ESSAYS ON ASYMMETRIC FISCAL AND MONETARY POLICY

by

HEDIEH SHADMANI

B.S., Allameh Tabatabai University, 2005
M.A., Alzahra University, 2008

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Economics
College of Arts and Sciences

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2015

Abstract

This dissertation consists of three essays on modeling the behavior of both fiscal and monetary policy by allowing for asymmetry in preferences of the policy authorities. Whether the responses of fiscal or monetary policy to the business cycle conditions are symmetric or asymmetric is still an unresolved question. The idea behind asymmetric behavior is that policy makers take stronger action during times of distress than during ordinary times. The following chapters investigate this question empirically using data for the United States and show that policy makers do behave asymmetrically.

Chapter 1 investigates whether the asymmetric monetary policy preferences for the output gap as shown in Surico (2007) disappeared during the post-Volcker period spanning 1982:04- 2003:02. The results show Surico's conclusion to be fragile as moving the starting period for the estimation a few quarters forward shows strong asymmetric policy behavior.

Chapter 2 investigates U.S. fiscal policy sustainability and cyclicality in empirical structures that allow fiscal policy responses to exhibit asymmetric behavior. Two quarterly intervals of data are investigated, both of which begin in 1955. The short sample was chosen for comparison to Bohn (1998), while the full sample uses all available data. The results for a short sample that ends in the second quarter of 1995 show some differences from the results for the full sample that includes the financial crisis and the Great Recession. For the full sample, U.S. fiscal policy is asymmetrical in regard to both sustainability and cyclicality. Regarding fiscal policy sustainability, the best fitting models show evidence of fiscal policy sustainability for the short sample. However, the fiscal sustainability question does become less clear for the full sample. Regarding fiscal policy cyclicality, we find during times of distress, policy is strongly countercyclical, but during good times the results are mixed.

Chapter 3 investigates the source of asymmetry in reaction of U.S. fiscal policy to business cycle conditions, as shown in chapter 2. By decomposing the fiscal policy variable into the tax revenues and the expenditures, we show that both series exhibit asymmetry in a way which is analogous to the results found in chapter 2.

ESSAYS ON ASYMMETRIC FISCAL AND MONETARY POLICY

by

HEDIEH SHADMANI

B.S., Allameh Tabatabai University, 2005
M.A., Alzahra University, 2008

A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Economics
College of Arts and Sciences

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2015

Approved by:

Major Professor
Steven P. Cassou

Abstract

This dissertation consists of three essays on modeling the behavior of both fiscal and monetary policy by allowing for asymmetry in preferences of the policy authorities. Whether the responses of fiscal or monetary policy to the business cycle conditions are symmetric or asymmetric is still an unresolved question. The idea behind asymmetric behavior is that policy makers take stronger action during times of distress than during ordinary times. The following chapters investigate this question empirically using data for the United States and show that policy makers do behave asymmetrically.

Chapter 1 investigates whether the asymmetric monetary policy preferences for the output gap as shown in Surico (2007) disappeared during the post-Volcker period spanning 1982:04- 2003:02. The results show Surico's conclusion to be fragile as moving the starting period for the estimation a few quarters forward shows strong asymmetric policy behavior.

Chapter 2 investigates U.S. fiscal policy sustainability and cyclicality in empirical structures that allow fiscal policy responses to exhibit asymmetric behavior. Two quarterly intervals of data are investigated, both of which begin in 1955. The short sample was chosen for comparison to Bohn (1998), while the full sample uses all available data. The results for a short sample that ends in the second quarter of 1995 show some differences from the results for the full sample that includes the financial crisis and the Great Recession. For the full sample, U.S. fiscal policy is asymmetrical in regard to both sustainability and cyclicality. Regarding fiscal policy sustainability, the best fitting models show evidence of fiscal policy sustainability for the short sample. However, the fiscal sustainability question does become less clear for the full sample. Regarding fiscal policy cyclicality, we find during times of distress, policy is strongly countercyclical, but during good times the results are mixed.

Chapter 3 investigates the source of asymmetry in reaction of U.S. fiscal policy to business cycle conditions, as shown in chapter 2. By decomposing the fiscal policy variable into the tax revenues and the expenditures, we show that both series exhibit asymmetry in a way which is analogous to the results found in chapter 2.

Table of Contents

List of Figures

List of Tables

Acknowledgements

I would like to thank many people who have contributed, directly or indirectly, to my academic success throughout my journey at Kansas State University. Words are not capable of describing my gratitude and acknowledgment'. In this document, I would try to express my heartfelt appreciation for my alma mater.

First and foremost, I would like to express my sincerest appreciation to my advisor Dr. Steven Cassou. Without his continuous support, guidance, and encouragement, this work would not have been possible. His mentorship throughout my academic career has been an invaluable source of inspiration and success. I would also like to thank Dr. Jesus Vázquez. Working with both Dr. Cassou and Dr. Vázquez on different research projects has definitely been a rewarding experience.

I would also like to express my gratitude to the rest of my supervisory committee members, Dr. William Blankenau, Dr. Lance Bachemeier, Dr. Lloyd Thomas, and Dr. Allen Featherstone. I have greatly benefited from their helpful suggestions and technical comments over the course of my research, eventually leading to this dissertation. I would also like to acknowledge all graduate faculty in the Department of Economics, Dr. Philip Gayle, Dr. Yang-Ming Chang, Dr. Dong Li. I learned a lot from your classes and I hope to disseminate this attained knowledge effectively during my role as an educator. Additional thanks to Dr. Daniel Kuester and Dr. Mohanned Alhamdi, whose constant guidance and encouragement helped me immensely in developing my teaching skills. I would also thank all my friends and colleagues who made my graduate school experience enjoyable, especially Neda, Sheryll, Yang, Moayad, Aditi, Farah, Eugenio, Mercy, and Jules for their friendship and support.

I would like to thank my lovely family, Hani and Ali Kashani, Mariam and Earle Harrison, and my dear Hasti. Thank you for always being there for me when I needed. My deepest appreciation goes to my best friend and my love, Shahab, for his everlasting love, boundless support, and patience throughout the most challenging moments. I cannot imagine going through this process without him by my side.

Finally, my most heartfelt thanks go to my lovely parents for their unconditional love, support, and encouragement which has always inspired me to chase my dreams.

Dedication

Dedicated to my lovely parents.

تقدیم به پدر و مادر عزیزم.

Chapter 1

Did Asymmetric Monetary Preferences for the Output Gap Disappear During Recent Economic Times?[1]

1.1 Introduction

Beginning with Barro and Gordon (1983), there has been considerable work that has investigated monetary policy as being carried out within the context of an optimal planning structure. Recent variations of these models that have attracted considerable attention are structures in which the planner has asymmetric preferences over one or more economic targets. Such models have been described and empirically investigated by Ruge-Murcia (2003, 2004), Nobay and Peel (2003), Surico (2007) and Cassou, Scott and Vázquez (2012) among others. The empirical results have been mostly favorable to the asymmetric preference structure, however, in Surico (2007), results were somewhat mixed. In particular, he did not find evidence in the more recent economic period of asymmetric preferences for the output gap, despite finding evidence in favor of it during an earlier period. In this paper we show that the results for the recent data are

[1] This chapter is the extended version of the paper titled "Did Asymmetric Monetary Preferences for the Output Gap Disappear During Recent Economic Times?" written with Dr. Steven Cassou and Dr. Jesus Vázquez, and has been published in Applied Economics Letters in 2014.

sensitive to the dates at which the empirical investigation is carried out. Using data that begins just a few quarters later, we show that the evidence for asymmetric preferences over the output gap becomes strong.

To some extent our investigation is motivated by a broader question about whether using the statutory end to the Volcker experiment of 1982:4, which Surico (2007) used, is the appropriate date at which to set as the initial date for investigating modern monetary policy. Alternatively one might consider the Great Moderation period as in the influential paper of Smets and Wouters (2007). Stock and Watson (2002) suggest that the onset of the Great Moderation occurred somewhere between 1982:4 and 1985:3 with a midpoint of 1984:1. Galí and Gambetti (2009), Kim and Nelson (1999), McConnell and Pérez-Quirós (2000) and Smets and Wouters (2007) also mark 1984:1 as the onset of the Great Moderation. We conduct a sensitivity analysis by rerunning the empirical equation in Surico (2007) and incrementally moving the starting date for the estimation one period forward. We find that by considering a sample period starting in 1984:1, a significant coefficient for the output gap reappears and remains for all further starting period increments. This result is robust to different endpoints, including the one Surico (2007) used of 2003:2 as well as 2007:4 which is the period just before the onset of the financial crisis in the U.S.

The rest of the chapter is organized as follows. Section 1.2 describes the model with asymmetric preferences as developed by Surico (2007). Section 2.3 discusses the empirical findings. Finally, Section 1.4 concludes.

1.2 Empirical Equations

This section describes the theoretical optimal monetary planner model as described in Surrico (2007) that incorporates asymmetric preferences. The evolution of the economy is represented by the following two-equation system.

$$\pi_t = k(Y_t - Y_t^*) + f_t, \tag{1.1}$$

$$(Y_t - Y_t^*) = -\varphi(i_t - E_t\pi_{t+1}) + g_t, \tag{1.2}$$

where π_t is inflation, $(Y_t - Y_t^*)$ is output gap, and $(i_t - E_t\pi_{t+1})$ denotes the real interest rate. The error terms $f_t = \theta E_t\pi_{t+1} + \eta_t^s$ and $g_t = E_t(Y_{t+1} - Y_{t+1}^*) + \eta_t^d$ are taken as given reflecting the fact that the monetary authorities cannot directly control expectations, and η_t^s and η_t^d are cost and demand disturbances that obey an autoregressive, mean reverting process.

The central bank problem is to choose the interest rate at the beginning of period t conditional upon the information available at the end of the previous period, so as to solve

$$\min_{\{i_t\}} E_{t-1} \left\{ \begin{array}{c} \left(\frac{1}{\delta^2}\right)(\exp(\delta(\pi_t - \pi^*)) - \delta(\pi_t - \pi^*) - 1) \\ +\left(\frac{\mu}{\gamma^2}\right)(\exp(\gamma(Y_t - Y_t^*)) - \gamma(Y_t - Y_t^*) - 1) \\ +\frac{\alpha}{2}(i_t - i^*)^2 \end{array} \right\}. \tag{1.3}$$

This objective function incorporates asymmetric preferences. The coefficient μ and α represent the central bank's aversion towards output and interest rate fluctuations around their targets, while δ and γ capture any asymmetry in the objective function of the monetary policy makers. This asymmetric loss function nests the quadratic loss function, which is consistent with symmetric preferences, as a special case when $\delta = \gamma = 0$. A negative value of γ implies that, everything else equal, an output contraction relative to the potential level is weighted more severely than an output expansion. A similar interpretation is true for δ. That is, a positive value of δ implies that monetary authorities are more concerned when inflation is higher than the target than when it is lower than the target.

Substituting (1.1) and (1.2)in to the objective function (1.3), we get

$$\min_{\{i_t\}} E_{t-1}\left\{\begin{array}{c} \left(\frac{1}{\delta^2}\right)(\exp(\delta(k(Y_t - Y_t^*) + f_t - \pi^*)) \; - \delta(k(Y_t - Y_t^*) + f_t - \pi^*) - 1) \\ +\left(\frac{\mu}{\gamma^2}\right)(\exp(\gamma(Y_t - Y_t^*)) \; - \gamma(Y_t - Y_t^*) - 1) \\ +\frac{\alpha}{2}(i_t - i^*)^2 \end{array}\right\}.$$

Taking the derivative, we can write the first order condition as,

$$E_{t-1}\left\{\begin{array}{c} \left(\frac{-k\phi}{\delta}\right)(\exp(\delta(k(-\varphi(i_t - E_t\pi_{t+1}) + g_t) + f_t - \pi^*)) \; - 1) \\ +\left(\frac{\mu}{\gamma}\right)(-\varphi\exp(\gamma(-\varphi(i_t - E_t\pi_{t+1}) + g_t) - 1) \\ +\alpha(i_t - i^*) \end{array}\right\} = 0. \tag{1.4}$$

Using (1.1) and (1.2), we get

$$E_{t-1}\left\{\begin{array}{c} \left(\frac{-k\phi}{\delta}\right)(\exp(\delta(\pi_t - \pi^*)) \; - 1) \\ +\left(\frac{-\mu\varphi}{\gamma}\right)(\exp(\gamma(Y_t - Y_t^*) - 1) + \alpha(i_t - i^*) \end{array}\right\} = 0. \tag{1.5}$$

Next, evaluating expectations, we get

$$\begin{array}{c} E_{t-1}\left\{\left(-\frac{k\phi}{\delta}\right)(\exp(\delta(\pi_t - \pi^*)) \; - 1)\right\} \\ E_{t-1}\left(-\frac{\mu\varphi}{\gamma}\right)(\exp(\gamma(Y_t - Y_t^*) - 1) + \alpha(i_t - i^*) = 0 \end{array} \tag{1.6}$$

Using Taylor Series Expansion, we can simplify the exponential parts, to get

$$
\begin{aligned}
\exp(\gamma(Y_t - Y_t^*)) - 1 = {} & \gamma(Y_t - Y_t^*) + \\
& \frac{(\gamma(Y_t - Y_t^*))^2}{2} + \frac{(\gamma(Y_t - Y_t^*))^3}{6} + \\
& \frac{(\gamma(Y_t - Y_t^*))^4}{24} + \ldots
\end{aligned} \tag{1.7}
$$

and

$$
\begin{aligned}
\exp(\delta(\pi_t - \pi^*)) - 1 = {} & \delta(\pi_t - \pi^*) + \\
& \frac{(\delta(\pi_t - \pi^*))^2}{2} + \frac{(\delta(\pi_t - \pi^*))^3}{6} + \\
& \frac{(\delta(\pi_t - \pi^*))^4}{24} + \ldots
\end{aligned} \tag{1.8}
$$

Substitutes (1.7) and (1.8) into (1.6), we get

$$
\left\{
\begin{array}{c}
E_{t-1}\left\{\left(-\frac{k\phi}{\delta}\right)\left(\delta(\pi_t - \pi^*) + \frac{(\delta(\pi_t - \pi^*))^2}{2}\right)\right\} \\
+E_{t-1}\left\{\left(-\frac{\mu\varphi}{\gamma}\right)\left(\gamma(Y_t - Y_t^*) + \frac{(\gamma(Y_t - Y_t^*))^2}{2}\right)\right\} \\
+\alpha(i_t - i^*) = 0
\end{array}
\right\}. \tag{1.9}
$$

Following a few more simplifying steps, eventually we get the linear regression

$$
\begin{aligned}
(i_t - i^*) = {} & \frac{k\phi}{\alpha}\pi^* + \left(\frac{k\phi\delta}{2\alpha}\right)(\pi^*)^2 + \frac{k\phi}{\alpha}E_{t-1}(\pi_t) \\
& + \left(\frac{k\phi\delta}{2\alpha}\right)E_{t-1}\{\pi_t^2\} - \left(\frac{k\phi\delta}{\alpha}\right)\pi^* E_{t-1}\{\pi_t\} \\
& + \frac{\mu\varphi}{\alpha}E_{t-1}\{(Y_t - Y_t^*)\} + \left(\frac{\mu\varphi\gamma}{2\alpha}\right)E_{t-1}\{(Y_t - Y_t^*)^2\},
\end{aligned} \tag{1.10}
$$

Further simplification implies the regression equation in terms of the original parameters of

$$
\begin{aligned}
i_t = i^* + \frac{k\phi}{\alpha}\pi^* + \left(\frac{k\phi\delta}{2\alpha}\right)(\pi^*)^2 \\
+ \frac{k\phi}{\alpha}E_{t-1}(\pi_t) + \left(\frac{k\phi\delta}{2\alpha}\right)E_{t-1}\{\pi_t^2\} - \left(\frac{k\phi\delta}{\alpha}\right)\pi^* E_{t-1}\{\pi_t\} \\
+ \frac{\mu\varphi}{\alpha}E_{t-1}\{(Y_t - Y_t^*)\} + \left(\frac{\mu\varphi\gamma}{2\alpha}\right)E_{t-1}\{(Y_t - Y_t^*)^2\}.
\end{aligned}
\tag{1.11}
$$

We replace expectations with realized values and, in line with most empirical studies on monetary policy rules, we introduce a lagged dependent variable capturing interest rate smoothing. Adding these changes, we can rewrite (1.11)

$$
i_t = c_0 + c_1\pi_t + c_2(Y_t - Y_t^*) + c_3(\pi_t^2) + c_4(Y_t - Y_t^*)^2 + \rho i_{t-1} + \nu_t. \tag{1.12}
$$

where $c_0 = i^* + \frac{k\phi}{\alpha}\pi^* + \left(\frac{k\phi\delta}{2\alpha}\right)(\pi^*)^2$, $c_1 = +\frac{k\phi}{\alpha} - \left(\frac{k\phi\delta}{\alpha}\right)\pi^*$, $c_2 = \frac{\mu\varphi}{\alpha}$, $c_3 = \left(\frac{k\phi\delta}{2\alpha}\right)$, $c_4 = \left(\frac{\mu\varphi\gamma}{2\alpha}\right)$, and ν_t is an independent, zero mean error term.

