UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

BUSINESS SCHOOL
Te Kura Pakihi

ISSN 1178-2293 (Online)

University of Otago
Economics Discussion Papers
No. 1604

FEBRUARY 2016

Cheap Talk in a New Keynesian Model[*]

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Cheap Talk in a New Keynesian Model*

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January 12, 2016

Abstract

This paper shows that the stance of fiscal policy does have significant impact on the conduct of monetary policy in the United States. Further, we document that the implied fiscal-monetary policy interactions are subject to regime instability, using a Markov-switching model.

Then, we develop a microfoundation of regime switches using a cheap talk game between central bank and government. As a case study, we simulate the effects of regime switches within an otherwise standard New Keynesian model using the cheap talk game in the state-space of our model.

Keywords: Markov-switching, Monetary and Fiscal Policy Interactions, Policy Coordination Games, Sequential Games.

JEL codes: C32, C7, E5, E6.

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[*] I would like to thank Ester Faia, Céline Poilly, and Olaf Posch for comments and suggestions. All remaining errors are my own.

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1 Introduction

The high inflation period of the late 1970s and early 1980s lead economic research to start modelling the interactions between monetary and fiscal policy as a coordination game between policy makers.[1] Although it is a common factor in developed countries that fiscal and monetary policies are determined by independent authorities, interactions between the two policies are ubiquitous. This seems intuitive as each policy affects the effectiveness of the other and, hence, the overall effect of the policy mix.[2]

More technically, the root of those monetary and fiscal policy interactions can be traced to the government budget constraint as it creates a dynamic link between deficits, interest rates, and, hence, the path of debt. Along this line, research has shown that existence and uniqueness of a rational expectation equilibrium hinge upon the specific design of the policy mix.[3] Within this strategic environment authorities may have at least partially different objectives, differ in their perception about the effectiveness of fiscal and/or monetary policy tools, or differ in their forecasts and/or assessment of states of the economy.[4]

Therefore, strategic interactions in the coordination of those policies play a key role in the design of the policy mix and in achieving macroeconomic policy goals. This is supported by various statements issued by Board members of the Federal Reserve (FED, for short). For example, Powell (2013) states that "[...] fiscal sustainability and its interaction with monetary policy is certainly timely.[...] accommodative monetary policy is often associated with successful fiscal consolidations.[...]", see also Bernanke (2013) and Yellen (2013a, 2013b).[5]

The second dimension to this policy problem is time-variability. More than monetary policy, fiscal policy is subject to changes to swings in political preferences. While the era of Paul A. Volcker as Chairman of the FED is often stressed as an example for switches in preferences of central bankers, other examples for switches in the conduct of fiscal policy can be found easily in the history of the United States. Consider, for example, the military spending programs by the Presidents Johnson, Carter, Reagan, and G. W. Bush as well as the tax cuts by Ford and Reagan. Further, fiscal policy under President Clinton can be considered to be motivated by fiscal stabilization, while the Bush tax cuts in the early 2000's resuscitated the discretionary fiscal policy design.[6] A dramatic consequence of this policy switch was the return of government deficits and a faster government debt accumulation. Given the evidence for switches in fiscal and monetary policy,

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[1] Seminal works include, but are not limited to, Pindyck (1976), Blinder (1982), Tabellini (1985, 1986), Alesina and Tabellini (1987), and Debelle and Fisher (1994). For coordination in the open economy setting see, for example, Hamada (1976), Canzoneri and Gray (1985), and Turnovsky et al. (1988). Games between monetary policy and economic agents were first considered by Kydland and Prescott (1977) and Barro and Gordon (1983).

[2] Some examples include credit crowding-out and wage-price spirals created by the effects of taxes on prices. Further, the expectation channel can have adverse effects on the stability of financial markets.

[3] Sargent and Wallace (1981), Leeper (1991), and Benhabib et al. (2001)

[4] See e.g. Pindyck (1976), Blinder (1982), and Tabellini (1986).

[5] For official statements by the Treasury see, e.g., Lew (2013).

[6] The Omnibus Budget Reconciliation Act in 1993 contained a promise to establish a balanced budget.

switches in the interactions between the two policies are an implication by the interrelatedness of both policies in the policy mix.

We add to the empirical and theoretical literature on monetary and fiscal policy coordination. Empirically, we proceed along the lines of Davig and Leeper (2006, 2007, 2008, 2011) using Markov-switching models to characterize the interaction between monetary and fiscal policy. To the best of our knowledge, this paper is the first to estimate those models including government surplus. We estimate a univariate Markov-switching model with time-varying probabilities and document frequent regime switches in the interaction between fiscal and monetary policy.

The theoretical model is based upon the work by Tabellini (1985, 1986) using a (non-cooperative) Stackelberg-game between monetary and fiscal authority.[7] In addition, we consider an imperfect information setting: In a strategic environment the fiscal authority can be seen as a sender of a signal about the path of fiscal policy and the monetary authority as the receiver of this signal. So far, Tabellini (1985, 1986) assumes that information is symmetrically distributed. But, this assumption might be too restrictive due to private information, for example, about the true level and future path of fiscal policy. For example, the fiscal authority might be interested in claiming that debt is higher than it actually is, creating an incentive for the monetary authority to increase inflation in order to lower the real debt burden or to create an incentive to monetize debt. This can be achieved by setting lower interest rates and, in addition, lower interest rate would generate positive real effects, i.e. increase output and employment. On the other side, the government might be tempted to signal lower debt, indicating that is able to meet its debt obligations, and to have access to capital markets to refinance its (future) debt.

To be precise, we use a cheap talk game between central bank and fiscal policy to microfound policy interactions and regime switches. Exogenous (or, in future research, endogenous) changes in the expectation of agents trigger policy shifts. This approach to model the interaction between monetary and fiscal policy using an expectation channel is motivated by the observation that one player (in this paper, fiscal policy) has private information and tries to extract rents from sending an optimal signal. We believe that this setting can be applied to various strategic policy problems from more general ones (like the game between monetary and fiscal policy studied in this paper) to more specific ones (like the Greek debt crisis).

For example, if a Ricardian government increases government spending this might trigger the expectation that the government becomes Non-Ricardian. We call a government Ricardian, if its path of debt is sustainable and it honors its debt obligations. Further, since debt matters for the conduct of monetary policy, the central bank reacts by changing its responsiveness to debt in the Taylor rule. Put differently, changes in the prior beliefs within this game, the pendant to the estimated Markov-switching probabilities, can trigger different outcomes and, hence, different weights in the Taylor-rule. This will have effects on the transmission of shocks and, hence, on the quantitative and qualitative results.

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[7] The assumption of a non-cooperative game is based upon the observation that monetary and fiscal policy do not always share the same targets. Therefore, fiscal policy wants to exploits rents from having private information.

The theoretical as well as the empirical contributions are related to the work by Bianchi and Melosi (2013) and Bianchi and Ilut (2015), building a (Markov-switching) DSGE model with a rich monetary/fiscal policy mix. In contrast to our paper, in those two papers there is no effect of government debt in the Taylor-rule and no microfoundation of regime changes.

Lastly, we present a case study to show how to implement this cheap talk (or any type of finite sequential or simultaneous move) game in a state-space DSGE model. Our solution approach allows the inclusion the game structure explicitly in the model. That is to say, the sequential move game and its solution algorithm are directly implemented in the state-space of our model, something that is a novelty in DSGE modelling. This guarantees a high degree of flexibility for modelling those interactions and allows to use this approach for a wide range of problems and also allows the analysis of repeated games. Games are implicitly considered in DSGE models but, for example, only to the extent that a Ramsey problem is a Nash solution which gives us a set of equations that can be solved. However, the game is not part of the state-space model and has de facto no direct impact on the solution.

2 Literature Review

The seminal work by Sargent and Wallace (1981) (using a game of chicken) shows that independent monetary policy is impossible, if the government runs deficits which creates the expectation that it might influence monetary policy in the future. This opposes the canonical monetarist view of inflation arguing that only monetary policy controls the price level by controlling money supply. A flaw in this theory is that once the velocity of money is non-constant, the price level cannot be determined independently from other variables. Hence, the entire equilibrium path of the model matters and, ultimately, multiple equilibria can arise.

A new and different theory to determine the price level was developed mainly by Leeper (1991), Sims (1994, 1997), and Woodford (1994, 1995, 1998, 2001), namely the fiscal theory of the price level (FTPL, for short). In a nutshell, this theory claims that the price level is solely determined by government instruments. As a central point, again, the government budget constraint is interpreted as an equilibrium restriction that leads to price level changes when fiscal variables change. Put differently, the government chooses a strategy for fiscal policy, that is, it chooses the path of surplus and debt. Then, conditional on this path of actions, the monetary authority chooses the path of the interest rate. Hence, the combination of fiscal and monetary policy (interactions) pins down the price path and a stable path is only achieved for some combination of policies. In conclusion, the FTPL points out that the monetarist point of view does only hold under strong assumptions on the behavior of the fiscal authority.

