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Essays In Fiscal Policy

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DEDICATION

For my wife, Briget,

Who supported me unconditionally

Throughout this process and sacrificed much

To ensure its completion.

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CHAPTER 1: INTRODUCTION

1.1 The return of fiscal policy

Fiscal policy has not been a research priority in macroeconomics during the last quarter century. The primacy of monetary policy and the fiscal stability of the Great Moderation turned the focus of researchers in other directions. However, it is clear that fiscal policy is once again drawing the attention of macroeconomists, and for good reason. The twenty-first century began with substantial modifications to the U.S. tax code, commonly referred to as the Bush tax cuts: the Economic Growth and Tax Relief Reconciliation ACT of 2001 (EGTRRA) and the Jobs and Growth Tax and Relief and Reconciliation Act of 2003 (JGTRRA). In addition to substantial reductions in marginal tax rates, the policy mix included both short-term stimulus such as income tax rebates, as well as reductions in capital gains taxes and changes to depreciation and retirement exemptions that affect the economy over longer time horizons. The alphabet soup of fiscal policy initiatives continued with the federal response to the financial crisis and subsequent recession of 2007-2009, highlighted by the ARRA (American Recover and Reinvestment Act of 2009). The case for countercyclical fiscal policy like the ARRA is perhaps strengthened by the current interest rate environment, which has witnessed short-term rates continuing to hover near the zero lower bound years after the end of the Great Recession. As of the middle of 2012, recovery.gov, a government website created under the Act to track the initiative’s progress, indicated that $757.5 billion of an estimated $840 billion had been distributed in the form of myriad tax benefits, contracts, grants, loans and entitlements.

After the U.S. economy’s sluggish emergence from the Great Recession in June of 2009, the focus of fiscal policymakers turned to the issue of long-run solvency and debt stabilization.

As reported in the Economic Report of the President 2012, the U.S. federal budget deficit was $1.3 trillion in 2011. By the end of 2013 the gross debt to GDP ratio exceeded 100%, a level not seen since the aftermath of World War II. Long-run projections are not any rosier: under current law, spending on the major federal health care programs alone will grow from more than 5 percent of GDP today to almost 10 percent in 2037, and will continue to increase thereafter (Congressional Budget Office, 2012 Long-Term Budget Outlook). Simply put, the current fiscal path is unsustainable. In the near term, the stage is set for continued discussion over the future of American fiscal policy as policymakers wrestle with sequesters, fiscal cliffs, debt ceilings, and the need to balance potentially conflicting policy goals: reaching maximum employment in the short run while formulating responsible tax and spending regimes in the medium to long run.

Fiscal policy is also prominent from a global perspective, as a protracted period of fiscal strain continues to affect the European continent. Mounting debt and reduced revenues forced euro zone countries Greece, Ireland, Portugal, and Cyprus to seek bailouts. European Union policymakers have faced the same fundamental quandary as their American counterparts, forced to choose between limiting spending and attacking tepid growth figures. In 2013, for the first time since 2008, the euro zone brought combined deficits in line with the target level of 3% of GDP. The merits of austerity have been vigorously debated as inflation remains low and output growth weak as of this writing.

The above described chain of events has led to a renewed interest in understanding the effects of changes in taxes, spending, and the financing of government debt on economic aggregates. How effective are stimulus programs likely to be? What are the long-run consequences of debt financing when it ultimately leads to increased distortionary taxation? The focus of this investigation will be on making a contribution to the growing body of fiscal policy literature by seeking answers to questions such as these.

1.2 The dynamics of fiscal financing with non-Ricardian household behavior

In chapter three I present a theoretical model designed to study fiscal policy in an environment that allows for household heterogeneity. I build from the foundation laid by Leeper, Plante, and Traum (2010), henceforth LPT, by using a neoclassical growth model to estimate rich fiscal policy rules, including non-trivial debt dynamics. The model includes a detailed fiscal specification in which income, capital and consumption taxes, government spending, and transfer payments all may adjust to stabilize debt. The original model can be viewed as an estimated analog to the calibrated exercise of Uhlig (2010). One opportunity presented by the LPT model is that only fully rational agents are considered. Therefore, exogenous changes to transfers have no effect on agents' consumption and saving decisions. Thus, as LPT point out, the only way in which the model is able to match certain correlations in the data is if transfers respond to endogenous variables. Of most concern is the negative correlation between transfers and debt that exists in the data, which can only be reproduced if transfers respond to debt. As a result of this feature, there is an innate preference for transfer financing. I attempt to fill this gap in the literature by considering a similar dynamic stochastic general equilibrium (DSGE) model containing both rational "savers" and non-Ricardian "spenders". Authors have used various terms to describe consumers that behave in a non-Ricardian fashion, including *rule-of-thumb* or *hand-to-mouth*. This extension of the literature is attractive because it still allows for expectations about policy rules to influence the path of the economy while ameliorating the inherent bias toward one particular fiscal instrument. It has the additional virtue of accurately reflecting the microeconomic realities regarding consumption.

Specifically, there is a growing body of evidence that suggests the assumption of perfect rationality and intertemporal optimizing behavior is unrealistic if applied to all consumers.

Two labor supply specifications are considered in chapter three. In the first specification, I place a restriction on hours worked so that labor supply is the same for both household types. This is done to mimic the behavior found in many medium-sized DSGE models that incorporate rule-of-thumb behavior. In the second specification, this restriction is relaxed by allowing non-Ricardian consumers to satisfy an intratemporal optimality condition. The model is fit to postwar U.S. data and estimated using Bayesian techniques. By incorporating the most recent U.S. data, the estimated parameters reflect information from one of the most salient periods of fiscal activity in the post war era. In addition to non-Ricardian behavior, the model features rich fiscal policy rules, endogenous debt evolution, distortionary taxation, and several real frictions found in medium-sized DSGE models.

I find that the inclusion of non-Ricardian households directly affects the value of the estimated parameters, the responses of macroeconomic aggregates to fiscal shocks, and the fiscal multipliers. Relative to the findings of LPT, capital and labor taxes become more important for debt stabilization while transfers play a smaller role. Capital taxes and transfers are found to be more important for output stabilization. In the restricted model, it is possible to generate a positive consumption multiplier in response to a government spending shock when the economy is populated by a large fraction of non-Ricardians, even in the absence of nominal rigidities or central bank intervention.