The key parameters which indicate asymmetric monetary policy preferences are c_3 and c_4. Standard theoretical interpretations for asymmetric preferences over inflation and output imply that c_3 should be positive while c_4 should be negative. In particular, a positive c_3 corresponds to a positive δ which shows asymmetric preferences for inflation. That is, positive deviations in inflation create more loss than negative ones. Similarly, it could be shown that, a negative c_4 corresponds to a negative γ which shows asymmetric preferences for the output gap. That is, negative deviations of output from potential output create more loss than positive ones. Finally, $c_3 = c_4 = 0$ corresponds to $\delta = \gamma = 0$ which shows symmetric preferences.

1.3 Sub-Period Empirical Results

Surrico (2007) estimates (1.12) using data from the Federal Reserve Bank of St. Louis data bank. In estimating this equation, the interest rate chosen by policy makers is the Federal Funds rate and the output gap is computed by subtracting potential GDP from observed GDP. Two measures for the inflation rate were used. One computes inflation from the personal consumption expenditure index (PCE index) and the other computes inflation from the GDP deflator.

Although Surico (2007) never finds c_3 to be significant, what has drawn greater attention is the finding that c_4 is significantly negative during the pre-Volcker period spanning 1960:1-1979:3, but is insignificant during the post-Volcker period spanning 1982:4-2003:2.[2] This has been interpreted as implying that monetary policy maker preferences have changed between these two periods from one which weighs output below potential output as more concerning during the pre-Volcker period to one in which positive and negative deviations for potential output are equally weighted.

To investigate this finding we began by replicating the original findings in Surico (2007). Table 1.1 summarizes Surico's original parameter estimates over the two sample periods for regressions using two alternative measures for inflation as well as our results over these two periods and an extension of the post Volcker period to run up until the onset of the U.S. financial crisis beginning in 2008:01.[3] Our regressions use the same Generalized Method of Moments (GMM) estimation procedure with 13 instruments, which implies 7 over identifying restrictions.

[2] To be consistent with Surico, we used the term "Pre-Volcker period" to refer to the period before Volcker experiment, and the term "Post-Volcker period" for the period after Volcker experiment of 1982:4. Although these terms may invoke some confusion, we thought that it would be useful to keep the terminology the same as Surico.

[3] Table 1.1 and Table 1.2 present only a subset of the empirical output. So here, we leave out the values for c_0 and ρ.

The instruments include two lags of inflation, squared inflation, output gap, squared output gap, the Federal Funds rate and the alternative measure of inflation. Although we were unable to get exactly the same numbers, our results confirm Surico's results, particularly for the c_4 estimates which are the focus of this essay. We attribute the inability to precisely match Surico's numbers as arising from periodic data revisions which the data undergo as statistical tabulation authorities periodically reevaluate the calculations.[4]

Table 1.1: Surico Results and Replication

		Sample Period				
		1960:1-1979:3		1982:4-2003:2		1982:4-2007:4
		Surico	Replication	Surico	Replication	Extension
	c_1	0.33**	0.344**	0.89**	0.603*	0.696*
		(0.12)	(0.129)	(0.36)	(0.304)	(0.320)
PCE	c_2	0.25**	0.259**	0.17**	0.123**	0.132**
		(0.04)	(0.049)	(0.04)	(0.037)	(0.031)
Inf	c_3	-0.01	0.004	-0.11	-0.085	-0.103
		(0.01)	(0.017)	(0.06)	(0.059)	(0.063)
	c_4	-0.04**	-0.030**	-0.01	0.006	0.008
		(0.01)	(0.010)	(0.01)	(0.007)	(0.007)
	c_1	0.17**	0.267*	2.23	0.688	0.680
		(0.12)	(0.129)	(1.17)	(0.450)	(0.462)
GDP	c_2	0.18**	0.239**	0.09	0.105*	0.123**
		(0.03)	(0.056)	(0.09)	(0.043)	(0.035)
Inf	c_3	0.01	0.006	-0.41	-0.121	-0.111
		(0.01)	(0.018)	(0.25)	(0.091)	(0.092)
	c_4	-0.03**	-0.032**	-0.02	0.008	0.009
		(0.01)	(0.012)	(0.02)	(0.009)	(0.009)

Notes: Standard errors in parentheses. One asterisk indicates significance at the 10% level, while two asterisks indicate significant at the 5% level.

[4] To be more precise, our data set is likely to differ from the one used by Surico (2007) since our data are thoroughly revised data whereas roughly one seventh of the last observations of inflation considered by Surico (2007), presumably collected around the third quarter of 2003, were not revised data at the time they were collected because National Income and Product Accounts variables take approximately three years to be fully revised (see Aruoba, 2008, and Croushore, 2011, for details on data revisions). Our revised output gap time series and the one used by Surico (2007) are also different because the output gap revisions are sizable as documented by Croushore (2011) and references therein.

In Table 1.2 we summarize the results of an empirical analysis that broadens the interpretation of the post-Volcker period. The table has two panels, with the upper panel focusing on the same end date as Surico's analysis of 2003:2 while the second panel focuses on the extended sample which has an end date of 2007:4. Next, we reran the basic regressions but incrementally started the sample period one quarter later. As Table 1.2 indicates, for both measures of inflation, as well as both sample endpoints, the c_4 parameter became significant when the start period began in 1984:1 and remained significant for all further increments to the starting period. Interestingly, 1984:1 is the quarter that Stock and Watson (2002) estimated to mark as the beginning of the Great Moderation. Moreover, the size of the parameter estimate c_4 and its associated standard error for the full sample period (1984:1-2007:4) are similar to those found for the pre-Volcker period as shown in Table 1.1. What these results show is that the finding that asymmetric monetary preferences for output gap being insignificant during recent economic times is fragile, and that using data intervals which begin somewhat later than the date of 1982:4 used by Surico (2007) shows that monetary authorities consistently exhibited asymmetric preferences during both the pre-Volcker and the post-Volcker periods.

Table 1.2: Variations on the Second Interval Sample Period

		Surico	1982:4	1983:1	1983:2	1983:3	1983:4	1984:1	1984:2	1984:3	1984:4
Results for start period given and ending in 2003:2											
PCE Inf	c_1	0.89**	0.603*	0.523	0.408	0.350	0.714*	0.930**	1.005**	1.024**	0.976**
		(0.36)	(0.304)	(0.300)	(0.301)	(0.307)	(0.311)	(0.308)	(0.296)	(0.281)	(0.259)
	c_2	0.17**	0.123**	0.115**	0.099**	0.095**	0.139**	0.174**	0.190**	0.194**	0.193**
		(0.04)	(0.037)	(0.036)	(0.035)	(0.035)	(0.038)	(0.040)	(0.039)	(0.037)	(0.033)
	c_3	-0.11	-0.085	-0.069	-0.049	-0.034	-0.093	-0.122*	-0.129*	-0.131**	-0.119**
		(0.06)	(0.059)	(0.059)	(0.059)	(0.058)	(0.057)	(0.055)	(0.052)	(0.048)	(0.044)
	c_4	-0.01	0.006	-0.009	0.016*	0.007	-0.035	-0.056**	-0.066**	-0.066**	-0.065**
		(0.01)	(0.007)	(0.007)	(0.008)	(0.017)	(0.018)	(0.017)	(0.015)	(0.014)	(0.014)
GDP Inf	c_1	2.23	0.688	0.608	0.399	0.300	0.692	0.951*	1.048*	1.183**	1.192**
		(1.17)	(0.450)	(0.432)	(0.444)	(0.465)	(0.471)	(0.480)	(0.468)	(0.450)	(0.399)
	c_2	0.09	0.105**	0.096*	0.080**	0.072	0.110*	0.148**	0.172^**	0.180**	0.180**
		(0.09)	(0.043)	(0.042)	(0.039)	(0.039)	(0.044)	(0.047)	(0.047)	(0.045)	(0.040)
	c_3	-0.41	-0.121	-0.104	-0.059	-0.037	-0.103	-0.137	-0.148	-0.174*	-0.174*
		(0.25)	(0.091)	(0.089)	(0.091)	(0.094)	(0.093)	(0.094)	(0.090)	(0.086)	(0.075)
	c_4	-0.02	0.008	-0.010	0.014	0.012	-0.024	-0.048**	-0.060**	-0.060**	-0.061**
		(0.02)	(0.009)	(0.009)	(0.008)	(0.016)	(0.017)	(0.018)	(0.017)	(0.016)	(0.015)
Results for start period given and ending in 2007:4											
		Surico	1982:4	1983:1	1983:2	1983:3	1983:4	1984:1	1984:2	1984:3	1984:4
PCE Inf	c_1	0.89**	0.696**	0.610	0.496	0.438	0.681*	0.746**	0.781**	0.779**	0.727**
		(0.36)	(0.320)	(0.321)	(0.324)	(0.321)	(0.301)	(0.288)	(0.276)	(0.261)	(0.243)
	c_2	0.17**	0.132**	0.127**	0.119**	0.113**	0.127**	0.135**	0.142**	0.143**	0.143**
		(0.04)	(0.031)	(0.031)	(0.030)	(0.028)	(0.029)	(0.029)	(0.029)	(0.028)	(0.026)
	c_3	-0.11	-0.103	-0.083	-0.058	-0.046	-0.100	-0.114*	-0.121*	-0.121*	-0.110*
		(0.06)	(0.063)	(0.064)	(0.065)	(0.064)	(0.060)	(0.057)	(0.055)	(0.051)	(0.048)
	c_4	-0.01	0.008	0.012	0.019*	0.011	-0.020	-0.031*	-0.039**	-0.038**	-0.037**
		(0.01)	(0.007)	(0.007)	(0.008)	(0.016)	(0.016)	(0.014)	(0.013)	(0.012)	(0.012)
GDP Inf	c_1	2.23	0.680	0.624	0.410	0.315	0.639	0.740	0.738	0.828	0.769*
		(1.17)	(0.462)	(0.439)	(0.454)	(0.475)	(0.468)	(0.468)	(0.451)	(0.431)	(0.381)
	c_2	0.09	0.123**	0.118**	0.102**	0.093**	0.109**	0.118**	0.128**	0.131**	0.127**
		(0.09)	(0.035)	(0.034)	(0.032)	(0.031)	(0.034)	(0.034)	(0.034)	(0.032)	(0.028)
	c_3	-0.41	-0.111	-0.097	-0.049	-0.028	-0.101	-0.124	-0.126	-0.146	-0.136
		(0.25)	(0.092)	(0.089)	(0.092)	(0.097)	(0.096)	(0.096)	(0.092)	(0.088)	(0.078)
	c_4	-0.02	0.009	0.012	0.016	0.015	-0.016	-0.028	-0.037**	-0.035**	-0.033**
		(0.02)	(0.009)	(0.009)	(0.009)	(0.016)	(0.016)	(0.015)	(0.014)	(0.013)	(0.013)

Notes: Standard errors in parentheses. One asterisk indicates significance at the 10% level, while two asterisks indicate significant at the 5% level.

One explanation for these results can be seen by inspection of Figure 1.1, which plots the output gap along with the two measures of inflation. Because the rate of inflation is still decreasing during the period between 1982:2-1983:4, the estimation results are likely influenced when the sample period starts during this interval. This can be understood by noting that in the central banker optimization problem solved in Surico (2007), the relevant explanatory variable is the inflation deviation from its target. If the inflation target is constant, (1.12) is well specified because the inflation target component adds to the intercept. However, when the inflation target is time-varying, (1.12) is misspecified. During the period 1980:1-1983:4, the inflation rate was still falling and thus it is likely that the inflation target was as well.

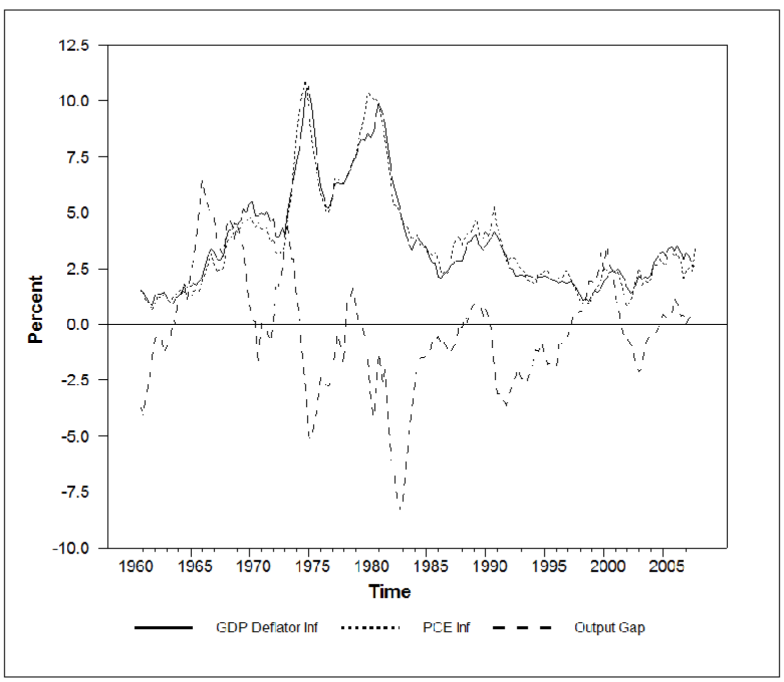

Figure 1.1: Inflation Rates and Output Gap

1.4 Conclusion

In this paper, we investigated whether the conclusion that asymmetric policy preferences for the output gap disappeared during the post-Volker period spanning 1982:4-2003:2. We show this conclusion to be fragile as incrementing the starting period for the estimation a few quarters forward shows strong asymmetric policy results. Furthermore, this conclusion is not sensitive to the end period of the sample as extending the data until the onset of the financial crisis at 2007:4 produces the same qualitative effects. We offer a simple explanation for what accounts for this result by showing that during the first few periods after the statutory end of the Volker period of 1982:4, the inflation rate was still falling rapidly. This suggests that the inflation target was likely unstable making regressions which model stable parameter behavior misspecified.