Time-dependence of policy interactions can be explained by intertemporal financing implications. The way a given fiscal policy expenditure will be financed and the way the monetary authority behaves in the future drives the effects of current policies. Here, regime-switches can trigger wealth effects as well as intra- and intertemporal substitution effects. Much more important, those effects can be generated by the pure expectation of regime switches.

In recent years more and more research has been conducted on time-variability in Taylor (1993)-rules. Research along this line has challenged the viewpoint that parameters in the Taylor rule are stable over time and assumed that changes in monetary policy are endogenous. This agenda has been motivated, to a large extent, by the end of the Great Inflation of the 1970's and the Great Moderation starting in the mid 80's.[8] From a more theoretical viewpoint, the perception alone that switches have occurred in the past and possibly occur in the future might be strong enough to generate macroeconomic effects through an expectation channel.

Relying on OLS and a subsample analysis Judd and Rudebusch (1998) show that monetary policy has been subject to changes over time. Clarida et al. (2000) and Orphanides (2004) find support for this viewpoint, stressing that policy was different during the pre-, post-Volcker era respectively. They show that monetary policy was accommodative pre-Volcker, not satisfying the Taylor principle and, hence, allowing for multiple equilibria. The more recent literature on VAR's and maximum likelihood estimation supports the premise of time-variability in the conduct of monetary policy. Cogley and Sargent (2001) confirm the previous findings using a reduced form VAR with drifting coefficients. However, Sims (1999, 2001) and Sims and Zha (2006) using Markov-switching models show that the results are not robust to including heteroscedasticity. They find that most of the changes are driven by time-varying volatility of the innovation terms. Then, Cogley and Sargent (2005) proceed and include heteroscedasticity in the applied reduced form VAR. They find evidence for significant changes in the parameters describing monetary policy. Along this line, Boivin (2006) uses the median-unbiased estimator with real time data allowing for heteroscedasticity and finds evidence for changes in the parameters on inflation and the output gap.[9] He finds that monetary policy likely did not satisfy the Taylor principle in the second half of the 1970's. Further, the changes put forward during the Volcker era occurred gradually, with the largest changes during 1980 and 1982. Starting in the middle of the 80's monetary policy reacted strongly to inflation but less strongly to output. Along this line, Kim and Nelson (2006) use a Heckman-type two-step estimator that accounts for endogeneity. They show that the FEDs policy varies across the three subperiods 70's, 80's, and 90's.

Further, Clarida et al. (2000) and Lubik and Schorfheide (2004) show that monetary policy violated the Taylor principle during the 70's and, therefore, did not ensure determinacy. This lead to multiple equilibria and higher volatility in the macroeconomy. Those two papers do not include expectation effects created by past policy switches. Davig and Leeper (2007) show that the presence of policy switches has crucial implications for determinacy. They show that a general Taylor principle applies, where the Taylor principle is satisfied in the long-run but not necessarily in the short-run. Along this line, Foerster (2013) shows that in periods of stable monetary policy, expectation of switches do create different outcomes depending on the switching type. While all of the papers cited so far assume that switches are exogenous, Davig and Leeper (2008) build a model

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[8] Lubik and Schorfheide (2004) and Boivin and Giannoni (2006) find that a New Keynesian model allowing for switches in the conduct of monetary policy generates the Great Moderation.

[9] Further evidence in favour of time-varying parameters is found, for example, by Fernández-Villaverde and Rubio-Ramirez (2008) and Bianchi (2013).

featuring endogenous switches. In this model, the parameters in the Taylor rule are themselves functions of endogenous variables and do not follow stochastic processes. Switches are triggered, once some endogenous variables reach certain thresholds. They find significant expectation effects and asymmetric effects of symmetric shocks.

Davig and Leeper (2006) estimate a Markov-switching model for monetary policy and fiscal policy for the United States. They find evidence in favor of regime switches in the fiscal-monetary policy mix.[10] Further, they show that the FTPL seems to be always present, as the estimation results imply that tax innovations always affect aggregate demand. They show that a tax cut of 1$ will raise output in the long-run by 0.76-1.02$ depending on the policy regime and a tax cut by 2 percent of output will increase the long-run price level by 1.2-6.7 percent. The FTPL works along the expectation channel, that is, agents believe that fiscal policy might switch to an active/Non-Ricardian state even when current policy is passive/Ricardian. Then, Davig and Leeper (2011) focus on the government spending multiplier and, again, estimate Markov-switching fiscal and monetary policy rules. They find that the macroeconomic effects of fiscal policy depend on the current and the expected fiscal-monetary policy regime due to inter- and intratemporal substitution effects as well as wealth effects. Further, they confirm switches between active and passive policy regimes.

Bianchi and Melosi (2013) build a New-Keynesian model with a fiscal rule and Bayesian learning. In this model, the monetary and fiscal policy mix is described by a three-state Markov-switching process. They show that the low long-term interest rates as well as low inflation expectations could hide the true underlying risk of inflation in the United States. Further, Bianchi and Ilut (2015) estimate a Markov-switching DSGE model on the U.S. economy. The model features, i.a., fiscal rules and a maturity structure for government debt. They show that movements in U.S. inflation can be explained by shifts in the balance of power between monetary and fiscal authority. In contrast to our paper, in both papers there is no effect of government debt in the Taylor-rule and no microfoundation of regime changes.

Favero and Monacelli (2005) estimate fiscal policy rules and a standard Taylor rule using an univariate Markov-switching model to identify switches in the fiscal-monetary policy regime. They find significant evidence in favor of regime switches in fiscal policy and document that fiscal policy in the United States follows a systematic rule. Further, they find no correlation in the switches of fiscal and monetary policy rules.

Historically, Woodford (1998, 2001) explains the U.S. policy between 1965 and 1989, as well as in the 1940's as being Non-Ricardian. Furthermore, Loyo (1999) explains the high inflation in Brazil in the 1970's and 1980's with the FTPL. He claims that the shift in monetary policy in 1985 aimed to reduce inflation by obeying the Taylor-principle was not sufficient, as agents still believed that fiscal policy will be Non-Ricardian in the future. More recently, Bassetto (2006) applies the FTPL to Italy during the 1990's prior to joining the EMU. He argues that private expectations driven by fiscal news were the main source of movements in the exchange rate and, to a smaller

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[10] Other papers include Davig (2004), Davig and Leeper (2006, 2007), Chung et al. (2007), and Bianchi (2010).

extend, in inflation. Furthermore, Sims (2008) explains the high inflation rates during the 1970s and early 1980s with Non-Ricardian policy, while Cochrane (2009) uses Non-Ricardian policy to explain the financial crisis in the United States that triggered the Great Recession.

3 Empirical Evidence

3.1 Data

We use seasonally adjusted, quarterly data from 1974:Q1 to 2012:Q4 (156 observations) for the United States obtained from the St. Louis FED system FRED. In detail, we use the time series for consumer price inflation (CPIAUCSL). Then, the time series for the real gross domestic product is in Billions of U.S. Dollars (GDP). Government spending is federal government consumption expenditures (FGCEXPQ027S). The time series for the budget surplus is the time series for federal government net operating surplus (FGOSNTQ027S) in Millions of Dollars. Total debt is the total amount of public debt (GFDEBTN) in Millions of Dollars.

Further, we use various control variables. We use the Chicago FED adjusted national financial conditions index (ANFCI) to control for risk, liquidity, and leverage in money and debt/equity markets. Positive values of this index imply tighter financial conditions than average. Then, we consider the spread between the returns of long-term and short-term bonds. The return of long-term bonds is measured by the bond buyer Go 20-Bond Municipal Bond index for states and local bonds (WSLB20) while the rate of return for short-term bonds is taken from the 3-month treasury bill (TB3MS). Finally, the interest rate is the effective federal funds rate (FEDFUNDS), which is not seasonally adjusted. The recession dummy is constructed from the NBER recession dates.

Then, for output and government debt we will use gap variables, denoted with a tilde, and defined as

$$\tilde{x} = 100\frac{x_{cycle}}{x_{trend}}, \tag{1}$$

where trend and cycle component (x_{cycle} and x_{trend}) are generated by applying a Hodrick-Prescott filter with smoothing parameter $\lambda = 1600$ to the original time series. The application of a HP filtered output gap follows many other studies and, in particular, Cúrdia et al. (2011) who show that the application of an HP filter performs particularly well in terms of fitting the data.

