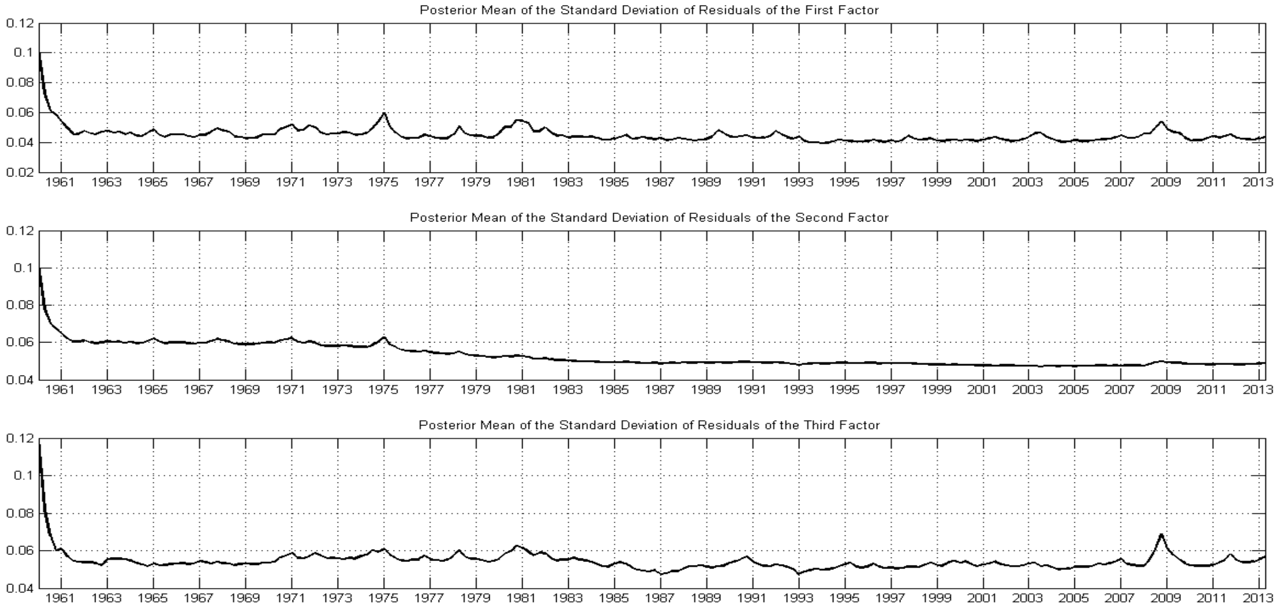
Appendix 3.B: Figures

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



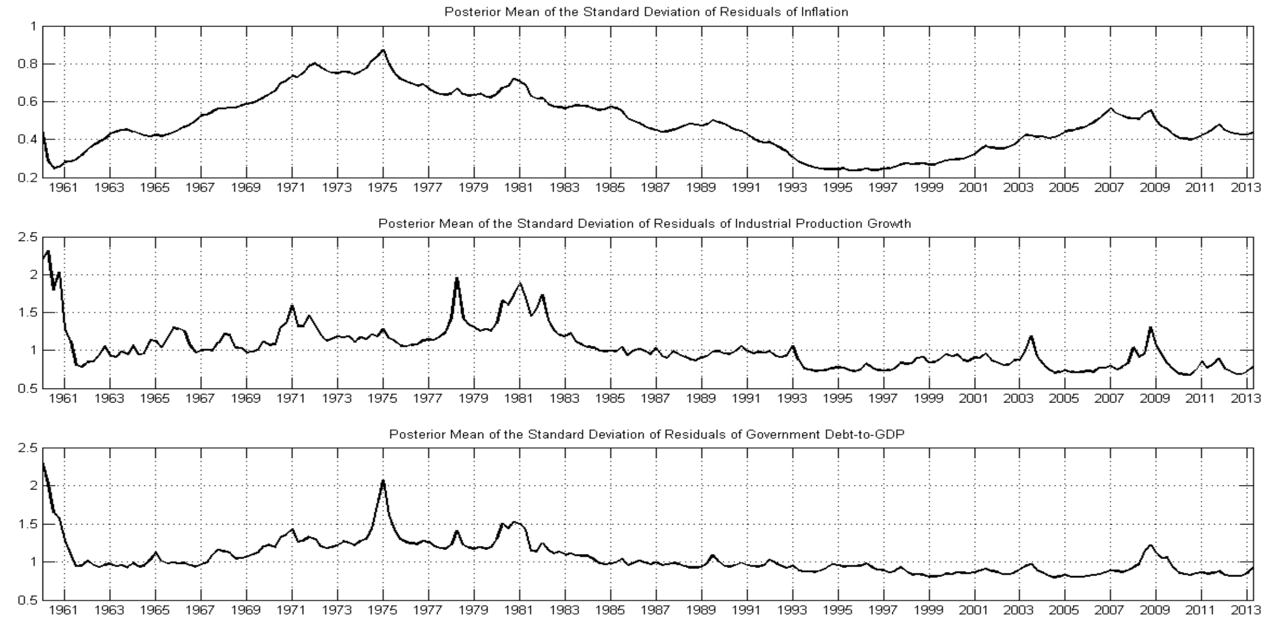
Note: This Figure illustrates different macroeconomic policy regimes estimated within a Markov-Switching model. The Figure is adopted from Davig and Leeper (2011).

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.

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