1.3 Anticipated Fiscal Policy

In recent times there has been much discussion in popular news outlets surrounding the impact of the debt ceiling, fiscal "cliffs", and sequesters, policy maneuvers that aim to encourage fiscally responsible legislation. In particular, how would the proposed changes in government spending affect the macro economy? From an academic perspective, which theoretical framework best explains these movements in macroeconomic aggregates? The fact these policy measures are made public and thoroughly discussed *before* they are implemented complicates any attempt to answer these questions. Changes to fiscal policy that emerge from a highly publicized debate are likely to be anticipated by agents to some extent. Legislation and implementation lags provide the necessary time for households to adjust their behavior to new policies before they take effect. Leeper, Walker, and Yang (2008) and Leeper, Richter, and Walker (2011) show that ignoring such anticipation effects can be troublesome for researchers, leading to a non-fundamental moving average component in structural vector autoregressions that misaligns the agents' and the econometrician's information sets.

Ramey and Shapiro (1997) tackled the fiscal foresight issue by examining a few salient military buildups that were likely to be anticipated. Their *narrative approach* relies on the fact that military spending is driven by events that are exogenous to the evolution of the domestic economy. This fact is exploited to identify government spending shocks in a vector autoregression (VAR) framework. Ramey (2011) extends this approach by chronicling military spending in popular news sources to create an extensive *fiscal news* time series that dates back to 1939. Ramey also uses Survey of Professional Forecasters (SPF) data in a similar manner to analyze more recent time periods. The narrative approach, also represented by Burnside, Eichenbaum, and Fisher (2004), Cavallo (2005), Edelberg, Eichenbaum, and Fisher (1999) and Eichenbaum and Fisher (2005) typically finds macro aggregates to behave much differently after a government spending shock. While most empirical estimates reveal a modest expansion of output and consumption in response to a change in government purchases, anticipated government spending changes are generally found to decrease consumption and the real wage while causing hours and GDP to rise. The responses to anticipated spending shocks are consistent with the negative wealth effect that characterizes the neoclassical framework typified by Baxter and King (1993). One concern that arises with the narrative approach is that the particular dates and news sources are chosen by the researcher and therefore are subjective. The use of SPF data may mitigate this concern, but unfortunately the available defense spending forecast series is short. To create a longer time series Ramey combines defense and federal spending forecasts and uses forecast errors[1] rather than the forecasts themselves.

The focus of chapter four is studying the effects of anticipated policy changes in both an identified VAR and the structural presented in chapter three of this work. My contribution to the literature is manifold. First, I bring a new data set to bear on the approach of Ramey which allows for greater flexibility in the way that forecasts are incorporated in the VAR. Second, I extend Ramey's approach in two ways: by analyzing VAR's with stochastic as well as deterministic trends and by examining the possibility that the VAR is misspecified using a structural DSGE model built to analyze fiscal policy. In pursuit of the first endeavor, I retrieved documents from Federal Reserve archives and compiled defense spending forecasts for the period 1965 – 2005. Since defense spending is forecasted for a much longer time period than found in the SPF, there is no need to combine disparate time series and use forecast errors. I incorporate the forecasts as a measure of anticipated military spending to identify government spending shocks in a VAR and examine how the results are affected by the manner in which the forecasts are utilized. Two primary results emerge. When I use the raw forecasts I find that GDP, hours, wages, and consumption all rise following a shock to the news variable—in similar

[1] The forecast error is the difference between forecasted and actual defense spending growth.

fashion to the results obtained using standard identification methods[2]. Output multipliers, when measured as the peak response, range from .5 to slightly larger than unity. When I instead incorporate forecast errors in the VAR I find just the opposite: hours increase while wages and consumption fall after a government spending shock as is typical with the narrative approach. Thus, the way in which the forecast data is incorporated into the VAR becomes crucially important to the results.

In addition to the empirical results obtained from the VAR analysis, I also use a structural DSGE model to seek corroborating evidence. If anticipated fiscal policy is an important part of the data generating process and effective proxies for fiscal news are utilized, then one would expect to find a systematic relationship between the structural model forecast errors and the fiscal news variable. In essence, fiscal news should improve the structural model's ability to forecast the data. To this end I test the fiscal news variable and the DSGE model forecast errors for consumption and hours worked for granger causality. I find little evidence that a systematic relationship exists. The structural model findings seem to indicate that either anticipated fiscal policy is not a visible component of household behavior, or the particular measures of fiscal news used here are not adequately capturing the anticipation effects. These are fundamental concerns when conducting an empirical investigation into anticipated fiscal policy.

[2] The standard identification scheme orders government spending first in the VAR and uses a Cholesky decomposition. The methodology is discussed in more detail in chapter two.

CHAPTER 2: LITERATURE REVIEW

2.1 Theoretical Literature

The theoretical literature that endeavors to understand the inner workings of fiscal policy, while offering many valuable insights, is far from reaching a consensus on the impacts of government spending and tax policies. Whether theoretical or empirical, fiscal policy model outputs are conventionally summarized by reporting fiscal multipliers, i.e. how much output, consumption, investment, and other endogenous variables change in response to a fiscal adjustment. Traditional Keynesian analysis generates positive output and consumption multipliers that can be quite large depending on the marginal propensity to consume. Large output multipliers were also predicted by Christina Romer, Chair of the President's Council of Economic Advisers, and Jared Bernstein, Chief Economist of the Office of the Vice-President in a 2009 paper analyzing the impact of the proposed fiscal stimulus legislation. Reporting the average of two quantitative macroeconomic models, they found that an increase in government purchases of 1 percent of GDP would create an increase in real GDP of 1.6 percent, boosting consumption and employment far out into the future. Large multipliers are also reported by Eggertson (2009), Leeper and Davig (2011) and others that model unique circumstances like the zero interest rate environment during the Great Recession or extreme central bank accommodation. After a broad survey of both theoretical and empirical evidence, Robert Hall (2009) concludes that the output multiplier for government purchases is probably around unity. In contrast, consumption multipliers are negative in the benchmark real business cycle model (Baxter and King (1993), for example) since forward-looking, optimizing consumers obey an intertemporal budget constraint. An increase in government spending reduces the present value of after-tax income, inducing a negative wealth effect that crowds out consumption. This feature is at odds with the bulk of empirical evidence, and persists in more complex models as long as households are fully rational.

Much of the theoretical literature utilizes a variant of the new-Keynesian style dynamic stochastic general equilibrium (DSGE) model. At their core, new-Keynesian models are neoclassical growth models (intertemporally optimizing households and firms) augmented with various frictions like sticky wages and prices, imperfectly competitive production markets, investment adjustment costs, and habit formation in consumption. The degree of nominal and real rigidity and the specification of the supply side of the economy, including labor markets, vary from author to author. Monetary policy is generally described by a Taylor-type rule while fiscal policy, if present, is based on the government's intertemporal budget constraint. Taxes are often lump-sum, but many recent models allow for distortionary taxation. One of the most cited, empirically estimated examples of this class of models is Smets and Wouters (2007) which is largely based on the similar general equilibrium framework of Christiano et al. (2005).