We also use a Hodrick-Prescott filter for the government surplus and use both, the trend and the cycle component in our estimation. The trend component captures structural deviations from a balanced budget, while the cycle component captures the discretionary deviations.

3.2 Univariate Markov-Switching Model

In this section we want to analyze a Taylor-rule augmented by a measure for fiscal policy using a univariate Markov-switching model.[11] Since switches in fiscal and monetary regimes occurred in

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[11] In the appendix we estimate a Taylor (1993)-type interest rate rule for the United States. Using GMM estimation techniques and subsample analysis we find that government debt is a significant factor in the policy rule describing

the past and are likely to happen in the future, agents will form expectations about possible regimes and, hence, their decisions will depend on this probability distribution. Given that agents form expectation about regimes and a credible commitment to keeping a given regime is not feasible, a regime-switching model seems to be the ultimate choice.

We follow the line of research started by Davig and Leeper (2008) and augment this model by allowing for time-variation in transition probabilities. This endogenous approach to modelling regime switches is consistent with the systematic conduct of monetary policy. The weights in the Taylor-rule should not stochastically vary over time but rather should be the result of the behavior of the monetary authority.

The advantage of using a univariate framework is the increase in the efficiency compared to a multivariate setting. Further, we are interested in characterizing the interactions between fiscal and monetary variables, in terms of switches in the weight attached to the fiscal stance.

We consider a univariate equation setting with four explanatory variables - inflation, the output gap, surplus, and the recession dummy - while controlling for heteroscedasticity. Further, we allow the transition probabilities to vary over time. Formally, this model is given by

$$\begin{aligned} i_t &= \alpha_0 + \alpha_{1,S_t}\pi_t + \alpha_{2,S_t}\tilde{y}_t + \alpha_{3,S_t}s_t + \alpha_{4,S_t}r_t + \varepsilon_{S_t}, && (2) \\ \varepsilon_{S_t} &\sim \mathcal{N}\left(0, \sigma^2_{S_t}\right), && (3) \end{aligned}$$

where S_t is the state in time t and we assume two states. The innovations are Gaussian distributed with state-dependent variance $\sigma^2_{S_t}$, while the α's are the coefficients of the explanatory variables.

Further, there exists a time-varying transition matrix $\mathbb{P}_t$ that describes the likelihood of state changes,

$$\mathbb{P}_t = \begin{bmatrix} p_{11,t} & p_{12,t} \\ p_{21,t} & p_{22,t} \end{bmatrix}, \tag{4}$$

where $p_{ij,t}$ gives the probability from changing from state i to state j at time t.

We estimate this model using a maximum likelihood estimator. Our estimation yields several interesting results. We find the following coefficients in the Taylor-rule

$$\begin{aligned} i_t &= \underset{(0.24)}{2.87} + \begin{bmatrix} \underset{(0.21)}{0.21} \\ \underset{(0.33)}{3.27} \end{bmatrix} \pi_t + \begin{bmatrix} \underset{(0.10)}{1.14} \\ \underset{(0.21)}{0.03} \end{bmatrix} \tilde{y}_t + \begin{bmatrix} \underset{(0.0001)}{-0.002} \\ \underset{(0.0001)}{0.0003} \end{bmatrix} s_t + \begin{bmatrix} \underset{(0.57)}{0.58} \\ \underset{(0.69)}{1.74} \end{bmatrix} r_t + \varepsilon_{S_t}, && (5) \\ \varepsilon_{S_t} &\sim \mathcal{N}\left(0, \begin{bmatrix} \underset{(0.19)}{0.90} \\ \underset{(1.65)}{9.62} \end{bmatrix}\right), && (6) \end{aligned}$$

where robust standard errors are shown in parenthesis.

First of all, we can identify two regimes: an accommodative (regime 2 - lower row) and a non-accommodative regime (regime 1 - upper row). In the accommodative regime, monetary policy

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the behavior of the FED. This finding is supported by an increased forecastability of the interest rate by a Taylor-rule augmented by debt.

decreases the interest rate if surplus turns negative (debt increases). On the flipside, in the non-accommodative regime a negative surplus will lead to an increase of the interest rate. Further, we observe that the coefficient is roughly fifteen times larger in regime 1 compared to regime 2. This implies a stronger response to changes in the fiscal stance in the non-accommodative regime than in the accommodative regime. This seems intuitive as non-accommodative policy should be stronger to create incentives large enough to have the desired effects on the behavior of fiscal policy.

The intercept is highly significant and estimated to be 2.87. In regime 1, the coefficient on inflation is insignificant while it is 3.27 in regime 2. Further, the coefficient on the output gap is significant and 1.14 in regime 1 but is insignificant in the regime 2. Observe that the coefficient in regime 1 does violate the Taylor principle of a coefficient larger than one. However, as shown by Davig and Leeper (2007) monetary policy does not need to fulfil to the Taylor principle in every point in time if they fulfil Taylor principle in the long-run (the general Taylor principle). As already stressed, conclusions on determinacy can not simply be inferred from the coefficient on inflation, as it also depends on the design of fiscal policy (see e.g. Benhabib et al. (2001)).

Finally, the variance of the errors varies considerably across the two regimes. This supports the findings by Sims (1999, 2001) and Sims and Zha (2006) showing that monetary policy shocks are characterized by a large time-varying variance. We find a small value of 0.9 in the first regime and a roughly ten times larger value (9.62) in regime 2. Put differently, our findings show that monetary policy in the accommodative policy regime is more volatile compared to the non-accommodative regime.

The estimated transition matrix (for the last period) is

$$\mathbb{P}_t = \begin{bmatrix} 0.96 & 0.05 \\ 0.04 & 0.95 \end{bmatrix}. \tag{7}$$

Our results show that tight monetary policy (regime 2) will persist for a longer period of time. We find that the expected duration is 21.83 quarters for regime 2, while the expected duration for regime 1 is 27.21 quarters. This result is supported by the estimated transition matrix. We find that the probability to stay in regime 2 is 96 percent, while it is 92 percent for regime 1. This implies a larger probability to leave the regime for accommodative monetary policy (regime 1). The exit probability from regime 1, 2 respectively is eight percent, four percent respectively.

Figure 1 shows the estimated probabilities of staying in regime 1, 2 respectively over time. Overall, we observe eleven switches from a low probability of staying in the regime - around 95 percent for regime 1 and 2 - to the state with a high probability in staying in the regime - roughly 1 for regime 1 and 0.9546 for regime 2.

The implied regime probabilities over time are shown in figure 2.

We find that for most of our observation period regime 2 prevailed. Further, over the entire time horizon six regime switches occurred. Between 1986 and 1995 we observe two local peaks of the probability for regime 1, while a switch did not occur. However, the probability for regime 1 was as high as 80 percent until regime 2 finally clearly took over. Towards the end of our sample

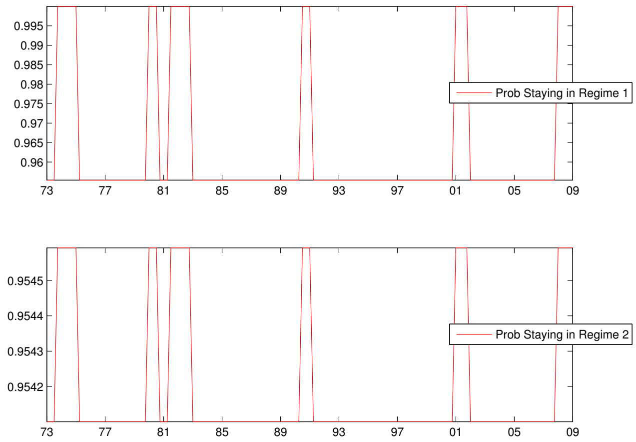

Figure 1: Time-varying transition probabilities.

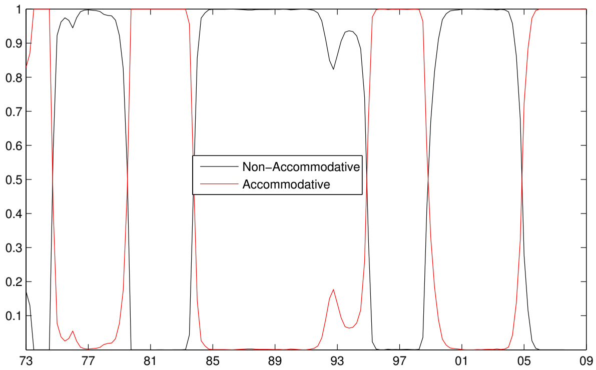

Figure 2: Markov-switching probabilities for both states.

we find three of our six switches. Those switches happen quite frequently with an average duration of a regime of about two years. Compared to the switches in the transition probabilities, we find less frequent switches but observe that both type of switches are not correlated. Intuitively, regime switches do not necessarily depend on transition probabilities. Since the transition probabilities reflect the expectations of agents that a given regime prevails and are driven by other variables, they do not need to be correlated with regime switches. The results show that the low probability regime (around 0.95 for both regimes) is present for most of the observed time span. High probabilities only last for a few quarters and are quickly reversed.