Chapter 2

Fiscal Policy Asymmetries and the Sustainability of U.S. Government Debt Revisited[5]

2.1 Introduction

Interest in the sustainability of the U.S. fiscal policy stance toward public debt became a concern to both policy makers and economists during the 1980s when the U.S. started to incur large government budget deficits. Many investigations, including Hamilton and Flavin (1986), Trehan and Walsh (1988), Kremers (1989), Hakkio and Rush (1991), Quintos (1995) and Davig (2005), used unit root and cointegration empirical methods to provide answers to this question.[6]

On the other hand, Bohn (1998) used a method that had a policy reaction interpretation. He showed that the U.S. government historically responded to increases in the debt-GDP ratio by increasing the primary surplus-GDP ratio. That is, the government has historically reacted to debt accumulation by taking corrective measures when the debt-GDP ratio starts to rise. In a later paper, Bohn (2007) further defended the policy reaction function approach and built on the

---

[5] This chapter is the extended version of the paper titled "Fiscal Policy Asymmetries and the Sustainability of US Government Debt Revisited" written with Dr. Steven Cassou and Dr. Jesus Vázquez in 2015.

[6] Hamilton and Flavin (1986) Trehan and Walsh (1988), Quintos (1995) and Davig (2005) found evidence in support of sustainability, while Kremers (1989), Hakkio and Rush (1991) were more pessimistic.

criticism of the unit root and cointegration methods, by showing that the work which used such methods could not properly evaluate sustainability because they implicitly ruled out higher-order integration which would still be consistent with the intertemporal government budget constraint. In short, Bohn (2007) showed that the intertemporal budget constraint alone imposes very weak econometric restrictions on debt and budget deficits and thus the policy reaction function approach is an effective way to evaluate the fiscal policy sustainability question.

Although some level of comfort regarding the sustainability of fiscal policy may have been established from this early body of work, the rapidly growing U.S. government debt since the start of the Great Recession in late 2007 has thrust the sustainability question back into the public consciousness, once again raising doubts about fiscal policy sustainability. This paper follows Bohn's (1998, 2007) approach based on the analysis of fiscal reaction functions to revisit the issue of U.S. fiscal policy sustainability by not only extending the data series, but by also extending the empirical model suggested by Bohn (1998) to account for, (i) the possibility of asymmetries in the fiscal reaction function to business cycle conditions, and (ii) changes in the size of shocks during the post-World War II period. More precisely, we investigate three related empirical models. The simplest model is a basic linear regression model which is close to the empirical model used in Bohn (1998) for the U.S. and Collignon (2012) for a sample of European Union countries, while the others are popular switching regression formulations which can address policy asymmetries. One of these non-linear formulations is piecewise linear and is such that the basic linear model is nested as a special case. This type of non-linear model has been used by Golinelli and Momigliano (2008) and Balassone, Francese and Zotteri (2010) to analyze asymmetries in fiscal policy for several European countries. The third formulation is a Markov switching model of the form described by Hamilton (1989). The advantage of a Markov switching model over a piece-wise linear model is that the former allows us to handle changes in shock volatility in a rather straightforward manner.

To investigate these issues, we estimate models over two different quarterly intervals of time, one running from 1955:1 until 1995:2 and the other from 1955:1 to 2013:3. The former, which we call the short sample, is intended to provide a quarterly data series that can roughly match the series in Bohn (1998), while the later, which we call the long sample, uses all available data. By investigating these two samples, we are able to demonstrate that the financial crisis and Great Recession are sufficiently different from the earlier period that the asymmetric empirical methods used in this paper are important and that the sustainability of U.S. government debt question needed to be revisited. We find several important results regarding fiscal policy modeling and the empirical analysis of fiscal policy for the United States. First, and perhaps most important, we find that recent economic data, that include the financial crisis and Great Recession, are sufficiently different from earlier data that simple linear models are not appropriate for modelling fiscal policy. Second, we find that for the long sample, the fiscal response to lagged debt and lagged output gap are asymmetric, however, over the shorter sample, the results for lagged debt do not exhibit asymmetric behavior. Third, regarding fiscal policy sustainability, we find that the sample period used is important. For the short sample, fiscal policy is sustainable, confirming results by Bohn (1998). Over the full sample period, fiscal policy is only sustainable during good economic times and is unsustainable during times of distress. We interpret the unsustainable behavior during times of distress as evidence that policy makers, by running larger budget deficits, are more concerned about getting the economy back on track and perhaps temporarily ignore sustainability. This finding that fiscal policy is not always sustainable is consistent with the recent doubts expressed by some policy makers and political pundits about sustainability of the U.S. fiscal policy. Finally, regarding the cyclicality of fiscal policy, we find robust evidence that fiscal policy is countercyclical during bad economic times and becomes less countercyclical during good times. A few of our models even indicate that during good economic times fiscal policy may become marginally procyclical. This procyclical finding is consistent with results found in Balassone et al. (2010) using European data and are interpreted to show that during good times, the government budget deficit-GDP ratio grows with the rest of the economy.

The rest of the chapter is organized as follows. Section 2.2 describes the empirical models analyzed in this paper. Section 2.3 discusses the empirical findings. In Section 2.4 we study an alternative sample period that is similar to the one analyzed by Bohn (1998), in order to see if his conclusion about debt sustainability holds up using our richer asymmetric fiscal policy empirical models and thus reconcile our empirical results with his findings. Finally, Section 2.5 concludes.

2.2 Empirical Equations

We investigate three related empirical models. The simplest model is a basic linear regression model, while the others are popular switching regression formulations. One of the more general formulations is piecewise linear and is such that the basic linear model is nested as a special case while the third formulation is nonlinear and, as such, the other two are not nested in general.

Some authors, such as Golinelli and Momigliano (2008), have considered other models that are further nested in a few of the switching regression formulations considered here. They referred to these different formulations as two parameter models and referred to the piecewise linear formulations considered in this paper as two sample models. The two sample models are more general and nest the two parameter models as restricted cases. In some earlier work, we investigated the two parameter models and tested the restrictions implied between them and the two sample models. We always rejected the restrictions, so here we only present the more general two sample models.

Following Bohn (1998), Balassone et al. (2010) and others, we focus on the primary balance as our measure for the fiscal policy stance.[7] Our models exhibit richer dynamics than the one used in Bohn (1998) and some are similar to the one used by Balassone et al. (2010). In particular, our models include the lagged primary balance as an explanatory variable to allow for fiscal policy persistence.[8] A significant role of the lagged primary balance may reflect, for instance, the existence of an optimal fiscal policy inertia where the fiscal authority aims at reaching the optimal primary balance target in small steps due to economic uncertainty. Also, all our models only include lagged variables as explanatory variables. This feature allows us to interpret our models as fiscal policy rules where the fiscal authority only reacts to variables included in its information set. This feature further helps to overcome endogeneity issues which may show up when current explanatory variables are used in the empirical model. Finally, two of the formulations studied in this paper are nonlinear. We choose this setup as it allows us to not only investigate debt sustainability, but it also allows us to investigate fiscal policy cyclicality. Further, these nonlinear features help to assess the presence of policy persistence since, as noted by Perron (1989), evidence of a persistent process may arise simply as a result of ignoring important sources of nonlinearity.

[7] Bohn (1998) actually used the primary surplus which is the primary balance multiplied by -1.
[8] Afonso, Agnello and Furceri (2010) provided empirical evidence of fiscal policy persistence in a cross-country study.

The basic regression model can be written as

$$b_t = \alpha + \beta_1 b_{t-1} + \beta_2 d_{t-1} + \beta_3 w_{t-1} + \varepsilon_t, \qquad (2.1)$$

where b_t is the ratio of the primary balance (spending, net of interest expenses, minus taxes) to gross domestic product (GDP) at date t , d_{t-1} is the ratio of federal debt to GDP at date $t-1$, and w_{t-1} is the output gap at date $t-1$.[9] In the tables and discussion below, we will often refer to this model as the linear model or LM for short.

The various anticipated signs for the parameters have been discussed in various places in the literature. For instance, following the arguments in Bohn (1998, 2007), sustainability of fiscal policy should be marked by negative values of β_2 .[10]

Intuitively a negative value for β_2 indicates that as lagged debt increases, policy makers take action to reduce b_t either by reducing spending or raising taxes. Also, as noted in Balassone et al. (2010), the sign of β_3 depends on whether policy is procyclical or countercyclical. A positive value corresponds to a procyclical policy, where higher values of the lagged output gap are accompanied by higher primary balances either through more government spending or lower taxes, while a negative value corresponds to a countercyclical policy.

Part of our empirical focus will be on a popular asymmetry hypothesis in which the policy variable, b_t, responds to the lagged output gap, w_{t-1}, differently, depending on whether the economy is strong or weak. To evaluate asymmetry, one approach is to replace the various

[9] There are alternative, but related, formulations used in the literature. For instance, Golinelli and Momigliano (2008) focus on the cyclically-adjusted primary balance and prefer to use differenced levels as the dependent variable.

[10] To be more precise, Bohn (1998) used the primary surplus as his dependent variable rather than the primary balance (or deficit) we use here. For his model, Bohn (1998) argued that sustainability is associated with a positive surplus coefficient which would imply that our deficit coefficient should be negative.

variables with two interaction terms in which a dummy indicating the strength of the economy at period $t-1$, I_{t-1}, is multiplied by each of the variables to get

$$\begin{aligned} b_t &= \alpha I_{t-1} + \beta_1 I_{t-1} b_{t-1} + \beta_2 I_{t-1} d_{t-1} + \beta_3 I_{t-1} w_{t-1} + \alpha'(1 - I_{t-1}) \\ &\quad + \beta_1'(1 - I_{t-1}) b_{t-1} + \beta_2'(1 - I_{t-1}) d_{t-1} + \beta_3'(1 - I_{t-1}) w_{t-1} + \varepsilon_t, \end{aligned} \tag{2.2}$$

where I_{t-1} is given by

$$I_{t-1} = \begin{cases} 0 & \text{for } w_{t-1} \leq w^T, \\ 1 & \text{for } w_{t-1} > w^T, \end{cases}$$

and w^T is referred to as the threshold value for the lagged output gap. This type of model is known as a Threshold Regression model and we will use the abbreviation TR to reference it from now on.

The parameters of (2.2) can provide evidence for a number of interesting policy questions. For instance, asymmetry in the response of the policy variable to economic conditions can be noted when $\beta_2 \neq \beta_2'$ or $\beta_3 \neq \beta_3'$. If $\beta_2 \neq \beta_2'$, then there is evidence that policy responds to lagged debt differently when the economy is doing well than when it is not, while if $\beta_3 \neq \beta_3'$, then there is evidence that policy responds to the lagged output gap differently when the economy is doing well than when it is not. It is also useful to note that (2.1) is nested in (2.2). So one can test whether the TR model fits better than the basic regression model by performing an F test on the null that $\alpha = \alpha'$, $\beta_1 = \beta_1'$, $\beta_2 = \beta_2'$, and $\beta_3 = \beta_3'$.

We also investigate two versions of the two state Markov Switching (MS) empirical model. These MS models use a nonlinear relationship between the primary balance and the explanatory variables given by

$$b_t = \alpha(s_t) + \beta_1(s_t)b_{t-1} + \beta_2(s_t)d_{t-1} + \beta_3(s_t)w_{t-1} + \sigma(s_t)u_t, \tag{2.3}$$

where u_t is a standard normal random variable and s_t denotes the unobservable regime or state variable featuring the reaction of the fiscal authority to both observables entering in its information set (b_{t-1} , d_{t-1} and w_{t-1}) and the fiscal shocks (u_t). This state variable has values of either 1 or 2 and follows a first-order two-state Markov process with transition matrix given by

$$P = \begin{pmatrix} p_{11} & 1-p_{22} \\ 1-p_{11} & p_{22} \end{pmatrix},$$

where the row j , column i element of P is the transition probability p_{ij} , which is the probability that state i will be followed by state j . Since the transition probabilities beginning in each state sum to 1, the off diagonal terms are given by $p_{12} = 1-p_{11}$ and $p_{21} = 1-p_{22}$.

A somewhat more flexible alternative two-state MS model allows the transition probabilities to depend on an observable variable of the economy. This is more analogous to the various TR models which switch between the two linear terms depending on the value of the output gap. We investigated this connection in one of our models. In particular, we also considered a two-state MS model that allowed the transition probabilities to depend on the lagged output gap and used a logistic functional form for the probabilities as follows

$$p_{11}(w_{t-1}) = \frac{\exp(\theta_{10} + \theta_{11} w_{t-1})}{1 + \exp(\theta_{10} + \theta_{11} w_{t-1})},$$

$$p_{22}(w_{t-1}) = \frac{\exp(\theta_{20} + \theta_{21} w_{t-1})}{1 + \exp(\theta_{20} + \theta_{21} w_{t-1})}.$$

This type of formulation is described in Filardo (1994). Because the transition probabilities are time varying, we refer to this model as a time varying transition probability Markov Switching model, or TVTP-MS for short. One thing to notice is that when the lagged output gap does not impact the transition probabilities (i.e. when $\theta_{11} = \theta_{21} = 0$) the TVTP-MS model collapses into the MS model with constant probabilities. In this case, there is a one-to-one map between p_{11} and θ_{10} and between p_{22} and θ_{20} .

The advantage of these MS models over the TR models is twofold. First, they allow changes in the size of shocks during the sample period. Second, they allow the interaction of fiscal policy asymmetries with changes in shock volatility. However, it is important to point out that fiscal policy sustainability issues in a MS framework does require some extra consideration. As shown by Francq and Zakoïan (2001), local stationarity conditions, i.e. stationarity within each regime, are neither sufficient nor necessary to achieve the global stationarity of a MS system, and thus, for our application, to rule out explosive behavior that results in the violation of the intertemporal budget constraint. But, as also pointed out by Francq and Zakoïan (2001), this situation occurs when the probability of staying in the same regime is small. As a consequence, we argue that the likelihood of explosive behavior largely decreases when local stationary regimes are largely persistent (i.e. when the probability of staying in the same stationary regime is close to one).