A pertinent example of such a model used to study fiscal policy is the work of Galí, López-Salido, and Vallés (2007). The authors first motivate the theoretical analysis by estimating a standard VAR that suggests consumption increases in response to a government spending shock. They then calibrate a small-scale new-Keynesian model to see if the empirical findings can be replicated under plausible assumptions. Key features of the model include the presence of rule-of-thumb consumers, sticky prices, and imperfectly competitive labor markets. These components interact in such a way as to reverse the sign of the consumption multiplier found in the traditional neoclassical and real business cycle literature, qualitatively matching their empirical VAR results. They report that an important lesson from their investigation is that it may be necessary to depart form the strict Ricardian behavior assumed in many macro models in order to capture important aspects of the economy's workings. The model I present in chapter three improves upon this work in two primary ways. First, I use time series data to estimate the historical ramifications of fiscal adjustment rather than calibrate model parameters. Second, the specification of fiscal rules is more robust, allowing for the simultaneous adjustment of five instruments and complex interactions between the instruments.

Cogan, Cwik, Taylor, and Wieland (2010) extend the more complex DSGE model of Smets and Wouters (2007) to include rule-of-thumb behavior and examine fiscal multipliers. They find that spending multipliers from permanent changes in federal purchases are much less in new-Keynesian models than in "old-Keynesian" models. The output multiplier upon impact was slightly less than unity and steadily decreased thereafter. After four quarters the output multiplier was roughly .4. The authors then simulated an actual path for government spending based on the ARRA and found that multipliers were even smaller than those found using a standard shock. Cogan et al. (2010) also highlight the need for robustness checks in fiscal policy analysis, and perform several exercises to that end. When non-Ricardian households were added to the model, multipliers were slightly larger but did not change the quantitative findings significantly. Likewise, when the effects of fiscal policy at the zero lower bound were explored by assuming a constant interest rate for 2 years, the multipliers only increased slightly. Importantly, they find that the anticipation of the time series of government spending and the monetary policy response are important and merit further study. This is part of the impetus for examining the issue of anticipation effects, which is addressed in chapter four of this work.

The models of Gali et al. (2007) and Smets and Wouters (2003, 2007) omit distortionary taxation, a feature that Uhlig (2010) and Uhlig and Thorsten (2011) demonstrate to be crucial in theoretical analysis of fiscal policy. Uhlig and Thorsten extend the Smets and Wouters framework to incorporate distortionary labor, capital and consumption taxes, and rule-of-thumb consumers in a calibrated environment. They show that when distortionary labor taxes are used to retire debt in place of lump-sum taxes, which is much more realistic from a political economy standpoint, impact multipliers are much more modest while long-run multipliers are very small or even negative. In the same vein, Leeper and Yang (2008) show that omitting the effects of debt financing can be severely misleading in real business cycle-style models, and agent's beliefs about which fiscal instruments finance debt play a crucial role in determining the path of endogenous variables. One of the main contributions to the literature in this work comes from combining these various threads of the literature. The model presented in chapter three includes distortionary taxation, rich fiscal policy rules, and reflects the historical circumstances of the U.S. economy. I also allow for different labor supply specifications for non-Ricardian households, a feature not found in the investigation of Cogan et al. (2010).

The theoretical environment for this investigation is based in large part on Leeper, Plante, and Traum, (2010). LPT use a neoclassical growth model and Bayesian econometric techniques to estimate rich fiscal policy rules. LPT estimate four versions of the model: one in which all fiscal instruments adjust to stabilize debt, one in which only capital and labor taxes adjust, one in which only government spending adjusts, and one in which only lump-sum transfers adjust. By calculating posterior odds ratios, they find that historical U.S. data favor a detailed fiscal specification, including non-trivial debt dynamics, in which income, capital, and consumption taxes, government spending, and transfer payments all adjust to stabilize debt. They find that impulse responses to fiscal shocks vary in important ways when distortionary taxation is accounted for. In the short run the response of capital taxes and transfers is strong while the response of labor taxes is weaker. Also, debt-financed fiscal adjustments have markedly different effects in the short run versus the long run.

After estimating the structural parameters, LPT conduct several fiscal policy experiments. They assume that fiscal policy parameters are different than the estimated values and compare the results. In particular, they analyze how the speed of adjustment affects multipliers, the effect of utilizing a single fiscal instrument to retire debt, and the effect of using enhanced automatic stabilizers. Generally speaking, multipliers are smaller when fiscal adjustments are accelerated. When capital taxes are primarily used to finance debt, long run multipliers turn negative while, surprisingly, labor tax financing presents no such tradeoff.

The LPT model only considers households that optimize intertemporally. This is important in a model that focuses on fiscal policy because of the implications for transfer payments, a key fiscal instrument. With perfect capital markets and the assumption of rational expectations, exogenous changes to transfers have no effect on agents' consumption and saving decisions. An increase in transfer payments today creates an expectation that taxes will increase to finance the transfer, whether it happens in the current period or at some unspecified time in the future. In other words, an increase in current transfers does not affect an agent's intertemporal budget constraint and will therefore not alter the optimal consumption bundle. Thus, as LPT point out, the only way in which the model is able to match the real-world correlation between transfer payments and debt is if transfers respond directly to debt. As a result of this feature, there is an inherent preference for transfer financing. I attempt to fill this gap in the literature by considering a similar dynamic stochastic general equilibrium (DSGE) model containing non-Ricardian agents alongside the traditional intertemporal optimizers. The non-Ricardian households do not have the same intertemporal budget constraint traditionally afforded rational agents; consequently, they will react to transfer payments in a decidedly more Keynesian fashion. Specifically, an increase in transfers is seen as an increase in current income, leading to more consumption. The fact that an exogenous change in transfer payments alters the path of endogenous variables has led to transfers being referred to as *non-neutral* in this context, even when modeled as lump-sum payments. Extending the current literature to include household heterogeneity and rich fiscal policy rules has several benefits. First, the extension still allows for expectations about policy rules to influence the path of the economy via the fraction of consumers that are rational. Second, allowing for a more flexible role for transfer payments removes the inherent bias toward one particular fiscal instrument. Finally, the model accurately reflects the microeconomic realities regarding consumption that are well documented in the empirical literature discussed below.