At the beginning of our sample the accommodative regime (regime 2) was active until in 1975 the first switch occurred. Two events coincide with this switch: first, the U.S. economy left the severe recession of the early 1970's and President Ford's Tax Reduction Act became law. The latter resulted in an increase of public deficit of more than 120 billion U.S. Dollars in 1975 and 1976.

The non-accommodative regime prevailed for about five years until the beginning of the first recession in the 1980's. At this time, President Reagan's policy change towards supply-side economics away from the famous Keynesian economics became common knowledge and it was expected (at least communicated) that the U.S. economy would benefit from lower tax rates as they were on the increasing part of the Laffer curve. However, this accommodative policy regime prevailed for only four years until 1984. In the previous year, the deficit reached a historic peak of six percent of GDP mainly driven by a large increase in military spending. Further, under the Reagan administration the United States started to borrow internationally to finance the increased deficits (debt increased from 1 trillion to 3 trillion under Reagan). As a consequence, the U.S. turned from the largest creditor to the largest debtor in the world.

From 1985 to 1995 the non-accommodative regime was active. Then, in 1995 we observe a switch towards the accommodative regime. Under the Clinton legislation the Omnibus Budget Reconciliation Act of 1993 became law. It contained corporate tax cuts, tax cuts for low-income families, and tax increases for the wealthiest families. More importantly, the law contained a promise to establish a balanced budget (mainly via spending cuts). Four years later, we observe another switch back to the non-accommodative policy regime. This switch occurred at the same time the Medicare, Medicaid, and SCHIP Balanced Budget Refinement Act of 1999 became law (still under the Clinton administration). After the implementation of his law, social transfers (mainly health care spending) started to surge up to unprecedented levels.

For the end of our sample, we find that monetary policy is accommodative again. The final switch in our sample occurs in 2005, shortly before the financial crisis and the following recession. This is not surprising as the Great Recession lead the FED to drive down interest rates, while the government spending programs increased debt. Interestingly, the accumulation of debt was slowed by large seigniorage gains due to the quantitative easing programs. Here, the FED intentionally or unintentionally avoided a much stronger increase in government debt.

We can draw the conclusion that switches in the relation between monetary and fiscal policy occurred frequently in the history of the United States.[12] Further, we find that all of our switches

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[12] The appendix provides robustness checks. We estimate a multivariate Markov-switching model (interest rate rule

can be related to policy actions that significantly affected the future path of the fiscal budget. In light of our story, those policy actions are likely to change the expectations of monetary policy makers triggering switches in their behavior.

4 Model Derivation

We now develop a business cycle model for the U.S. economy. Time is discrete and a period is assumed to be a quarter. Our economy is populated by four agents: households, firms, a fiscal, and a monetary authority. Households derive utility from consuming an aggregate consumption basket of differentiated goods and providing labor to firms. Firms produce those goods using a concave production function in labor and face price adjustment costs à la Calvo (1983). Fiscal policy provides spending, collects lump-sum taxes, and issues bonds. Monetary policy sets the nominal interest rate according to a Taylor-type interest rate rule augmented by government deficit. Furthermore, the parameter on debt in this rule is determined by the outcome of a cheap talk game between fiscal and monetary policy authorities and is subject to exogenous regime switches.

4.1 Households

We assume an infinitely lived representative household who seeks to maximize its utility given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U\left(C_t, N_t\right), \tag{8}$$

where $\mathbb{E}$ is the conditional expectation operator and $\beta \in (0,1)$ is the discount factor. Further, $U\left(C_t, N_t\right)$ is the single-period utility function in consumption, C_t, and labor, N_t, which is compatible with the requirements of balanced growth. We assume that it is separable in its arguments and, specifically, is given by

$$U\left(C_t, N_t\right) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi}, \tag{9}$$

where $\sigma > 0$ is the intertemporal elasticity of substitution and $\varphi > 0$ is the inverse of the Frisch labor supply elasticity.

The consumption bundle is defined as

$$C_t = \left[\int_0^1 C_t\left(i\right)^{\frac{\varepsilon-1}{\varepsilon}} \mathbf{d}i\right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{10}$$

where $\varepsilon > 0$ is the demand elasticity.

Then, the household faces the budget constraint

$$\int_0^1 P_t\left(i\right) C_t\left(i\right) \mathbf{d}i + Q_t B_t \leq B_{t-1} + \left(1-\tau_t\right) W_t N_t - T_t, \tag{11}$$

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and an equation for debt) and a Markov-switching VAR. Both models confirm the presence of frequent regime switches and two distinct interaction regimes. Further, we also estimate a time-varying parameter VAR and document the (slow-moving) changes in the coefficient of surplus in the interest rate rule. Again, we observe times with a positive and times with a negative sign.

and a solvency constraint

$$\lim_{T\to\infty} \mathbb{E}_t \left[B_T\right] \geq 0, \ \forall t. \tag{12}$$

The minimum expenditure price index is given by

$$P_t = \left[\int_0^1 P_t\left(i\right)^{\frac{\varepsilon-1}{\varepsilon}} \mathbf{d}i\right]^{\frac{\varepsilon}{\varepsilon-1}}. \tag{13}$$

Further, W_t is the nominal wage and $\tau_t > 0$ is the labor income tax rate. Dividend payments net of lump-sum taxes are denoted by T_t and households buy B_t one-period government bonds at a price Q_t. Later on, i_t will be the interest rate defined as $i_t = -\log Q_t$.

We assume that the economy begins with all households having identical financial wealth and consumption histories. This assumption assures that together with the optimal use of the available contingent claims markets, this homogeneity will continue. To be precise, agents have access to a full set of state-contingent Arrow-Debreu securities. Moreover, this allows us to only consider the consumption and savings decisions of a representative household.

The unique solution to the concave optimization problem, maximizing (8) subject to (11) are - assuming that the solution is interior - the following three optimality conditions.

First, using (10) and (13) gives the household's demand schedule

$$C_t\left(i\right) = \left[\frac{P_t\left(i\right)}{P_t}\right]^{-\varepsilon} C_t. \tag{14}$$

Second, given the neoclassical character of the labor market, we obtain a second static equation for the labor supply schedule

$$\frac{N_t^{\varphi}}{C_t^{-\sigma}} = \left(1-\tau_t\right)\frac{W_t}{P_t}. \tag{15}$$

Lastly, we obtain an intertemporal optimality condition for the path of consumption

$$C_t^{-\sigma} = \mathbb{E}_t\left[\beta \frac{P_t}{P_{t+1}} \frac{1}{Q_t} C_{t+1}^{-\sigma}\right], \tag{16}$$

which is the well-known consumption Euler equation.

4.2 Firms

Along the supply-side of the model, we assume the existence of a continuum of monopolistically competitive firms with names $i \in [0,1]$ producing differentiated goods. All firms make us of the same production technology

$$Y_t\left(i\right) = Z_t N_t\left(i\right)^{1-\alpha}, \tag{17}$$

where $\alpha > 0$ and Z_t is an aggregate Hicks-neutral technology shock that follows a first-order autoregressive process

$$\ln Z_t = \rho_Z \ln Z_{t-1} + \varepsilon_{Z,t}. \tag{18}$$

Its autocorrelation is determined by $1 > \rho_Z > 0$ and its innovations are i.i.d. over time and normally distributed,

$$\varepsilon_{Z,t} \sim \mathcal{N}\left(0, \sigma_Z\right). \tag{19}$$

Firms maximize profits by setting prices subject to the discrete time version of the Calvo (1983) mechanism. Accordingly, in each period a firm faces a constant probability of being able to re-set its price, given by $1-\theta$. If a firm is allowed to re-set its price, it solves

$$\max_{P_t^*} \sum_{k=0}^{\infty} \theta^k \mathbb{E}_t \left\{ Q_{t,t+k} \left[P_t^* Y_{t+k|t} - \Psi_{t+k}\left(Y_{t+k|t}\right) \right] \right\}, \tag{20}$$

$$s.t.$$

$$Y_{t+k|t} = \left[\frac{P_t^*}{P_{t+k}} \right]^{-\varepsilon} C_{t+k}, \tag{21}$$

where

$$Q_{t,t+k} = \beta^k \left[\frac{C_{t+k}}{C_t} \right]^{-\sigma} \left[\frac{P_t}{P_{t+k}} \right], \tag{22}$$

is the stochastic discount factor. Further, $\Psi_{t+k}(\cdot)$ is the cost function and $Y_{t+k|t}$ is output in period $t+k$ for a firm that was able to re-set its price in period t.