2.3 Empirical Results

Our empirical analysis mostly uses quarterly data for the U.S. economy obtained from the Federal Reserve Bank of St. Louis data set. There are two possible government perspectives one could use. One could use the total of the federal, state and local government budgets, which would be more closely connected to the data used by Balassone et al. (2010) in their study of debt sustainability in European Union countries or one could use just the federal government budget. We used both for our analysis, but report only the results for federal government budget perspective below.[11]

The primary balance series was obtained by dividing minus 100 times the sum of the net federal saving series (FGDEF) and federal government interest payments (A091RC1Q027SBEA) by the nominal GDP series (GDP).[12] For the debt variable, we used the total public debt series (GFDEBTN) and divided it by the nominal GDP (GDP) series.[13] For the output gap, we computed the difference between the observed annual growth rate and the average annual growth rate. In particular, we computed the growth rate in percentage terms by

[11] We choose the federal government data because the annual data we used in a robustness investigation, not shown for the sake of brevity, was more consistent to the quarterly data used in this section. In other words, the annual series for the total federal, state and local government budgets had quite different numerical values from the quarterly data series making the comparison between the two data series less clear.

[12] Note, this computation for the primary balance results in the proper calculation. The reason that interest payments are added to the federal savings series (before multiplying by a negative number) is that the federal saving series is the difference between current receipts and current expenditures, where current expenditures includes, among other things, interest payments. By adding the interest payment series, we cancel the interest payment portion of the current expenditures.

[13] The Federal Reserve Bank of St. Louis only has quarterly debt data from 1966:01 to the present, so to get the additional 11 years back to 1955:01, we used data from the US treasury which can be found at http://www.treasurydirect.gov/govt/reports/pd/mspd/mspd.htm.

multiplying 100 times the log difference between the current value of real GDP (GDPC1) and the value four quarters earlier. Next these growth rates were averaged and then the average was subtracted from the annual growth rate series to give a series that has positive values when the current growth rate exceeds the average and negative values when the growth rate is below the average.[14]

Our main empirical analysis uses the data interval from the first quarter of 1955 to the third quarter of 2013. However, in the further investigations, we investigate a restricted data interval with the end date of the second quarter of 1995 to conform with Bohn (1998) and investigate comparability to his results and to show the importance of the switching regression structures which are needed over the full sample.

Table 2.1 summarizes the results for the various empirical models. The first column describes various parameter possibilities that the different models may take as well as a row for the threshold value for the TR models. As is common in such empirical results tables, many of the parameters are specific to particular models that were estimated. Also, to save space, results for the constant terms are not reported.[15] We use the "AT" and "BT" shorthand when describing TR model estimates to indicate parameter estimates when the threshold variable is above the threshold and below the threshold, respectively. We also list the parameters for the MS models in the same rows as the TR models even though the models, and thus the model parameters, have quite different interpretations. We made this choice to save space in reporting our results, but

[14] In a preliminary draft of the paper, we defined the output gap as the cyclical component of real GDP obtained with the Hodrick-Prescott (HP) filter. The main qualitative conclusions about fiscal asymmetries in regard to both sustainability and cyclicality are robust to this alternative definition of the output gap. However, we choose the output gap definition described above over the output gap based on the HP filter for two main reasons. First, the use of the HP output gap introduces an endogeneity issue in the estimation of our empirical fiscal reaction function since the HP filter is a two-sided filter. Second, the interpretation of the empirical fiscal equation as a fiscal reaction function become dubious when the HP output gap is a regressor since the HP output gap uses, by construction, much more information on GDP than the one available for the policy maker at the time of fiscal policy implementation.
[15] Complete tables with all the constant terms can be obtained upon request.

would like to take a moment to clearly spell out the different interpretations for the parameters to avoid confusion. Table 2.1 shows that we grouped the above threshold parameters for the TR models with the state 1, s_1, parameters for the MS models and the below threshold parameters for the TR models with the state 2, s_2, parameters for the MS models. Although there is some logic to grouping these parameters as we have, there are also important differences. For the TR models, the AT parameters are the values for the linear portion of the model when the output gap is observed to be above the threshold, while for the MS model, the s_1 parameters are the values for the linear portion of the model when the unobserved state variable is in regime 1, which is shown below to be mostly associated with recent expansionary periods. Similarly, for the TR models, the BT parameters are the values for the linear portion of the model when the output gap is observed to be below the threshold, while for the MS model, the s_2 parameters are the values for the linear portion of the model when the unobserved state variable is in regime 2, which is somewhat related to economic downturns.

The second column presents the results of the basic regression model given by (2.1), which was run using OLS. This model has no threshold, so the first row is left blank as are many of the later rows which correspond to parameters from alternative models. This regression finds the lagged dependent variable is somewhat less than 1 and is highly significant, showing evidence of a highly persistent fiscal rule, the lagged debt coefficient is negative and insignificant and the lagged output gap coefficient is negative and significant. Even though it is insignificant, the negative sign on the lagged debt coefficient is useful to note because, as emphasized by Bohn (1998, 2007), Collignon (2012) and others, a negative value can be viewed as being consistent with a sustainable fiscal policy. In particular, high values of debt imply lower primary deficit values, which result in a decrease in the debt level the following period. Next note that the negative coefficient on the lagged output gap indicates that fiscal policy is countercyclical. Toward the bottom of the column are various measures of fit, which are used for comparison purposes with the alternative models.

The remaining columns of Table 2.1 present various nonlinear models in which the dependent variable is a nonlinear function of the various economic variables.[16] Part of the motivation for these models is to explore asymmetric policy and, furthermore, to see how fiscal policy sustainability results are impacted when the model is flexible enough to handle asymmetric policy responses. However, these models can also be motivated by statistical testing. One type of statistical test is a procedure suggested by Teräsvirta (1994). For our application, the test begins by first running the basic LM model (2.1) and obtaining the residuals, which we denote e_t. Next an unrestricted regression given by

$$\begin{aligned} e_t = {} & \alpha' + \beta_1' b_{t-1} + \beta_2' d_{t-1} + \beta_3' w_{t-1} \\ & + \gamma_{11}(b_{t-1} w_{t-1}) + \gamma_{12}(d_{t-1} w_{t-1}) + \gamma_{13}(w_{t-1} w_{t-1}) \\ & + \gamma_{21}(b_{t-1} w_{t-1}^2) + \gamma_{22}(d_{t-1} w_{t-1}^2) + \gamma_{23}(w_{t-1} w_{t-1}^2) \\ & + \gamma_{31}(b_{t-1} w_{t-1}^3) + \gamma_{32}(d_{t-1} w_{t-1}^3) + \gamma_{33}(w_{t-1} w_{t-1}^3) + \varepsilon_t', \end{aligned}$$

is run. Testing for the presence of nonlinearity amounts to testing whether the added terms are significant. In particular, this amounts to testing

$$H_0 : \left\{ \gamma_{ij} = 0 \text{ for } i = 1,2,3 \text{ and } j = 1,2,3 \right\}.$$

We implemented this and found an F-statistic value of 2.831. The 5% critical value for this statistic can be found in a standard table of the F distribution with 9 degrees of freedom in

[16] It is useful to emphasize that although the TR models are linear in the interaction terms denoted in equation (2.2), they are nonlinear in the economic variables.

the numerator and infinity in the denominator and is equal to 1.880. We see that linearity is rejected and conclude there is nonlinearity.

Since nonlinear models are appropriate for exploration, consider the estimates for the TR model presented in column 3.[17] This model uses the lagged output gap as the threshold variable and is analogous to the Balassone et al. (2010) model in that the threshold value is arbitrarily set to 0, hence the TR-0 notation. Estimates for the coefficients are mostly consistent with the LM regression. To be more specific, looking down column 3, we see that when the economy was both above and below potential output in the previous period (i.e. both above and below the threshold value of zero), the lagged balance coefficients are highly significant and close to one. We see that the lagged debt coefficient is negative and insignificant when the lagged output was above potential and positive and insignificant when the economy was below potential. Furthermore, the lagged output gap coefficients are negative when the economy was both above and below potential in the previous period, but only the below potential coefficient is significant.

The coefficients on the lagged debt and output gap variables provide insight into how fiscal policy makers behave. In particular, the negative lagged debt coefficient during above threshold values for the lagged output gap shows a sustainability feature to fiscal policy when the economy is doing well, while the positive lagged debt coefficient during below threshold values could be interpreted as showing that policy makers are more concerned with getting the economy back on track than fiscal policy sustainability during downturns. In other words, the positive coefficient indicates that during times of distress policy makers temporarily forgo fiscal policy sustainability (i.e. a long-term goal) in favor of trying to revive the economy back to a situation

[17] In our preliminary empirical analysis, we also investigated logistic smooth TR and exponential smooth TR type nonlinear models. These models did not fit as well as the MS models, so they have been left out of the final draft of the paper.

with higher-than-average output growth rates (i.e. a short-term priority), at which time they then follow a sustainable fiscal policy program. To some extent, this interpretation is consistent with ideas developed in Collignon (2012), where he noted that various European stability agreements allow for temporary deviations from various sustainability rules. However, we should qualify this conclusion by noting that the insignificant value for both debt coefficients does weaken this interpretation. A similar asymmetric contingent interpretation can be made for the lagged output gap coefficients. In particular, the larger (in absolute value) and significant coefficient during the below threshold case shows that policy makers are more focused on getting the economy on track during downturns than during good times where the coefficient is somewhat smaller (in absolute value) and is insignificant. This interpretation is consistent with the asymmetric fiscal policy result found in Balassone et al. (2010) for a sample of fourteen European Union countries and shows a strong countercyclical response when economic conditions are poor. The various fit parameters toward the bottom of the table show that the TR-0 model fits better than the simple LM model and the null hypothesis that there is no improvement in the fit, as indicated by the row labeled $F-Stat$, shows an F-statistic of 2.513, which is greater than the 5% critical value of 2.371, and thus can be rejected.

The fourth column of Table 2.1 presents the estimates for a TR model in which the threshold is endogenously chosen so as to obtain the best fit. We distinguish it by using the TR-E notation. The best fitting threshold for this model occurs at a lagged output gap value of -1.870 which is somewhat lower than the zero threshold used in the TR-0 model. The parameter estimates for this model are largely the same as those for the zero threshold model and can be interpreted as showing the same countercyclical behavior for fiscal policy makers. In particular, the lagged debt coefficients provide some weak evidence for fiscal policy sustainability during good times, but show that during bad times concerns toward improving the economy overwhelm sustainability concerns. Similarly, the negative coefficients on the lagged output gap show that fiscal policy is countercyclical. Furthermore, this policy is asymmetric in that there is a greater level of intervention during economic downturns. One difference between the endogenous TR model and the zero threshold TR model is that two of the coefficients which were insignificant in the zero threshold TR model are significantly different from zero in the endogenous TR. Finally, looking at the various measures of fit at the bottom of the fourth column we see that the endogenous threshold TR model fits somewhat better than the zero threshold TR model. The test that this model fits no better than the LM model, as indicated by the row labeled $F - Stat$, has an F-statistic of 4.483, which is larger than the 5% critical value of 4.122, and thus is easily rejected.[18]

The next two columns of Table 2.1 show the two-state MS model formulation parameter estimates. The fifth column shows the parameter estimates for the two-state MS formulation in which the switching probabilities are constant, hence the added notation below the MS notation, while the sixth column is a two-state MS model in which the transition probabilities are time varying, hence the notation TVTP. Before describing the estimation results, it is useful to study Figure 2.1 in order to understand how to interpret the two-state conditions. Figure 2.1 shows the smoothed state 1, s_1, probability for the constant probability MS model.[19] Focusing on the boom economic period of the 1990s, one can see that the probability of being in state 1 is very high.

---

[18] The critical value of 4.122 does not come from a conventional F distribution table. We computed this number by using a bootstrap simulation procedure described in Hansen (1997) which showed that the F-statistic in TR models do not have F distributions and that proper critical values can be found using a bootstrap procedure.

[19] The smoothed probabilities are computed using the information over the whole sample of size T (i.e., $prob[s_t = 1|I_T]$) as discussed in Hamilton (1994, p. 694). The plot for the MS model in which the transition probabilities are time varying is very similar. Moreover, Figure 2.1 and Figure 2.2 below show the smoothed probabilities along with various business cycle turning points which have been dated by the NBER.

Similarly, during the boom period of the middle 2000s, Figure 2.1 shows a high probability of being in state 1. These high probabilities for state 1 during good economic times show that we can say that state 1 is generally associated with good economic times and correspondingly, state 2 is generally associated with poor economic times. Moreover, state 1 is also strongly associated with the Great Moderation period, which is characterized by low volatility.[20]

[20] The precise dating for the Great Moderation is the subject of debate, but many studies, such as Stock and Watson (2002), have suggested this low volatility period starts around 1984. Furthermore, although the debate is still open, the end of this low volatility period likely ended with the financial crisis in late 2007.

Table 2.1: Federal Government Primary Balance (1955:1 - 2013:3)

	LM	TR-0	TR-E	MS const prob.	MS TVTP
Threshold		0	-1.87		
Lagged Balance	0.924**				
	(0.021)				
Lagged Debt	-0.001				
	(0.003)				
Lagged Output Gap	-0.104**				
	(0.018)				
Lagged Balance - AT or s_1		0.937**	0.942**	0.936**	0.936**
		(0.036)	(0.022)	(0.011)	(0.011)
Lagged Balance - BT or s_2		0.877**	0.779**	0.861**	0.863**
		(0.030)	(0.052)	(0.040)	(0.040)
Lagged Debt - AT or s_1		-0.003	-0.003	-0.012**	-0.012**
		(0.005)	(0.003)	(0.001)	(0.001)
Lagged Debt - BT or s_2		0.005	0.018**	0.006	0.006
		(0.004)	(0.006)	(0.006)	(0.006)
Lagged Output Gap - AT or s_1		-0.023	-0.061**	0.015**	0.015*
		(0.045)	(0.030)	(0.008)	(0.009)
Lagged Output Gap - BT or s_2		-0.177**	-0.260**	-0.173**	-0.173**
		(0.036)	(0.082)	(0.037)	(0.037)
1st-regime volatility $\sigma(s_1)$				0.129**	0.129**
				(0.016)	(0.016)
2nd-regime volatility $\sigma(s_2)$				0.760**	0.759**
				(0.079)	(0.079)
p_{11} or θ_{10}				0.982**	4.053**
				(0.014)	(0.763)
p_{22} or θ_{20}				0.884**	2.028**
				(0.016)	(0.158)
θ_{11}					-0.107
					(0.154)
θ_{21}					-0.101*
					(0.060)
RSS	90.383	86.55	83.765		
AIC	1066.453	1064.269	1056.585		
SBC	1080.292	1091.946	1084.262		
log-likelihood				-126.676	-126.11
F-Stat		2.513**	4.483**		

Notes: Standard errors in parentheses. One asterisk indicates significance at the 10% level, while two asterisks indicate significant at the 5% level. AT and BT stand for above threshold and below threshold respectively.