2.2 Empirical Literature

Why include non-Ricardian households in an analysis of fiscal policy? There is mounting empirical evidence (see the discussion of Shea (1995), Parker (1999), and Souleles (1999) below) that calls into question the assumption of universal consumption smoothing implied by both Friedman's permanent-income hypothesis (PIH) and Modigliani's life-cycle hypothesis (LCH). As pointed out by N. Gregory Mankiw (2000), the canonical models used to study fiscal policy incorporate households that smooth consumption over time, and thus fail to explain key facts observed in the data. For instance, the Barro-Ramsey model of infinitely lived households (Barro, 1974) and the Diamond-Samuelson overlapping generations model (Diamond, 1965) both assume consumers use financial markets to smooth purchases over their life-cycle; however, empirical evidence suggests that this brand of highly rational and forward-looking behavior is not universal. It follows that either consumers choose not to plan ahead or are unable to do so because of some constraint or market failure. One possible explanation for the former is that an agent may not be rational in the sense that they are myopic and fail to fully consider the long-run effects of not saving today. Plausible scenarios for the latter are numerous. A consumer with a poor credit history, unattractive collateral, or imperfect information may wish to borrow against future income in order to consume more today, but remain unable to acquire the financing necessary to do so. Capital markets will not be complete if some households lack access to credit markets, preventing even rational agents from making the required trades to satisfy intertemporal optimality conditions. The recent financial crisis in which the value of housing collateral sunk and credit tightened serves as a real world example of how individuals might find themselves facing financing constraints. Additionally, many individuals have zero net wealth while a small fraction of the population accumulates vast amounts of wealth, much more than needed to smooth consumption. Thus, it appears that the bequest motive leads some households to hold abundant savings while other families choose to spend all of their current income and leave nothing behind. According to Mankiw (2000), these facts can all be reconciled by developing models that include both types of individuals: the "savers" and the "spenders". With these realities in mind, the model of fiscal policy presented in chapter three incorporates both Ricardian savers and non-Ricardian spenders.

I will now briefly review three investigations into the nature of consumption at the microeconomic level which provide the impetus for including departures from strict rationality. Shea (1995) uses the Panel Study of Income Dynamics (PSID) to study consumption at the household level. Shea is able to isolate households in the PSID that can be linked to long-term union wage contracts. Published information detailing the compensation packages outlined therein is used to construct household-specific paths for expected future wage growth. Importantly, the changes in wages are predictable from the household's perspective. If neoclassical assumptions hold, predictable movements in lifetime income should not cause a change in the path of consumption as the agent would already be incorporating the information into their intertemporal budget constraint. However, Shea found that predictable wage movements are significantly correlated with consumption changes, contrary to the predictions of the PIH-LCH framework. Furthermore, agents respond more strongly to decreases in income than to increases in income, supportive of the type of loss aversion behavior predicted by prospect theory.

Parker (1999) also tests predictions made by the PIH-LCH models of consumption. Using household-level consumption data from the Consumer Expenditure Survey (CEX), Parker tests whether expenditures on nondurable goods are positively correlated with predictable changes in Social Security tax withholdings. Two sources of variation in the amount of taxes owed allow the response of consumption to predictable changes in income to be analyzed. First, a series of announced tax rate increases occurred in the 1980's. Because households differ in their share of the tax burden (some individuals are not subject to tax withholding), the proposed legislation would cause different percentage changes in income for different households. Second, since income that is taxable for Social Security purposes is capped at a predetermined level, disposable income rises in a predictable fashion once the cap is reached. In January of the following year disposable income falls again in a predictable fashion. Parker finds that consumption does in fact respond to these expected changes in income, contrary to the hypothesis of consumption smoothing. Specifically, durable goods consumption increases by about a half of a percent in response to a predictable one percent increase in after-tax income.

The investigation of Souleles (1999) provides similar evidence by examining household behavior in response to tax refunds. Since tax refunds are a function of events that took place in the prior calendar year, the amount of the refund is predictable in the year of its receipt. Conseqently, this forecastable increase in disposable income should not cause consumption to rise when it is received according to the benchmark PIH-LCH model. However, data studied by Souleles indicates a positive comovement between income tax refunds and consumption.

The bulk of empirical researchers focusing directly on fiscal policy have employed structural vector autoregressions (VAR's) to understand the effects of spending and tax shocks. Much like the body of theoretical literature, the empirical VAR approach provides only limited consensus as to the impact of tax and spending changes and debt financing. However, while the empirical literature fails to speak with a single voice, many estimates do reveal a modest expansion of output and consumption in response to a change in government purchases. Generally speaking, this finding is taken as evidence in favor of sticky price models of the economy in the vein of new-Keynesian DSGE models since neoclassical theory predicts a decrease in consumption in response to a government spending shock.

Contributors to the VAR literature, exemplified by Blanchard and Perotti (2002), Gali, Lopez-Salido, and Valles (2007), Perotti (2008), Mountford and Uhlig (2008) and Ramey (2011b), have used a variety of identification strategies to estimate fiscal multipliers. Of these, the investigations of Blanchard and Perotti (2002, 2008) stand out for the precedent they have set in the VAR literature dedicated to the study of fiscal policy. Fiscal shocks are identified by examining institutional information on tax, spending, and transfer programs. The data are used to estimate the contemporaneous (automatic) response of fiscal variables to changes in economic activity. Once the automatic response is accounted for, shocks to fiscal variables can be identified. Output and taxes are found to have no contemporaneous effect on government spending; consequently, the identification procedure utilized by Blanchard and Perotti (2002) is identical to a Choleski decomposition with government spending ordered first. Across all model specifications, government spending shocks have the same qualitative effect, causing consumption to increase. Government spending multipliers that peak in the range of .9-1.29 were reported. A section of this paper is dedicated to understanding the effect of anticipated fiscal policy, though its effect on consumption was not studied. Berndt, Lustig, and Yeltekin (2011), Fatas and Mihov (2001), Gali, Lopez Salido, and Valles (2007), Mountford and Uhlig (2002), and Perotti (2008) have used this basic approach to identifying fiscal shocks, generally finding that GDP, hours, wages, and consumption rise following a change in government spending[3]. Estimates of the output multiplier from this group range as high as 1.2 after 8 quarters (Perotti, 2008) while the consumption multiplier is found to be as high as .49 after 8 quarters (Gali et al., 2007), and generally is at least slightly positive.

Others have sought to understand the effect of *anticipated* fiscal policy in a structural VAR framework. The narrative approach, pioneered by Ramey and Shapiro (1997) and discussed more extensively in chapter one, is an alternative to the Blanchard and Perotti methodology described above. Identification is achieved by studying exogenous military buildups. The authors use this approach to find a much smaller output multiplier (just .3 on impact) and a consumption multiplier that is essentially zero on impact and turns negative over

[3] These results are generally taken as support for sticky wage and price models like New Keynesian DSGE models that incorporate monopolistically competitive markets.

time. Ramey (2011) extends the narrative approach by examining announced policy changes found in popular news outlets. One concern that arises with the narrative approach is that the particular dates and news sources are chosen by the researcher and are therefore subjective.