The first-order optimality condition for this problem is

$$\sum_{k=0}^{\infty} \theta^k \mathbb{E}_t \left\{ Q_{t,t+k} Y_{t+k|t} \left[P_t^* - \mu \Xi_{t+k|t} \right] \right\} = 0, \tag{23}$$

where $\mu = \frac{\varepsilon}{\varepsilon-1}$ is the price mark-up over nominal marginal costs in $t+k$, which we denote by $\Xi_{t+k|t} = \frac{\partial \Psi_{t+k}\left(Y_{t+k|t}\right)}{\partial P_t^*}$.

As (23) will later become the well-known Phillips curve, it is useful to re-write this equation in terms of the inflation rate, $\Pi_{t,t+k} = \frac{P_{t+k}}{P_t}$,

$$\sum_{k=0}^{\infty} \theta^k \mathbb{E}_t \left\{ Q_{t,t+k} Y_{t+k|t} \left[\frac{P_t^*}{P_{t-1}} - \mu \Upsilon_{t+k|t} \Pi_{t-1,t+k} \right] \right\} = 0, \tag{24}$$

where real marginal costs are defined as

$$\Upsilon_{t+k|t} = \frac{\Xi_{t+k|t}}{P_{t+k}}. \tag{25}$$

4.3 Fiscal Policy

Formally, our fiscal authority issues bonds, provides government spending (that does not affect the marginal utility of private consumption), and uses labor income taxes to generate revenues.

However, only two of those instruments can be set independently, while the third follows from the equilibrium restriction. The equilibrium restriction on the fiscal authority's actions is

$$B_t + \tau_t W_t N_t = Q_{t-1} B_{t-1} + G_t, \tag{26}$$

where G_t denotes government expenditures and $\tau_t W_t N_t$ are labor income revenues.

In order to generate an endogenous relation between fiscal and monetary policy, we assume that spending as well as taxes follow policy rules. This approach is needed as the alternative modelling scenario with exogenously determined processes would not allow effects from monetary policy on fiscal policy. If, instead, spending and taxes depend on endogenous variables this creates a transmission channel from monetary policy interventions to the conduct of fiscal policy.

For simplicity, we follow the work by Chung et al. (2007) and Davig and Leeper (2011) and assume that the fiscal rules have feedback to endogenous variables. We assume that the government has a cyclical target, output, and a structural target, government debt. Then, this rule in log-linear form can be written as

$$\begin{aligned} \hat{G}_t &= -\kappa_g \hat{Y}_t - \kappa_B \hat{B}_t + u_t^g, && (27) \\ \hat{\tau}_t &= -\zeta_g \hat{Y}_t - \zeta_B \hat{B}_t + u_t^\tau, && (28) \end{aligned}$$

where

$$\begin{aligned} \ln u_t^g &= \rho_g \ln u_{t-1}^g + \varepsilon_t^g, && (29) \\ \ln u_t^\tau &= \rho_\tau \ln u_{t-1}^\tau + \varepsilon_t^\tau. && (30) \end{aligned}$$

Further, I assume that all innovations are i.i.d. and normally distributed, i.e. $\varepsilon_t^X \sim \mathcal{N}(0, \sigma_X), X \in (g, \tau)$.

4.4 Monetary Policy - Cheap Talk

First, we assume that the interest rate is determined by a canonical Taylor-type interest rate rule

$$\hat{\imath}_t = \rho + \phi_\pi \hat{\pi}_t + \phi_y \hat{y}_t + \phi_{B,S} \hat{B}_t, \tag{31}$$

where $\rho > 0$ is an intercept and $\phi_\pi > 0, \phi_y > 0$ is the policy weight on inflation, output respectively. We use the standard Taylor-rule specification used in the New Keynesian literature and only add the surplus because we want to isolate the effect of regime switches in the interaction between fiscal and monetary policy.

Further, $\phi_{B,S}$ is the weight attached to the change in the debt level. In contrast to the policy weight on inflation or output, the weight on debt switches between two regimes

$$\phi_{B,S} = \begin{cases} -0.002 & \text{if } S = 1, \\ 0.0003 & \text{if } S = 2. \end{cases} \tag{32}$$

The values of the coefficients for the two regimes is taken from our Markov-switching estimation.

So far, we have established that the interest rate is set according to some Taylor-type interest rate rule augmented by government debt. Then, we have shown that the interaction coefficient varies across two regimes. In the last section we developed a stylized New Keynesian model of the U.S. business cycle with monetary and fiscal policy being governed by feedback (Taylor-type) rules. What misses is a microfoundation of regime switches.

We build on the work by Tabellini (1985, 1986): simultaneous move games with corresponding open-loop solutions are an inadequate representation of the institutional settings in all developed countries. He argues that fiscal policy actions are characterized with a sizeable implementation lag

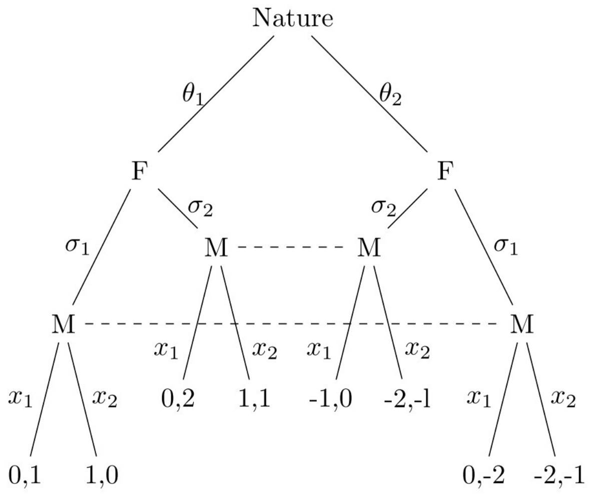

Figure 3: Extensive game with imperfect information between fiscal and monetary policy.

leading to a much lower frequency of fiscal policy decisions and are hence non-reversible in a given period. Hence, he assumes that fiscal policy is the Stackelberg-leader and monetary policy is the Stackelberg-follower. In the following we will therefore model the interaction between monetary and fiscal policy makers as an extensive game. But, in contrast to the assumption in Tabellini (1985, 1986), we consider imperfect information. Again, imperfect information are introduced based upon the existence of private information for each policy. The introduction of imperfect information is the key in modelling regime switches. We use swings in expectations to generate switches in the policy parameter $\phi_{B,S}$. Technically, movements in the probability put on each state of the world by the players change the payoff matrix and, therefore, affect the equilibrium strategy.

In the following we develop a cheap talk game between fiscal and monetary policy. In general, we could also assume costly signals but, given that the signals we are thinking about are speeches, news reports, and meetings between policy makers, the costless signal approach seems reasonable.

The $2 \times 2 \times 2$ extensive game between fiscal (F) and monetary policy (M) is shown in figure 3 and proceeds as follows.Nature (the choice player) chooses between two distinct states of the world, $\Theta = \{\theta_1, \theta_2\}$. We interpret those states as Ricardian, θ_1, with probability $\mathbb{P}(\theta_1)$ and Non-Ricardian, θ_2, with probability $\mathbb{P}(\theta_2)$. Those states might be related to elections, the economic outlook, or policy preferences. They are the key to the regime switches in the interest rate rule (31). For given probabilities $\mathbb{P}(\theta_1), \mathbb{P}(\theta_2)$ the game has a sequential equilibrium.[13] However, changes in the probability might trigger that the resulting sequential equilibrium is characterized by different

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[13] There will always exists at least one equilibrium as Kreps and Wilson (1982) show that every trembling hand equilibrium is a sequential equilibrium. Building on Selten (1975), trembling hand equilibria always exist for finite sequential games with perfect recall.

strategies. Consider an intuitive example: if the prior probability for Non-Ricardian increases (put differently, if the monetary authority believes that fiscal policy is more likely to be Non-Ricardian) it is more likely that the monetary authorities wants to constrain fiscal policy action's by acting aggressively and raising interest rates. This increase will lower output (by the usual New-Keynesian reasoning) and hence fiscal policy will lower spending (via the fiscal policy rules).[14]

Each of the policy maker has two strategies available. Fiscal policy can be Ricardian or Non-Ricardian $\Sigma = (\sigma_1, \sigma_2)$ and the monetary policy can be accommodative or non-accommodative $X = (x_1, x_2)$. The order of play is determined as follows: in the first place, nature chooses Ricardian or Non-Ricardian states. The fiscal authority observes this move and chooses a strategy. Then, the monetary authority observes the government's action but not nature's move.