Now focusing on the parameter estimates we see that, like the two TR models, the two MS models have very similar estimation results to each other and even to the TR models. Both show that the lagged balance coefficients are near 1 and significant in both states, the response to lagged debt is asymmetric, showing a negative and significant coefficient during state s_1 but an insignificant coefficient during state s_2, and the response to the lagged output gap is asymmetric, showing a negative and significant coefficient during state s_2 but a positive and marginally significant coefficient during state s_1. Moreover, the volatility of innovations in state 1, $\sigma(s_1)$, is roughly five times lower than the volatility of innovations in state 2, $\sigma(s_2)$. It is important to keep in mind this changing volatility feature uncovered by the MS formulation when comparing the estimation results obtained from the two approaches because the TR formulation assumes, in contrast to the MS formulation, an identical level of innovation volatility both above and below the threshold level.

Since state s_1 is generally associated with good economic times and s_2 is generally associated with poor economic times, the interpretations for these coefficients are largely the same as described for the TR models. In particular, during good economic times they show sustainability of fiscal policy and less concern with countercyclical policy, while during weak economic times they show no concern with sustainability of fiscal policy and a countercyclical fiscal policy. However, it is useful to point out that the fiscal policy sustainability result during good times is considerably stronger with the MS models than with the TR models as the good economic time coefficients are larger (in absolute value) and highly significant. Put differently, one can say that the MS models show stronger evidence that during the good economic times, which feature low volatility, policy makers are focused on fiscal policy sustainability.

Finally let us comment a bit on the parameters for the transition probabilities. Focusing on the constant probability model, we see that probability of staying in state 1 if one begins in state 1, p_{11}, is very high at 0.982, while the probability of staying in state 2 if one begins in state 2, p_{22}, is smaller at 0.884. These estimates show that there is high persistence for both states, with the persistence during good times being larger. As noted above, the high persistence of the fiscal sustainability state given by a value of p_{11} that is close to one reduces the likelihood of a situation described by Francq and Zakoïan (2001) and increases the likelihood that there is global fiscal policy sustainability. To understand the results for the time varying transition probability MS model, it is sufficient to look at the two parameters associated with the lagged output gap, θ_{11} and θ_{21}. Both are insignificant, which means that the transition probabilities for these models are largely the same as the constant probability MS model. This result is consistent with the fact that the parameter estimates for the two MS models are very close.

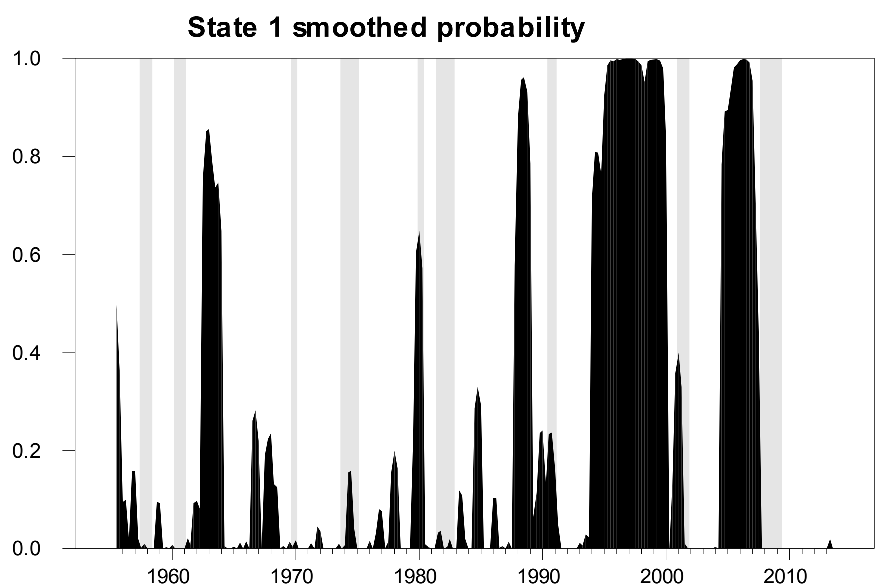

Figure 2.1: Two-State MS Model

Let us conclude this section with a brief summary of the key findings. In general, we find that there was a sequence of improvements in the fit and performance of the models presented. While the linear model exhibited desirable properties, such as debt sustainability and countercyclical behavior, it did not fit as well as both versions of the TR models which allowed asymmetric behavior on the part of policy makers. However the TR models showed their own weaknesses. For instance, they did not show debt sustainability during weak economic times. This behavior is interpreted as reasonable as it shows that during weak economic times policy makers are more concerned with getting the economy back on track. The MS models also showed some debt sustainability issues during weak economic times, but the coefficients were smaller than the TR models and insignificant. In addition, the good economic times showed larger (in absolute value) lagged debt coefficients indicating a stronger response towards fiscal policy sustainability.

2.4 An Alternative Sample Period

In this section we undertake an investigation which more directly compares our results with those in Bohn (1998). Using annual U.S. data from 1916 to 1995, Bohn (1998) argued that fiscal policy is consistent with sustainability in a simple static linear regression model. Here, we show that a similar, but dynamic, linear regression methodology as the one used by Bohn over this shorter sample is appropriate, but we also argue that when using the longer sample used in Section 2.3, the nonlinear models are more appropriate. Before discussing these results, let us first describe the data.

Since our quarterly data set begins in 1955:1, we cannot match the annual data starting date used in Bohn (1998), but we can match the end date of 1995 which we do with 1995:2 for our sample.[21] For ease of exposition, we will often refer to this data interval as the short sample while the longer data period from Section 2.3 will be referred to as the full sample.

Table 2.2 displays the results for the same models as in Table 2.1 using this short sample data. Table 2.2 shows many consistencies with the results from Section 2.3, but it also shows a few differences. One key difference between the short and long samples concerns the lagged debt parameter. The short sample shows a somewhat symmetric and sustainable fiscal policy. Indeed, the lagged debt coefficient in the LM is negative, significant and close to the corresponding estimated values under the two regimes associated with the TR and MS models. This contrasts with the long sample results in Section 2.3, which only showed the negative debt sustainability coefficients during above threshold or state 1 periods. These short sample results are in line with the results in Bohn (1998) who only used a simple linear model and show that fiscal policy does exhibit fiscal policy sustainability for this interval of time. It is also useful to point out that one could interpret the difference between these short and long sample results as showing that the addition of 18 years of data makes the question of fiscal policy sustainability less clear. This may in part account for the growing concern for the size of the U.S. government debt and deficits seen in more recent political debates.

[21] Moreover, Bohn (1998) also studied several subsamples, finding similar results to those found in his reference sample. One of his sample robustness exercises covered the period 1948-1995, which is rather similar to the sample period analyzed in this section.

Table 2.2: Federal Government Primary Balance (1955:1 - 1995:2)

	LM	TR-0	TR-E	MS Const prob.	MS TVTP
Threshold		0	-2.41		
Lagged Balance	0.796**				
	(0.041)				
Lagged debt	-0.010**				
	(0.004)				
Lagged Output Gap	-0.081**				
	(0.019)				
Lagged Balance - AT or s_1		0.828**	0.824**	0.935**	0.934**
		(0.059)	(0.044)	(0.013)	(0.013)
Lagged Balance - BT or s_2		0.754**	0.565**	0.715**	0.716**
		(0.057)	(0.097)	(0.084)	(0.084)
Lagged debt - AT or s_1		-0.007	-0.009*	-0.009**	-0.009**
		(0.006)	(0.005)	(0.001)	(0.001)
Lagged debt - BT or s_2		-0.011*	-0.015	-0.011*	-0.011*
		(0.006)	(0.010)	(0.006)	(0.006)
Lagged Output Gap - AT or s_1		-0.035	-0.047*	0.005	0.004
		(0.044)	(0.028)	(0.007)	(0.007)
Lagged Output Gap - BT or s_2		-0.141**	-0.386**	-0.132**	-0.132**
		(0.043)	(0.116)	(0.034)	(0.034)
1st-regime volatility $\sigma(s_1)$				0.080**	0.081**
				(0.009)	(0.009)
2nd-regime volatility $\sigma(s_2)$				0.711**	0.712**
				(0.091)	(0.090)
p_{11} or θ_{10}				0.999**	15.337**
				(0.002)	(0.828)
p_{22} or θ_{20}				0.870**	1.900**
				(0.016)	(0.141)
θ_{11}					0.241
					(0.561)
θ_{21}					-0.098
					(0.063)
RSS	53.769	52.616	50.185		
AIC	665.519	658.009	650.346		
SBC	665.87	682.71	675.047		
log-likelihood				-72.98	-72.498
F-Stat		0.843	2.749		

Notes: Standard errors in parentheses. One asterisk indicates significance at the 10% level, while two asterisks indicate significant at the 5% level. AT and BT stand for above threshold and below threshold respectively.

The results for the lagged output gap coefficient are largely the same between the two sample periods for both the TR and MS models. In particular, we see an asymmetric response to the lagged output gap in both samples with stronger countercyclical policy applied during economic weaknesses. Furthermore, as with the long sample, the short sample shows some differences between the TR models and the MS models, in that the TR models show countercyclical policy both above and below the threshold, while the MS models only show countercyclical policy during state 2.

Finally, we consider whether the nonlinear models are important for this data interval. First consider the nonlinear model test suggested by Teräsvirta (1994) which was described earlier. Running the same test as before, we found an F-statistic of 1.653 which is smaller than the 5% critical value of 1.880. Thus we reject the null that there is a nonlinearity in the data which is in contrast to the test over the full sample. Second, consider the tests that the threshold TR models fits no better than the LM model. As indicated by the row labeled $F-Stat$ in Table 2.2, the F-statistic of 0.843 for the zero threshold TR model is lower than the critical value of 2.371 from the regular F-distribution and the F-statistic of 2.749 for the endogenous threshold TR model is lower than the critical value of 4.147 computed using Hansen (1997) bootstrap procedure for the short sample. These tests show that the LM is not rejected for the short sample which is in contrast to the test over the full sample. Next consider the probability diagram associated with the constant probability MS model. Figure 2.2 displays the analogous short sample diagram to the long sample diagram given in Figure 2.1. This figure shows that the probability of being in state 1 is very low throughout the sample period. Interestingly, toward the end of the short sample, we do see a rising probability of being in state 1 and this period corresponds with some of the data periods in the long sample that also have a high probability of being in state 1. However, overall, state 1 does not appear to be useful for fitting the model and this indicates that the simple linear model similar to the one used by Bohn (1998) is sufficient to fit the data.

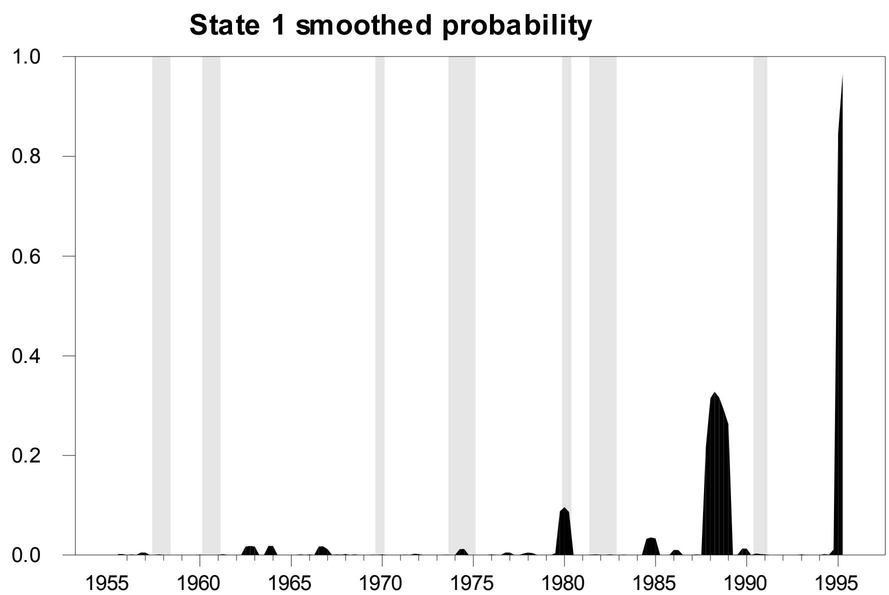

Figure 2.2: Two-State MS Model (Sample 1955-1995)

2.5 Conclusion

This paper has found several important results regarding fiscal policy modelling and the empirical analysis of fiscal policy for the United States. First, and perhaps most importantly, we showed that recent economic data, that include the financial crisis and Great Recession, are sufficiently different from earlier data. Therefore, the simple linear models are not appropriate for modelling fiscal policy.

Regarding our policy findings, we find that over a sample that includes the financial crisis and the Great Recession, the fiscal responses to lagged debt and lagged output gap are asymmetric, however, over the shorter sample, which ended in the second quarter of 1995, the results for lagged debt did not exhibit asymmetric behavior. Regarding fiscal policy sustainability, we also find that the sample period used is important. For the short sample, fiscal policy is sustainable, confirming results by Bohn (1998), while over the full sample period, fiscal policy is only sustainable during good economic times. While fiscal policy does not appear to be sustainable during times of distress over the full sample, we interpret this as evidence that policy makers are more concerned about getting the economy back on track and perhaps temporarily ignore sustainability. Overall, these empirical findings suggest that the fiscal sustainability question does become less clear when using data that includes the recent financial crisis and the Great Recession.

Regarding the cyclicality of fiscal policy, our analysis found robust evidence that fiscal policy is countercyclical during bad economic times and becomes less countercyclical during good times. A few of our models even indicated that during good economic times fiscal policy may become marginally procyclical. These latter findings are consistent with results found in Balassone et al. (2010) using European data and are interpreted to show that during good times, the government budget deficit-GDP ratio grows with the rest of the economy.

Chapter 3

Do U.S. Government Expenditures and Tax Revenues Respond to Debt Levels and Economic Conditions Asymmetrically Over the Business Cycle?

3.1 Introduction

Whether fiscal policy is countercyclical or procyclical and whether the reaction of fiscal variables is symmetric or asymmetric over the cycle are important questions which recently attracted a lot of attention. Over the last decades, several empirical works have analyzed the behavior of budgetary policies over the business cycle in different countries. Reviewing a group of 21 studies on the behavior of fiscal policy, Golinelli and Momigliano (2008) shows that the results of these studies are quite mixed. While some of these investigations conclude that policies tend to be procyclical, others suggest that policies are countercyclical. Furthermore, these studies find mixed results about the asymmetry in reactions of fiscal policy to business cycle conditions. The different results obtained by the empirical literature may in principle depend on the model of policy decisions used, the estimation procedures adopted, the countries included in the sample, the periods of time analyzed, or the source of data selected. Most of these studies such as

Balassone, Francese and Zotteri (2010) assessing the fiscal behavior in EMU[22]countries. One exception is Cassou, Shadmani, and Vázquez (2015) which investigates the asymmetry in behavior of fiscal policy for the United States.