A third approach to identifying fiscal policy shocks attempts to address both the subjectivity and the anticipation issues related to the previous two methods. Fisher and Peters (2009) use statistical innovations to the accumulated excess stock returns for large US defense contractors to identify government spending shocks. Like the narrative approach, the Fisher-Peters methodology, sometimes referred to as the EVAR approach, begins by assuming there are periodic changes in current and expected military spending that are exogenous. When such an episode occurs, the current and expected future earnings of companies receiving defense contracts should also change. Profit expectations will be incorporated in the valuation of the stocks of these defense contractors, affecting the returns to holding these securities. The authors find that after a positive excess return innovation output, hours, and consumption are constant for several quarters before rising in a hump-shaped pattern. After an initial decline, wages rise persistently. Taken as a whole, the results are closer to those typical of investigations using a Choleski decomposition to identify shocks to government spending.

I contribute to the above-described body of empirical literature in several ways. First, I retrieved documents from Federal Reserve archives and compiled defense spending forecasts for the period 1965 – 2005 in order to bring a new data set to bear on the approach of Ramey. The new data set creates a longer time series for government spending forecasts which allows for greater flexibility in the way that forecasts are incorporated in the VAR. Specifically, there is no longer a need to combine disparate times series to create a sufficiently long sample. This allows me to use both raw forecasts and forecast errors in the VAR. Second, I extend Ramey's approach by analyzing VAR's with stochastic as well as deterministic trends. My final contribution comes from examining the possibility that the VAR is misspecified. To this end, I use a structural DSGE model built to analyze fiscal policy to see if Fed forecasts are systematically related to the DSGE model residuals. For each VAR discussed, I present impulse response functions as well a complete characterization of fiscal multipliers over various time horizons.

CHAPTER 3: DYNAMICS OF FISCAL FINANCING WITH NON-RICARDIAN HOUSEHOLD BEHAVIOR

1. Model

The model presented in this chapter follows closely the neoclassical growth model presented in LPT. The primary distinguishing feature is consumer heterogeneity in the form of two types of representative household. The first household type displays optimizing behavior by maximizing an intertemporal utility function, henceforth referred to as *Ricardian* households (model variables are denoted with a superscript *r*). The second type of representative agent exhibits rule-of-thumb, or *non-Ricardian* behavior. Model variables pertaining to non-Ricardian households are denoted with a superscript *nr*. The model also contains a representative firm and the government. The model economy is buffeted by nine temporary innovations: shocks to government spending, capital, labor, and consumption taxes, transfer payments, technology, investment adjustment costs, and preferences.

1.1. *Ricardian Households*

A fraction of the population $\gamma \in [0,1]$ is non-Ricardian. The remaining $(1-\gamma)$of households is Ricardian and maximizes expected utility. Preferences, common to *all* households, are described by the following separable utility function:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t u_t^b \left[(1-\omega)^{-1} (c_t^J - hC_{t-1})^{1-\omega} - u_t^l (1+\kappa)^{-1} (l_t^J)^{1+\kappa} \right]$$

for $J \in \{r, nr\}$. Utility is derived from consumption, c_t^J, relative to a habit stock defined as a fraction $h \in [0,1]$ of the previous period's aggregate consumption, C_{t-1}. Hours worked, l_t^J, yield disutility. The utility function contains two preference shocks, one general (u_t^b) and one specific to labor supply (u_t^l). The parameters $\omega, \kappa \geq 0$ represent the coefficient of risk aversion and the inverse of the Frisch labor supply elasticity respectively, and $\beta \in [0,1]$ is the discount factor. The shocks u_t^b and u_t^l evolve according to the following AR(1) processes:

$$(1) \quad \ln(u_t^b) = \rho^b \ln(u_{t-1}^b) + \sigma_b \varepsilon_t^b, \quad \varepsilon_t^b \sim N(0,1)$$

$$(2) \quad \ln(u_t^l) = \rho^l \ln(u_{t-1}^l) + \sigma_l \varepsilon_t^l, \quad \varepsilon_t^l \sim N(0,1)$$

Maximization for Ricardian agents is subject to a flow budget constraint,

$$(3) \quad (1+\tau_t^c)c_t^r + i_t^r + b_t^r = (1-\tau_t^l)w_t^r l_t^r + (1-\tau_t^k)R_t^k v_t K_{t-1}^r + R_{t-1}b_{t-1}^r + z_t^r$$

Ricardians have at their disposal after-tax labor and capital income, interest on government bonds held the previous period, and lump-sum transfer payments from the government, z_t^r. Income is consumed, invested in physical capital, or used to purchase government debt. Capital income is computed as the rental rate of capital, R_t^k, multiplied by the effective quantity of capital employed by Ricardian households in period t, $v_t K_{t-1}^r$. The variable v_t is a household control variable that measures the utilization rate of the capital stock. R_{t-1} is the return on one-year government debt owned by Ricardian households, b_t^r. The tax rates on consumption, labor income, and capital income are given by τ_t^c, τ_t^l, and τ_t^k respectively. It should be emphasized that only Ricardian households save and invest in physical capital and consider an intertemporal resource allocation decision.

The capital stock evolves according to the following law of motion:

(4) $$k_t^r = (1-\delta(v_t^r))k_{t-1}^r + \left[1 - S(\frac{u_t^i i_t^r}{i_{t-1}^r})\right] i_t^r$$

The depreciation of the capital stock is assumed to depend positively on the intensity of capital utilization chosen by the household. Specifically, the depreciation function $\delta(\cdot)$ takes the quadratic form presented in Schmitt-Grohe and Uribe (2007):

(5) $$\delta(v_t) = \delta_o + \delta_1(v_t - 1) + \delta_2 / 2(v_t - 1)^2$$

The function $S(\cdot)$ describes an adjustment cost associated with changing the level of investment from period *t-1* to *t*. As in Smets and Wouters (2003) and Christiano et al. (2005), $S(1) = S'(1) = 0$ in steady state, with $S''(1) > 1$. Following LPT, adjustment costs are subject to a shock u_t^i that follows an AR(1) process:

(6) $$\ln(u_t^i) = \rho^i \ln(u_{t-1}^i) + \sigma_i \varepsilon_t^i, \quad \varepsilon_t^i \sim N(0,1)$$

The shock is designed to capture exogenous changes in the efficiency with which investment can be transformed into physical capital.