The sequential equilibrium for this game can be found by transforming the extensive game into its normal form. In the following we consider two cases. First, we assume that the first state of the world is more likely, i.e. $\mathbb{P}(\theta_1) = 0.9$, and then consider the case in which the second scenario is more likely, i.e. $\mathbb{P}(\theta_2) = 0.9$. We will show that there exists a (unique) equilibrium in both cases. In the former scenario, the equilibrium strategy for the monetary policy is to be accommodative while in the latter scenario being non-accommodative is optimal. Changes in the probability, interpreted as changes in expectation by agents, then trigger the regime switches.

First, we make the assumption that all players believe $\mathbb{P}(\theta_1) = 0.9$ on state 1 and, for simplicity, we assume w.l.o.g. that $\mathbb{P}(\theta_2) = 1 - \mathbb{P}(\theta_1)$ for the remainder of this section.[15] Then, the usual considerations lead to the Nash equilibrium in the normal form (see figure 4). The strategy profile $\{(\sigma_1, \sigma_1), (x_1, x_1)\}$ is the unique Nash equilibrium of this game. We interpret this notation as playing σ_1 at the first information set (following θ_1) and σ_1 at the second information set (following θ_2). The optimal action for the second player is to play x_1 at her first information set (following action σ_1) and playing x_1 at her second information set (following σ_2).

The next step is to find a system of beliefs that supports this strategy as a sequential equilibrium. We suggest that the system

$$\begin{aligned} \mu(\theta_1 | \sigma_1) &= 1, \mu(\theta_1 | \sigma_2) = 0, \qquad (33) \\ \mu(\theta_2 | \sigma_1) &= 1, \mu(\theta_2 | \sigma_2) = 0, \end{aligned}$$

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[14] We would like to point out that there is no payoff function pinning down the payoffs. This is due to two factors. First, it is not yet possible to solve the model with a direct link from variables, such as output, to payoffs or the probabilities. This results from the standard backward/forward solution approach to state-space models. the problem is recursivity: each state-space for each point in time would depend on the solution of the game at that point, which itself would depend on the solution of each state-space. A full endogenous specification is left to future research. Second, the numerical value of the payoffs play no role in this model. Therefore, the existence of a payoff function would have no effect on the strategies as the relation between the payoffs would be unaffected (due to the Cheap Talk character of the relation: fiscal policy does not want to fight monetary policy).

[15] For simplicity, we abstract from assuming a distribution function with mean and variance. An example with a normal distribution yields the same conclusions.

	x_1, x_1	x_1, x_2	x_2, x_1	x_2, x_2
σ_1,σ_1	$0, 0.7$	$0.7, -0.1$	$0, 0.7$	$0.7, -0.1$
σ_1,σ_2	$-0.1, 0.9$	$0.8, 0$	$-0.2, 0.8$	$0.7, -0.1$
σ_2,σ_1	$0, 1.6$	$-0.2, 1.7$	$0.9, 0.7$	$0.7, 0.8$
σ_2,σ_2	$-0.1, 1.8$	$-0.1, 1.8$	$0.9, 0.8$	$0.7, 0.8$

Figure 4: Normal form of the extensive game, $\mathbb{P}(\theta_1) = 0.9$, $\mathbb{P}(\theta_2) = 0.1$.

forms the beliefs of all players and take them as given from now on.

Then, at the information set following action σ_1, x_1 is the optimal action for player 2. This can be seen by comparing her payoff alternatives. Playing x_1 gives her a payoff of 1, while playing x_2 gives her a payoff of 0. Similarly, at the information set following action σ_2 the optimal response is to play x_1 for player 2. The payoff comparison gives 0 for playing x_1 and 0 for playing x_2.

Hence, we have shown that the system of beliefs supports the strategy profile $\{(\sigma_1, \sigma_1), (x_1, x_1)\}$ as part of a sequential equilibrium. The last step is to show that our assessment (the combination of strategy and belief system) is consistent. For this purpose, we need to find a sequence $\{(\mu_n, \sigma_n)\} \subseteq \Lambda_0$ in the subset Λ_0 of consistent assessments Λ, in which $\sigma \in \Sigma_0$ and beliefs are computed from $\mathbb{P}$ and σ by Bayes' rule. Straightforward, $\sigma \in \Sigma_0$ is fulfilled. Therefore, we can suggest the following sequence of purely mixed behavioral strategies of player 1

$$\begin{aligned} \beta_1^n(\theta_1 | \sigma_1) &= \frac{1}{n}, \beta_1^n(\theta_1 | \sigma_2) = 1 - \frac{1}{n}, \\ \beta_1^n(\theta_2 | \sigma_1) &= \frac{1}{n}, \beta_1^n(\theta_2 | \sigma_2) = 1 - \frac{1}{n}. \end{aligned} \tag{34}$$

Next, we need to show that if beliefs for those sequences are pinned down via Bayes' rule they converge to the suggested system (33). Using Bayes' rule, we find that the system of posterior beliefs, μ^n, is given by

$$\begin{aligned} \mu^n(\theta_1 | \sigma_1) &= \frac{\frac{1}{n}}{1 - \frac{1}{n} + \frac{1}{n}} = \frac{1}{n}, \mu^n(\theta_1 | \sigma_2) = \frac{1 - \frac{1}{n}}{1 - \frac{1}{n} + \frac{1}{n}} = 1 - \frac{1}{n}, \\ \mu^n(\theta_2 | \sigma_1) &= \frac{\frac{1}{n}}{\frac{1}{n} + 1 - \frac{1}{n}} = \frac{1}{n}, \mu^n(\theta_2 | \sigma_2) = \frac{1 - \frac{1}{n}}{\frac{1}{n} + 1 - \frac{1}{n}} = 1 - \frac{1}{n}. \end{aligned} \tag{35}$$

We can then show that for $n \to \infty$ the system of posterior beliefs converges to the suggested belief system. Formally, $\lim_{n\to\infty} \mu^n \to \mu$, such that

$$\begin{aligned} \lim_{n\to\infty} \mu^n(\theta_1 | \sigma_1) &= 1, \lim_{n\to\infty} \mu^n(\theta_1 | \sigma_2) = 0, \\ \lim_{n\to\infty} \mu^n(\theta_2 | \sigma_1) &= 1, \lim_{n\to\infty} \mu^n(\theta_2 | \sigma_2) = 0. \end{aligned} \tag{36}$$

We have shown that the strategy profile $\{(\sigma_1, \sigma_1), (x_1, x_1)\}$ together with the belief system (33) is a consistent (provided the existence of a sequence (35)) and sequentially rational assessment that, hence, supports a sequential equilibrium.

Next, we consider the case in which the second state of the world is more likely, $\mathbb{P}(\theta_1) = 0.1$. Given the new probabilities, we obtain a new payoff matrix shown in figure 5.

	x_1, x_1	x_1, x_2	x_2, x_1	x_2, x_2
σ_1,σ_1	$0, -1.7$	$-1.7, -0.9$	$0, -1.7$	$-1.7, -0.9$
σ_1,σ_2	$-0.9, 0.1$	$-0.8, 0$	$-1.8, -0.8$	$-1.7, -0.9$
σ_2,σ_1	$0, -1.6$	$-1.8, -0.7$	$0.1, -1.7$	$-1.7, -0.8$
σ_2,σ_2	$-0.9, 0.2$	$-0.9, 0.2$	$-1.7, -0.8$	$-1.7, -0.8$

Figure 5: Normal form of the extensive game, $\mathbb{P}(\theta_1) = 0.1$, $\mathbb{P}(\theta_2) = 0.9$.

In this game, the strategy profile $\{(\sigma_1, \sigma_1), (x_2, x_2)\}$ is the unique Nash equilibrium. One can show that this strategy is the (unique) sequential equilibrium provided the belief system

$$\begin{aligned} \mu(\theta_1 \,|\sigma_1) &= 1, \mu(\theta_1 \,|\sigma_2) = 0, \\ \mu(\theta_2 \,|\sigma_1) &= 1, \mu(\theta_2 \,|\sigma_2) = 0. \end{aligned} \tag{37}$$

To sum up, we consider two cases: first, we assume that the first state of the world, being Ricardian, is more likely, i.e. $\mathbb{P}(\theta_1) = 0.9$. Second, we considered the Non-Ricardian state to be more likely, $\mathbb{P}(\theta_2) = 0.9$. This change in the probabilities affects the payoff matrix of the game, ultimately resulting in different optimal strategies. Then, we have shown that for both games a unique sequential equilibrium exists. For the first case, the expectation of the Ricardian state results in an equilibrium in which monetary policy is accommodative. Then, changing the expectations, letting the Non-Ricardian state be more likely, leads monetary policy to switch its strategy and be non-accommodative. Hence, changes in the probability, interpreted as changes in expectation by agents, trigger regime switches.