Cassou et al. (2015) investigates the asymmetric reaction of the federal government primary surplus to business cycle condition and incorporate this issue with the sustainability of fiscal policy in U.S. economy which attracted a lot of attention recently after the financial crisis and the Great Recession period of late 2007. Focusing on the U.S. quarterly data over the period of 1955:1 to 2013:3, they find strong evidence of asymmetric countercyclical reactions of fiscal policy to debt levels and economic conditions over the business cycle, with the primary deficit increasing during times of distress more severely than decreasing during expansion periods. In particular, using popular regime switching models such as Threshold Regression models (TR) and Markov Switching models (MS) they show that the reactions of fiscal policy to debt to GDP ratio and to the output gap as a proxy of economic conditions significantly depends on the strength of the economy. Furthermore, their empirical results find that fiscal policy is sustainable during economic good times, but less sustainable in economic bad times.[23]

One interpretation for this asymmetric behavior, provided in this paper, is that generally during bad times policy makers try to get the economy back on track through increasing government expenditure or cutting taxes, in order to revive the economy back to a situation with higher-than-average output growth rates. This reaction results in accumulation of debt in next period, hence an unsustainable policy.

[22] Economic and Monetary Union (EMU) of the European Union
[23] According to Cassou et al. (2015), fiscal policy is sustainable if policy makers take corrective action in response to an increase in debt levels (by increasing taxes to decreasing expenditure).

The main purpose of this paper is to provide more details on the empirical analysis used in Cassou et al. (2015) and investigate the source of the asymmetry in the reaction of fiscal policy as shown in their paper. Whether this asymmetry arises from the government expenditure or tax revenues is an unsettled question in their paper that is going to be addressed in this paper.

To investigate this issue, we decompose the policy variable, the primary deficit, into the tax revenues and the primary expenditure.[24] Then, we separately estimate the same regime switching models, as proposed by Cassou et al. (2015), for each budget component series. This approach is analogous to the one used in Balassone et al. (2010) for a sample of 14 European countries and used in Sorensen and Yosha (2001) for 48 continental states.[25]

We find several important results regarding the reactions of budget components for the United States. First, most of our empirical models find that both series, i.e. federal government tax revenues and federal government primary expenditure, behave in an asymmetric fashion which is analogous to the asymmetric fiscal policy shown in Cassou et al. (2015). In particular, our empirical analysis generally shows that responses of both series to debt to GDP ratio highly depend on the strength of the economy. In other words, only during the economic good times the responses of the budget components to the accumulation of debt imply fiscal sustainability. In addition, most of the empirical models find solid evidence of countercyclical reaction of tax revenues and primary expenditure to business cycle conditions, with being more effective at mitigating the economic slumps than at muting booms. Finally, it is useful to note that the results

[24] Primary expenditure is government current expenditure net of interest payment.

[25] Balassone et al. (2010) finds significant cyclical asymmetry in the behaviour of fiscal variables in a sample of 14 EU countries over 1970--2007, with budgetary balances (both overall and primary) deteriorating in contractions without correspondingly improving in expansions. Their analysis of budget components reveals that cyclical asymmetry comes from expenditure.

Sorensen and Yosha (2001) find that state revenue and expenditure display significant asymmetry over the business cycle, with nearly offsetting effects on the budget surplus. As a result, state fiscal policytends to mute economic booms to roughly the same degree it mitigates slowdowns.

of MS models for the expenditure series cannot be interpreted in a way which is useful for our purpose since in this model the two regimes are not necessarily associated with economic boom times and bad times. Therefore, for the expenditure series, we can conclude that TR model is the most appropriate model for the purpose of our investigation.

The rest of the paper is organized as follows. Section 3.2 describes the empirical models analyzed in this paper. Section 3.3 discusses the empirical findings. Finally, Section 3.4 concludes.

3.2 Empirical Equations

Following Cassou et al. (2015), we investigate three related empirical models. The simplest model is a basic linear regression model, while the others are popular switching regression formulations. One of the more general formulations is piecewise linear and is such that the basic linear model is nested as a special case while the third formulation is nonlinear and, as such, the other two are not nested in general.

Some authors, such as Golinelli et al. (2008) and Balassone et al. (2010), have considered other models that are further nested in a few of the switching regression formulations considered here. They referred to these different formulations as two parameter models and referred to the piecewise linear formulations considered in this paper as two sample models. The two sample models are more general and nest the two parameter models as restricted cases.[26]

Following Balassone et al. (2010), in order to analyze the cyclical behavior of different budget components we focus on the tax revenues and primary expenditure as our measure for the

[26] In some earlier work, we investigated the two parameter models and tested the restrictions implied between them and the two sample models. We always rejected the restrictions, so here we only present the more general two sample models.

fiscal policy stance. In particular, in our model each component depends on its lagged value, the lagged debt, and the lagged output gap. Our models include the lagged value of each component as an explanatory variable to allow for fiscal policy persistence.[27]

A significant role of the lagged value of each component may reflect, for instance, the existence of an optimal fiscal policy inertia where the fiscal authority aims at reaching the optimal target for the policy variable in small steps due to economic uncertainty. Also, all our models only include lagged variables as explanatory variables. This feature allows us to interpret our models as fiscal policy rules where the fiscal authority only reacts to variables included in its information set. This feature further helps to overcome endogeneity issues which may show up when current explanatory variables are used in the empirical model. Finally, two of the formulations studied in this paper are nonlinear. We choose this setup as it allows us to investigate the asymmetry in reactions of budget components to business cycle conditions. Further, these nonlinear features help to assess the presence of policy persistence since, as noted by Perron (1989), evidence of a persistent process may arise simply as a result of ignoring important sources of nonlinearity.

The basic regression model can be written as

$$X_t = \alpha + \beta_1 X_{t-1} + \beta_2 d_{t-1} + \beta_3 w_{t-1} + \varepsilon_t, \tag{3.1}$$

where X_t is the ratio of the budget components (tax revenues X_t^R or primary expenditure X_t^G) to gross domestic product (GDP) at date t, d_{t-1} is the ratio of federal debt to GDP at date

[27] Afonso, Agnello and Furceri (2010) provided empirical evidence of fiscal policy persistence in a cross-country study.

$t-1$, and w_{t-1} is the output gap at date $t-1$.[28] In the tables and discussion below, we will often refer to this model as the linear model or LM for short.

The various anticipated signs for the parameters have been discussed in various places in the literature. For instance, following the arguments in Cassou et al. (2015), sustainability of fiscal policy should be marked by negative values of β_2 when $X_t = X_t^G$, and positive values of β_2 when $X_t = X_t^R$.[29] Intuitively for primary expenditure regression a negative value for β_2 indicates that as lagged debt increases, policy makers take action to reduce spending X_t^G, and for tax revenues regression a positive value for β_2 indicates that as lagged debt increases, policy makers take action to increase tax revenues X_t^R. Also, as noted in Balassone et al. (2010), the sign of β_3 depends on whether policy is procyclical or countercyclical. For primary expenditure regression a positive value, corresponds to a procyclical policy, where higher values of the lagged output gap are accompanied by higher government spending, while a negative value corresponds to a countercyclical policy. Conversely, for tax revenues regression a positive value corresponds to a countercyclical policy, where higher values of the lagged output gap are accompanied by higher tax revenues, while a negative value corresponds to a procyclical policy.

Part of our empirical focus will be on a popular asymmetry hypothesis in which the policy variable, X_t, responds to the explanatory variables, differently, depending on whether the economy is strong or weak. To evaluate asymmetry, one approach is to replace the various

---

[28] Primary expenditure is government current expenditure net of interest payment.
There are alternative, but related, formulations used in the literature. For instance, Golinelli et al. (2008) focus on the cyclically-adjusted primary balance and prefer to use differenced levels as the dependent variable. Balassone et al. (2010) used the lagged value of the other budget items and the change in interest spending and its lagged level as other explanatory variables.

[29] To be more precise, Cassou et al. (2015) used the primary deficit (government spending net of interest payment minus government tax revenue) as their dependent variable. For their model, sustainability is associated with a negative coefficient for the lagged debt.

variables with two interaction terms in which a dummy indicating the strength of the economy at period $t-1$, I_{t-1}, is multiplied by each of the variables to get

$$\begin{aligned} X_t = {} & \alpha I_{t-1} + \beta_1 I_{t-1} X_{t-1} + \beta_2 I_{t-1} d_{t-1} + \beta_3 I_{t-1} w_{t-1} + \alpha'(1 - I_{t-1}) \\ & + \beta_1'(1 - I_{t-1}) X_{t-1} + \beta_2'(1 - I_{t-1}) d_{t-1} + \beta_3'(1 - I_{t-1}) w_{t-1} + \varepsilon_t, \end{aligned} \tag{3.2}$$

where $X_t = X_t^R$ or X_t^G, and I_{t-1} is given by

$$I_{t-1} = \begin{cases} 0 & \text{for } w_{t-1} \le w^T, \\ 1 & \text{for } w_{t-1} > w^T, \end{cases}$$

and w^T is referred to as the threshold value for the lagged output gap. This type of model is known as a Threshold Regression model and we will use the abbreviation TR to reference it from now on.

The parameters of (3.2) can provide evidence for a number of interesting policy questions. For instance, asymmetry in the response of the policy variable to economic conditions can be noted when $\beta_2 \neq \beta_2'$ or $\beta_3 \neq \beta_3'$. If $\beta_2 \neq \beta_2'$, then there is evidence that the budget component responds to lagged debt differently when the economy is doing well than when it is not, while if $\beta_3 \neq \beta_3'$, then there is evidence that the budget component responds to the lagged output gap differently when the economy is doing well than when it is not. It is also useful to note that (3.1) is nested in (3.2). So one can test whether the TR model fits better than the basic regression model by performing an F test on the null that $\alpha = \alpha'$, $\beta_1 = \beta_1'$, $\beta_2 = \beta_2'$, and $\beta_3 = \beta_3'$.

We also investigate the two state Markov Switching (MS) empirical model. These MS models use a nonlinear relationship between the primary balance and the explanatory variables given by

$$X_t = \alpha(s_t) + \beta_1(s_t)X_{t-1} + \beta_2(s_t)d_{t-1} + \beta_3(s_t)w_{t-1} + \sigma(s_t)u_t, \tag{3.3}$$

where u_t is a standard normal random variable and s_t denotes the unobservable regime or state variable featuring the reaction of the fiscal authority to both observables entering in its information set (X_{t-1} , d_{t-1} and w_{t-1}) and the fiscal shocks (u_t). This state variable has values of either 1 or 2 and follows a first-order two-state Markov process with transition matrix given by

$$P = \begin{pmatrix} p_{11} & 1-p_{22} \\ 1-p_{11} & p_{22} \end{pmatrix},$$

where the row j , column i element of P is the transition probability p_{ij} , which is the probability that state i will be followed by state j . Since the transition probabilities beginning in each state sum to 1, the off diagonal terms are given by $p_{12} = 1-p_{11}$ and $p_{21} = 1-p_{22}$.

The advantage of these MS models over the TR models is twofold. First, they allow changes in the size of shocks during the sample period. Second, they allow the interaction of fiscal policy asymmetries with changes in shock volatility.

3.3 Empirical Results

Our empirical analysis uses quarterly data for the U.S. economy from the first quarter of 1955 to the third quarter of 2013 which are obtained from the Federal Reserve Bank of St. Louis data set.

The tax revenues series was obtained by dividing 100 times the federal government current receipts (FGRECPT) by the nominal GDP series (GDP). The primary expenditure series was obtained by dividing 100 times the federal government current expenditures (FGEXPND) minus federal government interest payments (A091RC1Q027SBEA) by the nominal GDP series (GDP). For the debt variable, we used the total public debt series (GFDEBTN) and divided it by the nominal GDP (GDP) series.[30]

For the output gap, we computed the difference between the observed annual growth rate and the average annual growth rate. In particular, we computed the growth rate in percentage terms by multiplying 100 times the log difference between the current value of real GDP (GDPC1) and the value four quarters earlier. Next these growth rates were averaged and then the average was subtracted from the annual growth rate series to give a series that has positive values when the current growth rate exceeds the average and negative values when the growth rate is below the average.[31]

---

[30] The Federal Reserve Bank of St. Louis only has quarterly debt data from 1966:01 to the present, so to get the additional 11 years back to 1955:01, we used data from the US treasury which can be found at http://www.treasurydirect.gov/govt/reports/pd/mspd/mspd.htm.

[31] As noted in Cassou et al. (2015), we choose the output gap definition described above over the output gap based on the HP filter for two main reasons. First, the use of the HP output gap introduces an endogeneity issue in the estimation of our empirical fiscal reaction function since the HP filter is a two-sided filter. Second, the interpretation of the empirical fiscal equation as a fiscal reaction function become dubious when the HP output gap is a regressor since the HP output gap uses, by construction, much more information on GDP than the one available for the policy maker at the time of fiscal policy implementation.

Table 3.1 and Table 3.2 summarize the results for the various empirical models for the tax revenues and the primary expenditure, respectively. The first column of the Tables describes various parameter possibilities that the different models may take as well as a row for the threshold value for the TR models. As is common in such empirical results, many of the parameters are specific to particular models that were estimated. Also, to save space, results for the constant terms are not reported.[32]

We use the "AT" and "BT" shorthand when describing TR model estimates to indicate parameter estimates when the threshold variable is above the threshold and below the threshold, respectively. We also list the parameters for the MS models in the same rows as the TR models even though the models, and thus the model parameters, have quite different interpretations. We made this choice to save space in reporting our results, but would like to take a moment to clearly spell out the different interpretations for the parameters to avoid confusion. Table 3.1 and Table 3.2 show that we grouped the above threshold parameters for the TR models with the state 1, s_1, parameters for the MS models and the below threshold parameters for the TR models with the state 2, s_2, parameters for the MS models. Although there is some logic to grouping these parameters as we have, there are also important differences. For the TR models, the AT parameters are the values for the linear portion of the model when the output gap is observed to be above the threshold, while for the MS model, the s_1 parameters are the values for the linear portion of the model when the unobserved state variable is in regime 1. Similarly, for the TR models, the BT parameters are the values for the linear portion of the model when the output gap is observed to be below the threshold, while for the MS model, the s_2 parameters are the values for the linear portion of the model when the unobserved state variable is in regime 2.

[32] Complete tables with all the constant terms can be obtained upon request.

The second column presents the results of the basic regression model given by (3.1), which was run using OLS. This model has no threshold, so the first row is left blank as are many of the later rows which correspond to parameters from alternative models. The remaining columns of the tables present various nonlinear models in which the dependent variable is a nonlinear function of the various economic variables.[33]

Column 3 presents the estimates for the TR model which uses the lagged output gap as the threshold variable and is analogous to the Balassone et al. (2010) model in that the threshold value is arbitrarily set to 0, hence the TR-0 notation. The fourth column presents the estimates for a TR model in which the threshold is endogenously chosen so as to obtain the best fit. We distinguish it by using the TR-E notation. The fifth column shows the parameter estimates for the two-state MS formulation. Finally, toward the bottom of the tables are various measures of fit, which are used for comparison purposes with the alternative models.