The Ricardian household optimization problem involves choosing c_t^r, l_t^r, b_t^r, i_t^r, k_t^r and v_t^r to maximize utility subject to the flow budget constraint (3) and the law of motion for capital (4). The problem is solved using dynamic programming. Details of the solution including first order conditions can be found in appendix A.

2.1. *Non-Ricardian Households*

The response of consumption to fluctuations in income depends on the particular specification of non-Ricardian households. A mild departure from Ricardian behavior (Coenen, McAdams, and Straub (2008), for example) assumes households lack access to capital markets, but can still smooth consumption by adjusting money balances. I choose to follow the original specification of Cambell and Mankiw (1989), and more recently, Galí, López-Salido, and Vallés (2007) and Forni, Monteforte, and Sessa (2009) by assuming non-Ricardian households are constrained to consume all of their current after-tax income. These rule-of–thumb agents are allowed to co-exist with the traditional optimizing households. While this specification is admittedly somewhat extreme with respect to the response of consumption to variations in income, it does not constrain the response of consumption to be positive.

Formally, a fraction $\gamma \in [0,1]$ of households lack access to financial and capital markets and must consume all current disposable income. Income is derived from working (taxed at rate τ_t^l) and lump-sum transfers from the government, z_t^{nr}. Consumption expenditures are subject to taxation at rate τ_t^c. The non-Ricardian budget constraint is therefore given as:

(7) $$(1+\tau_t^c)c_t^{nr} = (1-\tau^l)w_t^{nr} l_t^{nr} + z_t^{nr}$$

2.3 *Labor Supply*

The issue of labor supply merits some discussion. When modeling non-Ricardian households it is common to make assumptions than ensure hours worked are the same for both types of consumer. In the monopolistically competitive market structures found in many DSGE models, it is often assumed that households will always supply enough labor to satisfy firm demand (see, for example, Forni et al. (2009)[4] and Leeper et al. (2012)). Assuming wage rates are equal across household types and firms do not discriminate between labor types, the total supply of labor services by Ricardians and non-Ricardians will be identical in equilibrium. In other words, the number of hours worked is demand driven. However, this assumption has the side effect of constraining each household type to adjust hours in the same way after a shock. Therefore, a shock that creates a negative wealth effect for Ricardians and induces an increase in hours worked will also lead non-Ricardians to supply more labor, even though the shock may increase current disposable income and consumption (thereby decreasing the marginal utility of consumption for non-Ricardians)—a situation that not only contradicts intratemporal optimization requirements, but also exaggerates the aggregate demand effect of government spending and transfers shocks.

[4] Forni et al. (2009) also consider a more general labor market specification in which non-Ricardians do not fully inherit the labor supply consequences from the wealth of Ricardians by exploring a union bargaining model. They find the results little changed from the basic specification.

To address this issue, I first assume a perfectly competitive labor market with the restriction that $l_t^r = l_t^{nr} = l_t$. I then observe the effect of relaxing this assumption, allowing for different levels of consumption and labor supply for Ricardians and non-Ricardians. The unrestricted formulation is similar that of Galí et al. (2007), where non-Ricardians cannot optimize intertemporally, but can still adjust hours to solve a static optimization problem taking their budget constraint as given. Temporarily ignoring taxes, the problem becomes:

$$\max \ U(c^{nr}, 1 - l^{nr})$$

$$s.t. \ \ c^{nr} = \ wl^{nr} + z^{nr}$$

The first order conditions with respect to c^{nr} and l^{nr} are familiar:

$$U_c = \lambda$$

$$U_l = w\lambda$$

The intratemporal Euler equation for non-Ricardians then takes the form:

(8) $$U_c/U_l = \frac{1}{w}$$

In equilibrium, the optimality condition for non-Ricardians is identical to that of Ricardians except for the levels of consumption and labor supply. Thus, the only way labor supply will be equalized across households is if the equilibrium level of consumption is also the same for both

Ricardians and non-Ricardians. While not a perfect analog, the restricted model ensures that non-Ricardians adjust supply labor in the same manner as Ricardians after a fiscal shock, mimicking the behavior found is many medium-sized DSGE models.

2.4 *Firm Problem*

The firm's problem is straightforward profit maximization. Profit is given as revenue less the cost of renting labor and capital services from the household:

$$\max \pi = y_t - w_t l_t - R_t^k v_t k_{t-1}^r$$

Total output y_t is produced using constant returns to scale Cobb-Douglas technology:

(9) $$y_t = u_t^a (v_t k_{t-1})^\alpha l_t^{1-\alpha}$$

where $\alpha \in [0,1]$ and u_t^a is a neutral technology shock assumed to follow an AR(1) process:

(10) $$\ln(u_t^a) = \rho^a \ln(u_{t-1}^a) + \sigma_a \varepsilon_t^a, \quad \varepsilon_t^a \sim N(0,1)$$

The first order conditions for the firm equate the rental rate of capital and the wage rate to the marginal products of capital and labor respectively, which simplify to:

(11) $$\frac{\alpha y_t}{k_{t-1}} = R_t^k v_t$$

(12) $$\frac{(1-\alpha) y_t}{l_t} = w_t$$

2.5 *Government Sector*

As the focus of this paper is fiscal policy, several salient features of the model are found in the government sector formulation, taken from LPT. The government faces a flow budget constraint:

(13) $$B_t + \tau_t^k R_t^k v_t K_{t-1} + \tau_t^l w_t L_t + \tau_t^c C_t = R_{t-1} B_{t-1} + G_t + Z_t$$

where G_t and Z_t are government spending and transfer payments respectively. In addition to issuing debt, the government sources funds by levying capital, labor, and consumption taxes. Funds are used to service debt, purchase final goods and services, and redistribute wealth via lump-sum transfer payments.

Fiscal instruments behave according to a rich specification that allows for a response to the state of the economy. The fiscal rules capture two important policy considerations: business cycle stabilization and debt stabilization. First, contemporaneous co-movement with output allows fiscal instruments to behave as automatic stabilizers, acting to bring the economy closer to potential GDP. Second, fiscal instruments are allowed to respond to the level of the federal debt. Higher government debt in period *t* will trigger fiscal responses in period *t+1* that tend to bring debt back to its steady state level. Linearized, in terms of log-deviations from the steady state, the policy rules are:

(14) $\hat{G}_t = -\varphi_g \hat{Y}_t - \gamma_g \hat{B}_{t-1} + \hat{u}_t^g$

$$\hat{u}_t^g = \rho_g \hat{u}_{t-1}^g + \sigma_g \varepsilon_t^g, \qquad \varepsilon_t^g \sim N(0,1)$$