At the end of this section let us emphasize that regime changes are triggered exogenously. Agents's expectations vary over time and, if the movements are larger enough, trigger the switch in the weight on surplus in the Taylor-rule. Where do these expectation changes could come from? As we have discussed in the empirical part of the paper, policy actions by the monetary and the fiscal authority, elections, recessions, or policy actions or economic developments in other countries can affect agents' expectations.

4.5 Equilibrium and Calibration

A competitive equilibrium for given initial conditions, the stochastic processes $\{u_t^g, u_t^\tau, Z_t\}$ and a set of prices $\{W_t\}$, is a tuple of processes for $\{B_t, C_t, i_t, G_t, \tau_t, N_t, P_t^*, Y_t\}$ such that

1. Household optimality

Given $\{W_t\}$, the processes for $\{C_t, N_t\}$ solve the optimization problem, maximizing (8) s.t. (11) and the solvency condition (12).

2. Profit maximization

The processes for $\{N_t, P_t^*\}$ maximize (20) s.t. (21).

3. Fiscal policy

The processes for $\{B_t, G_t, \tau_t,\}$ are determined by (27) and (28), while the government budget constraint, (26), holds with equality.

4. Monetary policy

The interest rate is determined by (31) and the imperfect information game determines (exogenous) regime switches. Further, the Taylor-type interest rate puts restrictions on the out-of-equilibrium dynamics of the model. However, it does not influence the steady state, as the steady state interest rate is pinned down by the Euler equation.

5. Market clearing

Aggregate output is defined as follows

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} \mathbf{d}i\right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{38}$$

further the labor market clears

$$N_t = \int_0^1 N_t(i)\, \mathbf{d}i. \tag{39}$$

Then, the aggregate resource constraint is given by

$$Y_t = C_t + G_t. \tag{40}$$

The set of equations is log-linearized around the non-stochastic steady state. Notice that, as usual, equilibrium existence does not depend on the coefficients in the Taylor-rule as the interest rate in equilibrium is pinned down by the Euler equation for consumption in steady state.

Finally, the solution of the game is based upon algorithmic game theory using a bimatrix solution algorithm in the normal form of the game tree (cf. figure 3). Since we don't know how expectations are created, we assume that they are generated by an exogenous process. Then, the algorithm uses the processes for agents' expectations as an input and computes the equilibrium. It maps the equilibrium strategy to one of the two possible values of the debt coefficient in the Taylor-rule. Given the coefficient, the state-space system is solved using the usual methods. Future research will endogenize the regime switching process and analyze different expectation building processes.

The model is calibrated to match U.S. stylized facts. The intertemporal elasticity of substitution, σ, is set to 2 and the discount factor, β, is set to 0.99 such that we obtain an interest rate of 4 percent p.a.. Further, we assume a quadratic disutility of labor, $\varphi = 1$ and the demand elasticity is set to 6. Hours in steady state are calibrated to 1/3, which equals an average working day of eight hours. The elasticity of the production function is $\alpha = 1/3$. The probability to re-set prices is 2/3 implying an average price duration of three quarters. Monetary policy targets inflation with a parameter of 1.5 and output with a parameter value of 1. Government spending is set to 20 percent from output and debt is calibrated to be 34 percent of output in line with debt holdings of private agents in the United States. The parameters in the two fiscal rules are taken from the estimations by Leeper et al. (2010). They estimate fiscal policy rules for the United States and report a debt coefficient of government spending, labor taxes respectively of -0.23, -0.05 respectively. Those values imply a stronger reaction of government spending to movements in debt. In contrast, the coefficient on output in the fiscal rules is -0.36 for the labor tax rate and -0.03 for government spending. The autocorrelation of the technology shock is set to 0.9.

5 Simulation Results

In the following we discuss the differences between the impulse responses to a permanent technology shock and a permanent increase of government spending shock respectively for the baseline case without policy switch(es) and the case with policy switches. We start with a discussion of the impulse responses subject to only one policy shock. Then, we discuss the response to an anticipated policy switch. Finally, we discuss the response of our stylized model subject to multiple policy switches.

5.1 One Shock

Our first exercise is to analyze the adjustment path of our stylized model economy to a permanent increase in technology. We use the technology shock as a tool to drive the economy away from its initial steady state as regime switches in steady state will have no effect. Technology shocks seem to be a reasonable choice as they occur frequently and are considered to be a main driver of business cycle movements and economic growth.

We compare the baseline scenario without policy switch with the switching scenario, in which policy switches from accommodative (A) to non-accommodative (NA). The shock as well as the policy switch occur at time 0. Figure 6 presents the impulse response functions for key macroeconomic variables.

In the baseline scenario, the positive technology shock shifts the production frontier outwards and the representative firm produces more goods. Furthermore, higher productivity reduces the marginal costs of the firm which, in turn, allows the firm to set lower prices. As a consequence, inflation falls via the New Keynesian Phillips curve relation. Moreover, the increased productivity puts upward pressure on wages. This creates income and substitution effects. The net effect is a drop in hours worked. Put differently, the firm substitutes technology for labor. Consumption of households increases due to higher output and lower prices. The monetary authority puts a larger weight on inflation than on output and, hence, the interest rate decreases. The lower interest rate additionally increases consumption. Fiscal policy is countercyclical in the model where debt has a stronger effect on government spending but output has a stronger effect on taxes. Hence, spending increases, as debt decreases by more than output increases. For taxes the opposite result holds.

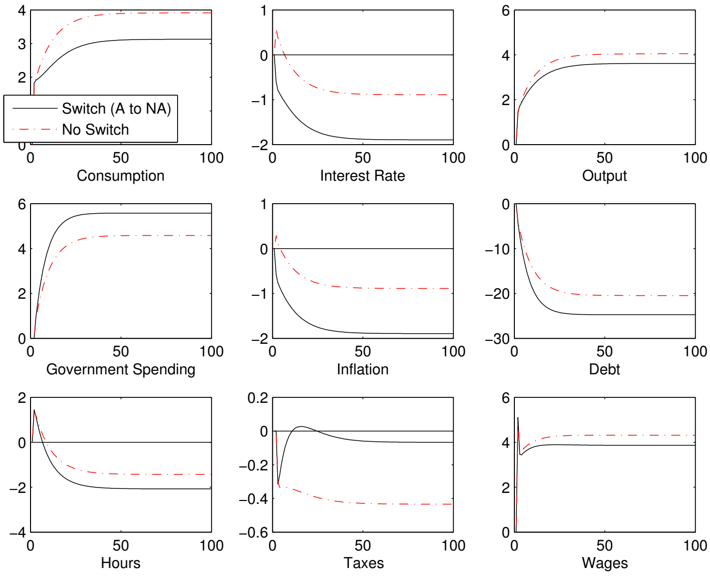

Figure 6: Impulse responses to a permanent technology shock. The black line is the switching scenario (from accommodative to non-accommodative). Horizontal axes measure quarters and vertical axes deviations from steady state.

Debt decreases due to lower interest rates and the higher tax base.

Next, we discuss the differences between the baseline scenario and the switching scenario. Here, we assume that the monetary authority now believes that the fiscal authority is Non-Ricardian and changes its behavior to create incentives for the fiscal authority to return to Ricardian behavior. The key difference between the two scenarios is the behavior of the interest rate. Recall that debt already decreases due to the higher labor tax base (wages increase by more than hours fall). Hence, since now the coefficient on debt is negative, we obtain an even larger drop in the interest rate. Therefore, debt decreases by even more which, via the fiscal rules, affects spending and taxes. Spending increases further, while the tax rate does not decrease as much as in the baseline scenario. The net effect is a further downward pressure on debt compared to the baseline scenario. Higher government spending crowds out private consumption and the net effect is a slight downward pressure on output. This spills over to lower wages affecting the consumption-leisure allocation.

So far, we considered a switch from accommodative to non-accommodative behavior. Figure 6 also presents this case, if we invert the labelling of the impulse response functions. In this scenario the monetary authority changes its beliefs about the fiscal authority from Non-Ricardian to Ricardian. We already discussed the transmission mechanisms at work. As expected, in the Non-Ricardian regime debt does not decrease as much as it does in the Ricardian regime. Output and consumption are higher. Agents work more and earn higher wages.