First we focus on Table 3.1 which shows the results for the various empirical models where the dependent variable is the tax revenues. LM model finds that the coefficient of the lagged dependent variable is somewhat less than 1 and is highly significant, showing evidence of a highly persistent fiscal rule. The lagged debt coefficient is positive and insignificant and the lagged output gap coefficient is positive and significant. Even though it is insignificant, the positive sign on the lagged debt coefficient is useful to note because, as emphasized by Cassou et al. (2015), Collignon (2012) , and others, a positive value for the lagged debt coefficient in tax revenues regression can be viewed as being consistent with a sustainable fiscal policy. In particular, high values of debt imply higher tax revenues values, which result in a decrease in the

[33] It is useful to emphasize that although the TR models are linear in the interaction terms denoted in equation (3.2), they are nonlinear in the economic variables.

debt level the following period. Next note that the positive coefficient on the lagged output gap indicates that the reactions of tax revenues to economic conditions are countercyclical.

Looking down column 3 of Table 3.1, we see that when the economy was both above and below potential output in the previous period (i.e. both above and below the threshold value of zero), the lagged tax revenues coefficients are highly significant and close to one. We also see that the lagged debt coefficient is positive and insignificant when the lagged output gap was above potential and negative and insignificant when the economy was below potential. Furthermore, the lagged output gap coefficients are negative when the economy was above and positive when the economy was below potential in the previous period, but only the below potential coefficient is significant.

The coefficients on the lagged debt and output gap variables provide insight into how fiscal policy makers behave. In particular, the positive lagged debt coefficient during above threshold values implies that tax revenues increase in response to an increase in debt to GDP ratio when the economy is doing well, while the negative lagged debt coefficient during below threshold values could be interpreted as showing that policy makers are more concerned with getting the economy back on track and therefore they cut taxes in favor of trying to revive the economy. To some extent, this interpretation is consistent with ideas developed in Cassou et al. (2015), where they noted that during times of distress policy makers temporarily forgo fiscal policy sustainability (i.e. a long-term goal) in favor of trying to revive the economy back to a situation with higher-than-average output growth rates (i.e. a short-term priority), at which time they then follow a sustainable fiscal policy program.[34]

A similar asymmetric contingent interpretation can be made for the lagged output gap coefficients. In particular, the larger (in absolute value) and significant coefficient during the below threshold case shows that policy makers are more focused on getting the economy on track during downturns by cutting taxes more severely than good times, where the coefficient is somewhat smaller (in absolute value) and is insignificant. This interpretation is consistent with the asymmetric fiscal policy result found in Balassone et al. (2010) for a sample of fourteen European Union countries, and found in Cassou et al. (2015) for U.S. economy.[35]

[34] Their result shows during economics good times (above threshold) primary balance (government primary expenditure - government tax revenues) declines in response to an increase in debt to GDP ratio while during economic bad times (below threshold) primary balance increases in response to an increase in debt to GDP ratio.
[35] Balassone et al. (2010) and Cassou et al. (2014) both show a strong countercyclical response when economic conditions are poor.

Table 3.1: Federal Government Tax Revenues (1955:1 - 2013:3)

	LM	TR-0	TR-E	MS
Threshold		0	-1.957	
Lagged Tax Revenues	0.902** (0.027)			
Lagged Debt	0.001 (0.002)			
Lagged Output Gap	0.036** (0.012)			
Lagged Tax Revenues - AT or s_1		0.938** (0.041)	0.935** (0.030)	0.993** (0.030)
Lagged Tax Revenues - BT or s_2		0.825** (0.042)	0.621** (0.070)	0.733** (0.096)
Lagged Debt - AT or s_1		0.0008 (0.003)	0.002 (0.002)	0.0005 (0.001)
Lagged Debt - BT or s_2		-0.001 (0.002)	-0.015** (0.004)	0.0012 (0.006)
Lagged Output Gap - AT or s_1		-0.006 (0.033)	0.015 (0.020)	0.016 (0.014)
Lagged Output Gap - BT or s_2		0.072** (0.025)	0.067 (0.051)	0.072 (0.051)
1st-regime volatility $\sigma(s_1)$				0.137** (0.021)
2nd-regime volatility $\sigma(s_2)$				0.752** (0.094)
p_{11}				0.975** (0.008)
p_{22}				0.843** (0.024)
RSS	45.958	44.38	41.607	
AIC	907.518	907.307	892.142	
SBC	921.356	934.984	919.819	
log-likelihood				-23.355
Null 1: F-Stat		2.018	5.935**	

Notes: Standard errors in parentheses. One asterisk indicates significance at the 10% level, while two asterisks indicate significant at the 5% level. AT and BT stand for above threshold and below threshold respectively.

The various fit parameters toward the bottom of the table show that the TR-0 model fits better than the simple LM model and the null hypothesis that there is no improvement in the fit, as indicated by the row labeled F-Stat, shows an F-statistic of 2.018, which is less than the 5% critical value of 2.371, and thus cannot be rejected.

The fourth column of Table 3.1 shows that the best fitting threshold for this model occurs at a lagged output gap value of -1.957 which is somewhat lower than the zero threshold used in the TR-0 model. The parameter estimates for this model are largely the same as those for the zero threshold model and can be interpreted as showing the same asymmetric behavior for government tax revenues. In particular, the lagged debt coefficients provide some evidence that tax revenues increase in response to an increase in debt to GDP ratio in good times, but show that tax revenues significantly decrease during bad times. This result is similar to the interpretation provided in Cassou et al. (2015) that concerns toward improving the economy overwhelm sustainability concerns in bad times. Similarly, the positive coefficients on the lagged output gap for both above and below the threshold values show that tax revenues react in a countercyclical fashion. Furthermore, these reactions are asymmetric in that there is a greater level of intervention during economic downturns. However, we should qualify this conclusion by noting that the insignificant value for both output gap coefficients does weaken this interpretation. Finally, looking at the various measures of fit at the bottom of the fourth column we see that the endogenous threshold TR model fits somewhat better than the zero threshold TR model. The test that this model fits no better than the LM model, has an F-statistic of 5.935, which is larger than the 5% critical value of 4.1174, and thus is easily rejected.[36]

The fifth column of Table 3.1 shows the parameter estimates for the two-state MS model when dependent variable is the tax revenues. Before describing the estimation results, it is useful

[36] The critical value of 4.122 does not come from a conventional F distribution table. We computed this number by using a bootstrap simulation procedure described in Hansen (1997) which showed that the F-statistic in TR models do not have F distributions and that proper critical values can be found using a bootstrap procedure.

to study Figure 3.1 in order to understand how to interpret the two-state conditions. Figure 3.1 shows the smoothed state 1 probability for the MS model.[37]

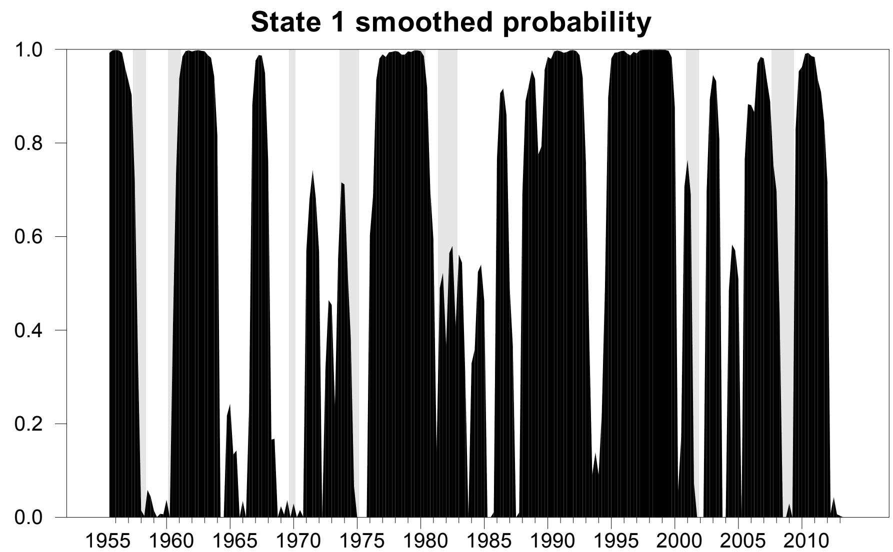

Figure 3.1: Two-State MS Model (Tax Revenues)

Focusing on the boom economic period of the 1990s, one can see that the probability of being in state 1 is very high. Similarly, during the boom period of the mid 2000s, Figure 3.1 shows a high probability of being in state 1. These high probabilities for state 1 during good economic times show that we can say that state 1 is generally associated with good economic times and correspondingly, state 2 is generally associated with poor economic times. Moreover, state 1 is also strongly associated with the Great Moderation period, which is characterized by low volatility.[38]

[37] The smoothed probabilities are computed using the information over the whole sample of size T (i.e., prob[s_{t}=1|I_{T}]) as discussed in Hamilton (1994, p. 694). Moreover, Figure 3.1 and Figure 3.2 below show the smoothed probabilities along with various business cycle turning points which have been dated by the NBER.

[38] The precise dating for the Great Moderation is the subject of debate, but many studies, such as Stock and Watson (2002), have suggested this low volatility period starts around 1984. Furthermore, although the debate is still open, the end of this low volatility period likely ended with the financial crisis in late 2007.

Now focusing on the parameter estimates we see that the lagged balance coefficients are near 1 and significant in both states. The response to lagged debt shows positive and insignificant coefficients for both states, with the responses during bad times or state 2 being a bit larger. The response of tax revenues to the lagged output gap is positive for both states which shows countercyclical behavior with the higher value for state 2 compare to state 1 which implies stronger responses in economic bad times and therefore shows asymmetric reactions to the lagged output gap. However, the insignificant values for both coefficients weaken this interpretation. Moreover, the volatility of innovations in state 1, $\sigma(s_1)$, is roughly five times lower than the volatility of innovations in state 2, $\sigma(s_2)$. It is important to keep in mind this changing volatility feature uncovered by the MS formulation when comparing the estimation results obtained from the two approaches because the TR formulation assumes, in contrast to the MS formulation, an identical level of innovation volatility both above and below the threshold level.

Finally let us comment a bit on the parameters for the transition probabilities. Focusing on the MS model, we see that probability of staying in state 1 if one begins in state 1, p_{11}, is very high at 0.975, while the probability of staying in state 2 if one begins in state 2, p_{22}, is smaller at 0.843. These estimates show that there is high persistence for both states, with the persistence during good times being larger.

Next we focused on Table 3.2 which shows the results for the various empirical models where the dependent variable is the government primary expenditure. The LM finds the lagged dependent variable is close to 1 and is highly significant, showing evidence of a highly persistent expenditure, the lagged debt coefficient is negative and insignificant. Although it is insignificant, the negative value for the lagged debt coefficient in primary expenditure regression can be viewed as being consistent with a sustainable fiscal policy, as emphasized by Cassou et al. (2015). In particular, high values of debt imply lower primary expenditure values, which result in a decrease in the debt level the following period. The lagged output gap coefficient is negative and significant implying that the behavior of primary expenditure is countercyclical.

Column 3 of Table 3.2 also shows that when the economy was both above and below potential output in the previous period, the lagged primary expenditure coefficients are highly significant and close to one. The lagged debt coefficient is negative and insignificant when the economy was above potential and positive and insignificant when the economy was below potential. Furthermore, the lagged output gap coefficients are negative when the economy was both above and below potential in the previous period, but only the below potential coefficient is significant.

To be more precise, the negative lagged debt coefficient during above threshold values implies that policy makers decline government expenditure in response to an increase in debt to GDP ratio when the economy is doing well, while the positive lagged debt coefficient during below threshold values could be interpreted as showing that policy makers are more concerned with getting the economy back on track and therefore they increase government expenditure in favor of trying to revive the economy. This interpretation is also consistent with the ideas developed in Cassou et al. (2015).

Table 3.2: Federal Government Primary Expenditure (1955:1 - 2013:3)

	LM	TR-0	TR-E	MS
Threshold		0	1.163	
Lagged Primary Expenditure	0.950**			
	(0.015)			
Lagged Debt	-0.001			
	(0.001)			
Lagged Output Gap	-0.062**			
	(0.010)			
Lagged Primary Expenditure - AT or s_1		0.928**	0.873**	0.972**
		(0.027)	(0.040)	(0.018)
Lagged Primary Expenditure - BT or s_2		0.950**	0.947**	0.948**
		(0.020)	(0.018)	(0.028)
Lagged Debt - AT or s_1		-0.003	-0.012**	-0.0055
		(0.003)	(0.005)	(0.002)
Lagged Debt - BT or s_2		0.001	0.001	0.002
		(0.002)	(0.017)	(0.003)
Lagged Output Gap - AT or s_1		-0.032	-0.037	-0.113**
		(0.027)	(0.036)	(0.014)
Lagged Output Gap - BT or s_2		-0.090**	-0.085**	-0.028*
		(0.019)	(0.015)	(0.020)
1st-regime volatility $\sigma(s_1)$				0.094**
				(0.011)
2nd-regime volatility $\sigma(s_2)$				0.439**
				(0.048)
p_{11}				0.977**
				(0.016)
p_{22}				0.874**
				(0.026)
RSS	27.043	26.219	25.656	
AIC	782.896	783.622	778.523	
SBC	796.735	811.299	806.199	
log-likelihood				0.024
Null 1: F-Stat		1.784	3.068	

Notes: Standard errors in parentheses. One asterisk indicates significance at the 10% level, while two asterisks indicate significant at the 5% level. AT and BT stand for above threshold and below threshold respectively.

A similar asymmetric interpretation can be made for the lagged output gap coefficients. In particular, the larger (in absolute value) and significant coefficient during the below threshold case shows that policy makers are more focused on getting the economy on track during downturns by increasing primary expenditure more severely in bad times. However, during good times, they mute the economic booms slowly by decreasing primary expenditure where the coefficient is somewhat smaller (in absolute value) and is insignificant. This interpretation is also consistent with the asymmetric fiscal policy result found in Balassone et al. (2010) and Cassou et al. (2015). The various fit parameters toward the bottom of the table show that the TR-0 model fits better than the simple LM model and the null hypothesis that there is no improvement in the fit, shows an F-statistic of 1.784, which is less than the 5% critical value of 2.371, and thus cannot be rejected.

The fourth column of Table 3.2 shows that the best fitting endogenous threshold model is achieved at the lagged output gap value of 1.163 which is somewhat higher than the zero threshold used in the TR-0 model. The parameter estimates for this model are largely the same as those for the zero threshold model and can be interpreted as showing the same asymmetric and countercyclical behavior for government primary expenditure. In particular, the lagged debt coefficients provide some strong evidence that policy makers decline primary expenditure in response to an increase in debt to GDP ratio in good times, but show that during bad times they increase primary expenditure in order to revive the economy which is similar to the interpretation provided in Cassou et al. (2015). Coefficients for lagged output gap also provide evidence of countercyclical reactions of primary expenditure to the economy. Furthermore, these reactions are asymmetric in that there is a greater level of intervention during economic downturns. Finally, looking at the various measures of fit at the bottom of the fourth column we see that the endogenous threshold TR model fits somewhat better than the zero threshold TR model. The test that this model fits no better than the LM model, as indicated by the row labeled F-Stat, has an F-statistic of 3.068, which is not larger than the 5% critical value of 4.1168, and thus cannot be rejected.