(15) $\hat{\tau}_t^k = \varphi_{tk} \hat{Y}_t + \gamma_{tk} \hat{B}_{t-1} + \phi_{kl} \hat{u}_t^{tl} + \phi_{kc} \hat{u}_t^{tc} + \hat{u}_t^{tk}$

$$\hat{u}_t^{tk} = \rho_g \hat{u}_{t-1}^{tk} + \sigma_k \varepsilon_t^{tk}, \qquad \varepsilon_t^{tk} \sim N(0,1)$$

(16) $\hat{\tau}_t^l = \varphi_{tl} \hat{Y}_t + \gamma_{tl} \hat{B}_{t-1} + \phi_{kl} \hat{u}_t^{tk} + \phi_{lc} \hat{u}_t^{tc} + \hat{u}_t^{tl}$

$$\hat{u}_t^{tl} = \rho_l \hat{u}_{t-1}^{tl} + \sigma_{tl} \varepsilon_t^{tl}, \qquad \varepsilon_t^{tl} \sim N(0,1)$$

(17) $\hat{\tau}_t^c = \phi_{kc} \hat{u}_t^{tk} + \phi_{lc} \hat{u}_t^{tl} + \hat{u}_t^{tc}$

$$\hat{u}_t^{tc} = \rho_{tc} \hat{u}_{t-1}^{tc} + \sigma_{tc} \varepsilon_t^{tc}, \qquad \varepsilon_t^{tc} \sim N(0,1)$$

(18) $\hat{Z}_t = -\varphi_z \hat{Y}_t - \gamma_z \hat{B}_{t-1} + \hat{u}_t^z$

$$\hat{u}_t^z = \rho_z \hat{u}_{t-1}^z + \sigma_z \varepsilon_t^z, \qquad \varepsilon_t^z \sim N(0,1)$$

where $\varphi_i \geq 0 \; for \; i = \{g, k, tl\}$ captures the fiscal response to deviations in output from potential GDP and $\gamma_i \geq 0 \; for \; i = \{g, k, tl, z\}$ models the response to government debt. The consumption tax rate, largely capturing movement in excise taxes on gasoline, tobacco, and the like, is assumed to be an exogenous process. Since excise taxes are used mainly for special funds, it is reasonable to believe they do not respond to changes in economic conditions.

Additionally, each fiscal instrument is subject to persistent, random shocks, represented in the model by the u_t's. The coefficients on the lagged shocks ($\rho_i \in [0,1]\ for\ i = \{g, tk, tl, tc, z\}$) measure the degree of persistence of an exogenous change in policy. Furthermore, exogenous changes in one tax instrument are allowed to affect the remaining tax instruments. This response is quantified by the parameter $\phi_i\ for\ i = \{kl, kc, tc\}$.

2.6 *Aggregation*

With a representative agent model, aggregate per capita quantities (denoted with a capital letter throughout the model) are equivalent to their representative counterparts in equilibrium:

$$X_t = x_t,\ \forall\ x$$

Aggregate quantities of household variables are weighted averages of Ricardian and non-Ricardian components:

(19) $$C_t = (1-\gamma)C_t^r + \gamma C_t^{nr}$$

(20) $$L_t = (1-\gamma)L_t^r + \gamma L_t^{nr}$$

(21) $$K_t = (1-\gamma)K_t^r$$

(22) $$I_t = (1-\gamma)I_t^r$$

(23) $B_t = (1-\gamma) I_t^r$

It is also assumed that both Ricardians and non-Ricardians receive the same transfer payments, so that $Z_t^r = Z_t^{nr} = Z_t$. It is interesting to note that the definitions of aggregate consumption and aggregate labor supply (equations (19) and (20)) are the only places the parameter γ (the fraction of non-Ricardians) appears in the log-linearized model. When $\gamma = 0$, the model collapses to the specification of LPT.

2.7 *Equilibrium and solution*

In equilibrium, aggregate supply equals aggregate demand for private consumption and investment goods and government purchases:

(24) $Y_t = C_t + I_t + G_t$

The non-Ricardian consumption function (7), first order conditions for the household (appendix A) and firm (11) and (12), the law of motion for capital (5), the government budget constraint (13), the fiscal policy rules (14) - (18), the additional exogenous processes given by (1), (2), (6), and (10), the definitions of aggregate household variables given by equations (19)-(23), and the aggregate resource constraint (24) characterize a symmetric equilibrium. Additionally, the transversality condition for debt and capital accumulation must be satisfied.

The system is log-linearized around the deterministic steady state and solved using the gensys algorithm developed by Christopher Sims (2001), yielding a solution in the form of:

$$y_t = A(\Theta) y_{t-1} + B(\Theta) z_t$$

where the coefficient matrices $A(\cdot)$ and $B(\cdot)$ are functions of the model's structural parameters which will be estimated in the following section. A complete characterization of the system of equations and steady state used to solve the model can be found in appendix A.

3. Estimation

3.1 Identification

Parameter identification has long been a concern when estimating DSGE models. A straightforward type of identification issue, stochastic singularity, is rectified by including measurement errors or matching the number of shock processes to the number of observables. However, more delicate identification problems may arise in DSGE models that are not readily apparent. Komunjer and Ng (2011) provide a relatively simple set of rank and order conditions that can be used prior to posterior simulation (for both stochastically singular and nonsingular models) to test whether the parameters of a DSGE model are identifiable from the first and second moments of the data, and state them in terms of a matrix $\Delta(\theta)$. Using the Matlab code provided by Komunjer and Ng, I tested both the model presented in this paper and the LPT model for identifiability. I first test the completely unrestricted model and find that nine restrictions are required for identification at all tolerance levels $\leq .01$. I then imposed the nine restrictions used by LPT to find that the rank and order conditions are indeed satisfied for both models at all tolerance levels $\leq .01$, indicating the parameters can be identified from the data[5]. Fixing the fraction of non-Ricardians and placing a restriction on hours worked does not affect the identification results. See appendix B for details regarding the Komunjer and Ng test results.

3.2 Methodology

The model is fit to US data using Bayesian methods a la An and Schorfheide (2007). The posterior distribution of the model is given as:

$$p(\theta|x) \propto p(x|\theta)p(\theta)$$

where $p(x|\theta)$ is the likelihood of the data conditional on the parameters of the model and $p(\theta)$ represents the prior distributions of the parameters. The posterior distribution is simulated using the random walk Metropolis-Hastings (MH) algorithm. To execute the random walk MH algorithm, the mean and variance of the candidate distribution were initialized with the posterior mode and the inverse Hessian evaluated at the mode. In order to find the posterior mode, I minimize the negative of the log posterior using the Sims csminwel optimization routine. I performed fifty searches, each initialized with unique parameter values drawn at random from the prior distributions. The search that yielded the largest likelihood was chosen as the posterior mode. For the unrestricted model, I took 550,000 draws from the posterior, with the first 25,000 draws discarded as a burn-in period. The sample was thinned every 35th draw, to arrive at a final sample size of 15,000. The entire process was completed for both labor supply specifications.