In conclusion, the monetary authority is able to create incentives to reduce debt compared to the baseline scenario. However, this it at the cost of lower output compared to the baseline scenario. Let us also emphasize that the differences are not just transitory, but are in fact permanent. The reason is that fiscal policy generates incentives that affect demand and supply side of the economy. Along the demand side, higher government spending increases aggregate demand but crowds out private consumption. The supply side is affected by higher taxes creating effects on the consumption-leisure decision.

5.2 Anticipation Effects

We have shown that regime switches in the interaction between monetary and fiscal policy are able to generate sizable short- and long-run effects. In this section we want to address possible anticipation effects of switches. Because the driving force of regime switches is changes in expectations about the character of fiscal policy, anticipation of those expectation changes play an important role for policy makers.

Figure 7 presents the impulse responses to a permanent, positive technology shock. We present the baseline scenario without switch, the already shown case with the unanticipated switch at time 0, and an anticipated switch. Agents in this last economy anticipate that such a policy switch will occur in three periods. We find that the three quarters in which the interaction is accommodative leads to a higher level of output and consumption. Wages increase and households supply more labor. The monetary authority sets a lower interest rate while the fiscal authority - due to the accommodative monetary policy - accumulates more debt because of higher spending. When the regime switch materializes, the tax rate increases faster compared to the unanticipated scenario. Further, we observe that the non-accommodative monetary policy maker raises the interest rate and output and consumption undershoot the respective unanticipated saddle paths. Those adjustments take roughly five to ten quarters until the saddle paths overlap. The largest and most persistent difference is obtained for taxes. This can be explained by the larger response of taxes to government debt.

Finally, we notice that the anticipation effects are fairly small for all variables at hand. This, of course, should at least partially be attributed to the fact that we consider a stylized model. For example, the observed differences in the tax rate will have larger effects in a model with Non-Ricardian agents. Nevertheless, even if those differences are fairly small in this stylized model, they should matter if we would perform a welfare analysis in a more involved model, as the paths of consumption and hours worked are affected.

5.3 Multiple Shocks

Figure 8 shows the response of the model to a positive, permanent technology shock and two policy switches. The first switch occurs at the same time the technology shock hits and the second shock occurs after 8, 20 periods respectively.

First, we present the impulse responses for the scenario without any policy switch; already discussed in the previous sections. The scenario with a switch to non-accommodative policy and back to accommodative policy after eight quarters is presented with the solid, black line. For

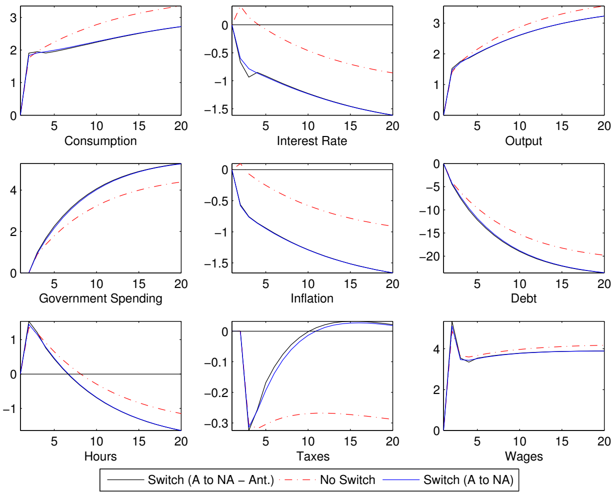

Figure 7: Impulse responses to a permanent technology shock. The black line is the switching scenario (from accommodative to non-accommodative). Horizontal axes measure quarters and vertical axes deviations from steady state.

this scenario, we find that the impulse responses overlap with the one shock non-accommodative impulse responses for the first three periods until the anticipation effects kick in. Agents realize that policy will be accommodative and revise the previous (optimal) plans made under the non-accommodative policy regime. The anticipation of accommodative monetary policy, as we have seen in our previous discussion, leads towards a lower saddle path of consumption and output. This holds until one period after the policy switch. Further, we find that the interest rate is larger compared to the no switch scenario because output is smaller, inflation is larger, and debt is larger compared to the no switch scenario. The fiscal authority spends less and decreases tax rates by a larger amount. After the switch back to accommodative policy, the effects are reversed. Agents realize that plans aren't optimal any more and the lower levels of output and consumption call for a higher level of production, driven by more hours worked and lower wages. The interest rate decreases even further boosting output, consumption, and hours worked. For the fiscal authority, the accommodative policy allows a higher level of spending and lower taxes. The period of non-accommodative policy has sizable and fairly persistent effects on the adjustment paths.

In the last scenario the switch back to the accommodative regime occurs after 20 periods. We observe that the impulse responses coincide with the already discussed one shock scenario until roughly ten periods before the policy switch back to accommodative behavior. Then, we observe that the anticipation of the policy switch towards accommodative behavior drives the impulse responses back to the no switch impulse responses. Because the non-accommodative policy regime prevails for a much longer time, the impulse responses are similar to the one shock switch scenario. After ten periods anticipation effects become visible. Agents realize that output and consumption are too low compared to the optimal levels under the accommodative policy regime.

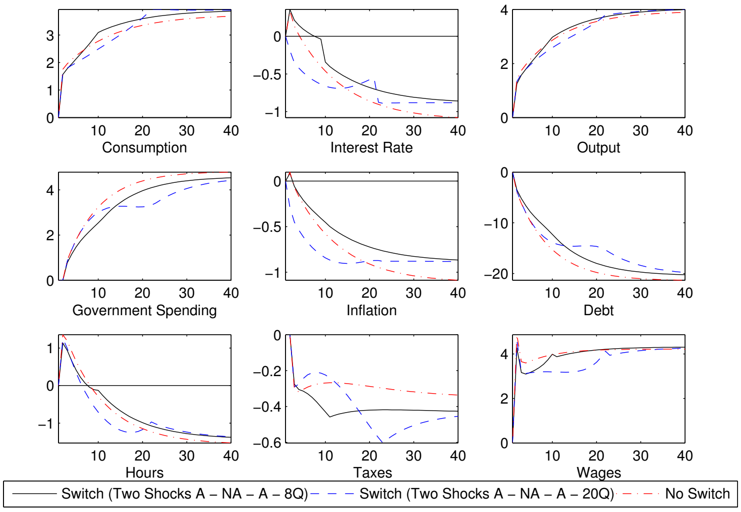

Figure 8: Impulse responses to a permanent technology shock. The black line is the switching scenario (from accommodative to non-accommodative). Horizontal axes measure quarters and vertical axes deviations from steady state.

As a consequence, agents provide more labor and wages remain on a low level. The economy accumulates more debt which - since we are still in the non-accommodative regime - leads to a lower level of spending and higher taxes (compared to the no switch scenario). Once the policy regime finally switches those adverse effects disappear and output and consumption overshoot the no switch scenario. Higher labor supply, lower wages, and lower interest rate (due to the switch in the debt coefficient) boost economic activity and lead to a compensation of the "losses" during the non-accommodative regime.

In summation, multiple regime switches can have large and persistent effects on the adjustment of the model economy. Our findings show that the effects increase in the time between policy switches and that anticipation effects, in the context of multiple switches, are non-negligible.

6 Conclusion

This paper has three contributions. First, we estimate a Markov-switching model and document frequent regime switches in the interaction between fiscal and monetary policy in line with historical policy actions by the FED and the U.S. government.

Second, we use a cheap talk game between monetary and fiscal authority to microfound policy interactions. Regime switches are exogenously triggered by changes in the expectation of agents. For example, if a Ricardian government increase government spending this might trigger the expectation that the government becomes Non-Ricardian. Since debt matters for the conduct of monetary policy, the central bank reacts by changing its responsiveness to debt in the Taylor rule. Put differently, changes in the prior beliefs within this game, the pendant to the estimated Markov-switching probabilities, can trigger different outcomes and, hence, different weights in the Taylor-rule. This will have effects on the transmission of the shock and, hence, on the quantitative and qualitative results.

Finally, we implement this cheap talk game in a state-space DSGE model. The sequential move game, its solution algorithm respectively, is directly implemented in the state-space of our model; something that is a novelty in DSGE modelling. This guarantees a high degree of flexibility for modelling those interactions and allows to use this approach for a wide range of problems and also allows the analysis of repeated games. In a case study, we simulate the impulse responses generated by a stylized New Keynesian model with fiscal policy with and without regime switches. We discuss the differences across the scenarios and show that anticipation effects are fairly small in this model.

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