Before describing the estimation results for two-state MS model, it is useful to study Figure 3.2 in order to understand how to interpret the two-state conditions. Unlike the model for tax revenues where State 1 is generally lined up with the boom periods and state 2 is generally lined up with recessions, Figure 3.2 does not clearly determine which states is associated with good times and which one is associated with bad times. In particular, looking at Figure 3.2, we see that the probability of being in state 2, not only is high in recession periods, but also is high in some of the boom periods. In fact one of the characteristics of MS model is that the state variable, unlike TR models, is unobservable. Therefore, MS model assigns the observations to each state in a way that obtains the best fit, not necessarily in a way that clearly separates economic good times from economic bad times like what we observed in TR models. Therefore, the interpretations for these coefficients are not quite the same as described for the TR models. However, looking at Figure 3.2 more carefully, we see that state 2 is largely associated with the periods prior to 1980s, late 1990s, late 2000s, and early 2010s which are generally lined up with the periods when democratic parties dominated the political scene, while state 1 is largely lined up with the periods when conservative parties were dominating.

Now focusing on the parameter estimates we see that the lagged dependent variable coefficients are near 1 and significant in both states. The response to lagged debt is asymmetric, showing a negative and insignificant coefficient during state 1, but a positive and insignificant coefficient during state 2. The response to the lagged output gap is negative in both states, it is highly significant in state 1, but marginally significant in state 2. Moreover, the volatility of innovations in state 1, $\sigma(s_1)$, is roughly four times lower than the volatility of innovations in state 2, $\sigma(s_2)$.

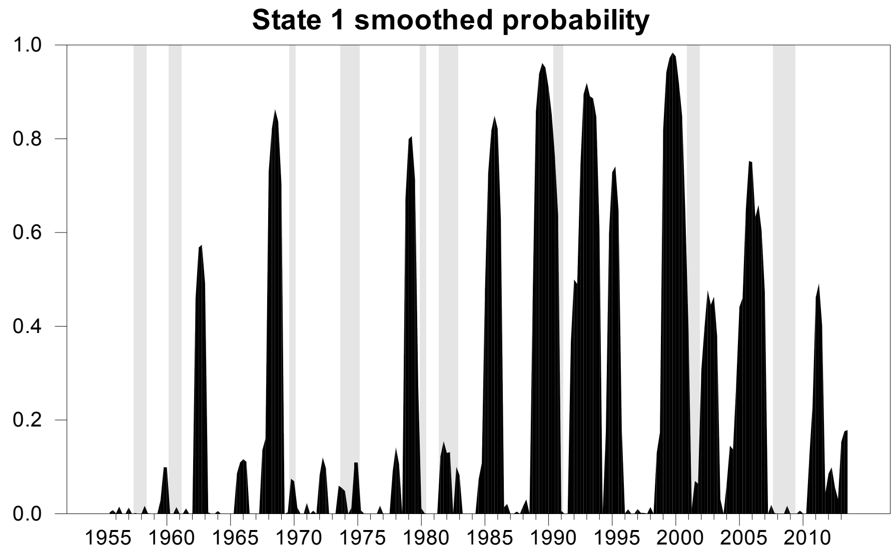

Figure 3.2: Two-State MS Model (Primary Expenditure)

Since state 1 is generally associated with the Republican dominating periods and state 2 is roughly associated with the Democratic dominating periods, one interpretation for the parameters estimate is that government expenditure tends to decrease in response to an increase in debt to GDP ratio in state 1, while it is likely to increase in state 2. Furthermore, the negative and significant response to lagged output gap for both states with the larger value (in absolute value) in state 1 implies the higher level of intervention in state 1.

Finally, it is useful to recall that our main purpose is to investigate the asymmetry in reaction of each budget component to debt level and economic conditions over the cycle. Therefore, according to the results for expenditure regression, MS model is not as useful as it was for tax revenue regression since it cannot clearly separate economic good times from bad times. Hence, one can conclude that when dependent variable is government expenditure, TR models provide a better interpretation for our goal than MS model.

Let us conclude this section with a brief summary of the key findings. In general, we found that there was a sequence of improvements in the fit and performance of the models presented. While the linear model exhibited desirable properties, such as debt sustainability and countercyclical behavior, it did not fit as well as the TR models and the MS models which allowed asymmetric behavior on the part of policy makers. However the TR and MS models showed their own weaknesses. For instance, they did not show debt sustainability during weak economic times. This behavior is interpreted as reasonable as it shows that during weak economic times policy makers are more concerned with getting the economy back on track. Furthermore, while the MS model for tax revenues showed somewhat symmetric and countercyclical responses to lagged debt and lagged output gap in both regimes, the MS model for government expenditure showed asymmetric responses to lagged debt and lagged output gap. However, it is useful to note that the interpretation of two regimes were not completely consistent in these to estimations. In particular, in MS model for tax revenues state 1 was generally associated with economic good times and state 2 was associated with bad time. This interpretation was in line with the purpose of this paper as it allowed us to study the reactions of tax revenues to different variables depending on the strength of economy. However, the MS model for government expenditure did not necessarily assign the observation into each state in a way which aligns with our purpose. Therefore, one can conclude that the TR models are the best way to model the reactions of government expenditure.

3.4 Conclusion

This paper extends the analysis in Cassou et al. (2015) to investigate whether the two major components of the U.S. fiscal budget exhibit asymmetric behavior in their reaction to debt levels and economic conditions over the business cycle. These budget components include tax revenues and the primary expenditure.

Both budget components exhibit these asymmetries, but the asymmetries for tax revenues show greater statistical significance. In addition, these results are somewhat weaker than those in Cassou et al. (2015). In particular, we find coefficient values that show asymmetries, but these coefficients are often statistically insignificant. The response of tax revenues to debt levels during good economic times are positive showing a policy concern for the high debt, but during poor times are negative showing a stronger policy concern for getting the economy back on track. Similar results, yet opposite in sign, are found for expenditures. Regarding fiscal policy sustainability, these findings show sustainability only during good times.

Regarding the cyclicality of the reactions, our analysis found robust evidence that both budget components are countercyclical to economic condition. Moreover, most of the models show that these countercyclical reactions are asymmetric over the business cycle in that there is a greater level of intervention during economic downturns.

References

Afonso, A., Agnello, L., and Furceri, D. 2010. Fiscal policy responsiveness, persistence, and discretion. Public Choice 145, 503-530.

Aruoba, B.S. 2008. Data revisions are not well-behaved. Journal of Money, Credit and Banking 40, 319-340.

Balassone, F., Francese, M., and Zotteri, S. 2010. Cyclical asymmetry in fiscal variables in the EU. Empirica 37, 381-402.

Barro, R., and Gordon, D. 1983. A positive theory of monetary policy in a natural rate model. Journal of Political Economy 91, 589-610.

Bohn, H. 1998. The behavior of U.S. public debt and deficits. The Quarterly Journal of Economics 113, 949-963.

Bohn, H. 2007. Are stationarity and cointegration restrictions really necessary for the intertemporal budget constraint? Journal of Monetary Economics 54, 1837-1847.

Cassou, S.P., Scott, C.P., and Vázquez, J. 2012. Optimal monetary policy with asymmetric preferences for output. Economics Letters 117, 654-656.

Cassou, S.P., Shadmani, H., and Vázquez, J. 2015. Fiscal policy asymmetries and the sustainability of U.S. government debt revisited.

Collignon, S. 2012. Fiscal policy rules and the sustainability of public debt in Europe. International Economic Review 53, 539-567.

Croushore, D. 2011. Frontiers of real-time data analysis. Journal of Economic Literature 49, 72-100.

Davig, T. 2005. Periodically expanding discounted debt: A threat to fiscal policy sustainability? Journal of Applied Econometrics 20, 829-840.

Galí, J., and Gambetti, L. 2009. On the sources of the Great Moderation. American Economic Journal: Macroeconomics 1, 26-57.

Golinelli, R., and Momigliano, S. 2008. The cyclical response of fiscal policies in the Euro area. Why results of empirical research differ so strongly? Banca d'Italia Temi di Discussione 654.

Enders, W. 2010. Applied Econometrics Time Series. Wiley (3rd Edition).

Filardo, A.J. 1994. Business-cycle phases and their transitional dynamics. Journal of Business and Economic Statistics 12, 299-308.

Francq, C., and Zakoïan, J.M. 2001. Stationarity of multivariate Markov-switching ARMA models. Journal of Econometrics 102, 339-364.

Hakkio, C.S. and Rush, M. 1991. Is the budget deficit too large? Economic Inquiry 24, 429-445.

Hamilton, J.D. 1989. A new approach to the economic analysis of nonstationary time series and the business cycle. Econometrica 57, 357-384.

Hamilton, J.D. 1994. Time series analysis. New Jersey: Princeton University Press.

Hamilton, J.D., and Flavin, M.A. 1986. On the limitations of government borrowing: A framework for empirical testing. American Economic Review 76, 808-819.

Hansen, B. 1997. Inference in TAR models. studies in nonlinear dynamics and econometrics 2, 1-14.

Ireland, P.N. 1999. Does the time-consistency problem explain the behavior of inflation in the United States? Journal of Monetary Economics 44, 279-291.

Kim, C.J., and Nelson, C.R. 1999. Has the U.S. economy become more stable? A Bayesian approach based on a markov-switching model of the business cycle. Review of Economics and Statistics 81, 608-616.

Kremers, J.M. 1989. U.S. Federal indebtedness and the conduct of fiscal policy. Journal of Monetary Economics 23, 219-238.

McConnell, M.M., and Pérez-Quirós, G. 2000. Output fluctuations in the United States: what has changed since the early 1980s? American Economic Review 90, 1464-1476.

Nobay, R.A., and Peel, D.A. 2003. Optimal discretionary monetary policy in a model of asymmetric central bank preferences. Economic Journal 113, 657-665.

Perron, P. 1989. The great crash, the oil price shock, and the unit root hypothesis. Econometrica 57, 1361-1401.

Quintos, C.E. 1995. Sustainability of the deficit process with structural shifts. Journal of Business and Economic Statistics 13, 409-417.

Ruge-Murcia, F.J. 2003. Does the Barro-Gordon model explain the behavior of U.S. inflation? A reexamination of the empirical evidence. Journal of Monetary Economics 50, 1375-1390.

Ruge-Murcia, F.J. 2004. The inflation bias when the central bank targets the natural rate of unemployment. European Economic Review 48, 91-107.

Sorensen, B.and Yosha, O. 2001. Is state fiscal policy asymmetric over the business cycle? Economic Review 86, 43-64.

Stock, J., and Watson, M.W. 2002. Has the business cycle changed and why? in Gertler, M., and K.S. Rogoff (eds.) NBER Macroeconomics Annual, Cambridge, MA: MIT Press, pp. 159-218.

Smets, F., and Wouters, R. 2007. Shocks and frictions in U.S. business cycles: A Bayesian DSGE approach. American Economic Review 97, 586-606.

Surico, P. 2007. The Fed's monetary policy rule and U.S. inflation: The case of asymmetric preferences. Journal of Economic Dynamics and Control 31, 3305-324.

Teräsvirta, T. 1994. Specification, estimation and evaluation of smooth transition autoregressive models. Journal of the American Statistical Association 89, 208-218.

Trehan, B., and Walsh, C. 1988. Common trends, the government budget constraint, and revenue smoothing. Journal of Economic Dynamics and Control 12, 425-444.

Appendix A. Full Version of Table 1.2

Table A.1: Variations on the Second Interval Sample Period

		Surico	1982:4	1983:1	1983:2	1983:3	1983:4	1984:1	1984:2	1984:3	1984:4	1985:1	1985:2	1985:3	1985:4
Results for start period given and ending in 2003:2															
	c_1	0.89**	0.603*	0.523	0.408	0.350	0.714*	0.930**	1.005**	1.024**	0.976**	0.889**	0.902**	0.902**	0.915**
PCE	c_2	0.17**	0.123**	0.115**	0.099**	0.095**	0.139**	0.174**	0.190**	0.194**	0.193**	0.140**	0.136**	0.128**	0.127**
Inf	c_3	-0.11	-0.085	-0.069	-0.049	-0.034	-0.093	-0.122*	-0.129*	-0.131**	-0.119**	-0.125**	-0.130^**	-0.133**	-0.136**
	c_4	-0.01	0.006	-0.009	0.016*	0.007	-0.035	-0.056**	-0.066**	-0.066**	-0.065**	-0.057**	-0.057**	-0.058**	-0.059**
	c_1	2.23	0.688	0.608	0.399	0.300	0.692	0.951*	1.048*	1.183**	1.192**	0.941*	0.933*	0.921*	0.934*
GDP	c_2	0.09	0.105*	0.096*	0.080*	0.072	0.110*	0.148**	0.172**	0.180**	0.180**	0.134**	0.136**	0.129**	0.130**
Inf	c_3	-0.41	-0.121	-0.104	-0.059	-0.037	-0.103	-0.137	-0.148	-0.174*	-0.174*	-0.151	-0.146	-0.146	-0.149
	c_4	-0.02	0.008	-0.010	0.014	0.012	-0.024	-0.048**	-0.060**	-0.060**	-0.061**	-0.048**	-0.048**	-0.049**	-0.049**
Results for start period given and ending in 2007:4															
		Surico	1982:4	1983:1	1983:2	1983:3	1983:4	1984:1	1984:2	1984:3	1984:4	1985:1	1985:2	1985:3	1985:4
	c_1	0.89**	0.696*	0.610	0.496	0.438	0.681*	0.746**	0.781**	0.779**	0.727**	0.816**	0.855**	0.879**	0.903**
PCE	c_2	0.17**	0.132**	0.127**	0.119**	0.113**	0.127**	0.135**	0.142**	0.143**	0.143**	0.125**	0.126**	0.120**	0.119**
Inf	c_3	-0.11	-0.103	-0.083	-0.058	-0.046	-0.100	-0.114*	-0.121*	-0.121*	-0.110*	-0.130**	-0.137**	-0.143**	-0.148**
	c_4	-0.01	0.008	0.012	0.019*	0.011	-0.020	-0.031*	-0.039**	-0.038**	-0.037**	-0.041**	-0.043**	-0.045**	-0.046**
	c_1	2.23	0.680	0.624	0.410	0.315	0.639	0.740	0.738	0.828	0.769*	0.746	0.745	0.753	0.778*
GDP	c_2	0.09	0.123**	0.118**	0.102**	0.093**	0.109**	0.118**	0.128**	0.131**	0.127**	0.121**	0.123**	0.119**	0.119**
Inf	c_3	-0.41	-0.111	-0.097	-0.049	-0.028	-0.101	-0.124	-0.126	-0.146	-0.136	-0.127	-0.125	-0.126	-0.132
	c_4	-0.02	0.009	0.012	0.016	0.015	-0.016	-0.028	-0.037**	-0.035**	-0.033**	-0.035**	-0.035**	-0.037**	-0.037**

Notes: One asterisk indicates significance at the 10% level, while two asterisks indicate significant at the 5% level.