[5] Calibrating the fraction of non-Ricardians simply adds an additional restriction, and does not affect the identifiability of the model.

The unrestricted model required a much longer MCMC chain to achieve statistical convergence[6]. I took 4.2 million draws from the posterior, with the first 1 million discarded as a burn-in. The sample was thinned every 100th draw to arrive at a final sample size of 32,000. A tuning parameter value of .3 led to final acceptance ratios of .3589 and .3601 for the two models, which sit comfortably in the neighborhood of the optimal value (between .23 and .45, depending on the dimensionality of the system (Koop, 2003)).

To test for convergence of the Markov Chain Monte Carlo series and provide reasonable assurance that the entire posterior distribution was sampled, I examine autocorrelations, the Raftery-Lewis diagnostics (1995), and the Geweke chi-squared test (1992). After burn-in and thinning, the Raftery-Lewis diagnostics indicate a sample sizes of only 1,249 and 998 are necessary for accurate parameter estimates and produced values of 1.333 and 1.065 for the I-statistic (values less than 5 indicate convergence). The Geweke test compares the means from the first 20% of the sample to the means from the last 50% of the sample, to see if an equilibrium has been reached. A Z-test of the hypothesis of equality of these two means is carried out and the chi-squared marginal significance calculated. The null cannot be rejected for α=.10 for nearly all of the parameters in both specifications. A complete account of MCMC diagnostics is available upon request.

3.3 Data

As in LPT, the study is necessarily limited to the behavior of federal government fiscal variables, for which data on the value of debt is readily available in the national income and

[6] Smaller MCMC chains did not pass convergence tests, but produced economically identical results.

product accounts.[7] I use quarterly data for the period 1960Q1 to 2011Q4 for nine time series: consumption, investment, hours worked, government debt, government spending, capital tax revenues, labor tax revenues, consumption tax revenues, and government transfers. The data are converted to real terms by dividing by the GDP deflator for personal consumption expenditures. To make the data stationary, I linearly detrend the natural logarithm of each time series independently. The observables are related to the model via the following measurement equation:

Parameter	Value
α	0.3
β	0.99
δ_0	0.025
G/Y	0.087
B/Y	0.34
τ^k	0.212
τ^l	0.191
τ^c	0.0256

Table 1. Calibrated parameters

$$x_t = Hy_t$$

where y_t is the vector of the observable variables. The matrix H maps the observables to the model variables. A complete account of the data construction and sourcing can be found in appendix D.

3.4 Priors and calibrated parameters

I calibrate nine parameters: $\beta = .99$ (implying a steady state interest rate of 4%), $\alpha = .3$ (which makes the steady state labor share of income approximately equal to 70%), and $\delta_o = .025$ (which implies an annual steady state depreciation rate of 10%). The parameter δ_1 is

[7] As noted by Leeper et al. (2010), this would seem to hamper the investigation by limiting its scope, but focusing solely on federal debt dynamics may actually be preferable. This is owed to the fact that federal, state, and local governments operate under very different fiscal constraints. Specifically, many state governments are forced to operate under a balanced budget.

Parameter	Prior Distribution			Posterior Distribution Restricted Labor Supply		Posterior Distribution Unrestricted Labor Supply	
	Density	*Mean*	*St. Dev.*	*Mean*	*St. Dev.*	*Mean*	*St. Dev.*
Risk aversion ω	Γ	2	0.5	2.317	0.450	2.262	0.409
Inverse Frisch elas. κ	Γ	2	0.5	2.431	0.565	1.726	0.403
Habit formation h	β	0.7	0.2	0.638	0.064	0.590	0.059
Capital util. costs δ_2	Γ	0.7	0.2	0.444	0.114	0.493	0.127
Investment adj. costs s''	Γ	5	0.25	5.636	0.264	5.651	0.264
Fraction of non-Ricardians γ	β	0.5	0.1	0.207	0.039	0.200*	-
Fiscal Policy							
Govt. spending debt coeff. γ_g	Γ	0.4	0.2	0.166	0.063	0.158	0.060
Capital tax debt coeff. γ_{tk}	Γ	0.4	0.2	0.471	0.110	0.481	0.114
Labor tax debt coeff. γ_{tl}	Γ	0.4	0.2	0.101	0.045	0.104	0.047
Transfer debt coeff. γ_z	Γ	0.4	0.2	0.376	0.079	0.364	0.081
Capital tax Y coeff. ψ_{tk}	Γ	1.25	0.3	2.214	0.318	2.217	0.324
Labor tax Y coeff. ψ_{tl}	Γ	0.5	0.25	0.296	0.128	0.311	0.132
Govt. spending Y coeff. ψ_g	Γ	0.07	0.05	0.063	0.044	0.060	0.041
Transfer Y coeff. ψ_z	Γ	0.2	0.1	0.238	0.109	0.197	0.091
Cap./Labor co-term φ_{kl}	N	0.25	0.1	0.199	0.030	0.202	0.029
Cap./cons. co-term φ_{kc}	N	0.05	0.1	0.029	0.032	0.029	0.033
Labor/cons. co-term φ_{lc}	N	0.05	0.1	-0.028	0.031	-0.027	0.031

* γ is calibrated to .20, the remaining parameters are estimated

Table 2. Selected prior and posterior distributions

calibrated to ensure that the capacity utilization, v, is equal to unity in steady state. Additionally, I set the steady state tax rates and the ratios of government spending and debt to output equal to the mean values of my data set, which can be found in table 1. With respect to the fraction of non-Ricardian consumers, results for a variety of specifications are reported to ensure robustness. Based on empirical evidence, Campbell and Mankiw (1989) suggested 50% of consumers are non-Ricardian, while estimates from structural models generally range from 18% to 50% (see Traum and Yang, 2012, Cogan et al., 2010, and Forni et al., 2009 for examples). In recognition of this uncertainty, I report results when the fraction of non-Ricardians (γ) is estimated from the data as well as for various calibrations of γ with the remaining parameters being estimated.

Parameter	Prior Distribution			Posterior Distribution Restricted Labor Supply		Posterior Distribution Unrestricted Labor Supply**	
	Density	*Mean*	*St. Dev.*	*Mean*	*St. Dev.*	*Mean*	*St. Dev.*
Tech AR coeff. ρ_a	β	0.85	0.1	0.968	0.012	0.969	0.011
Pref. AR coeff. ρ_b	β	0.85	0.1	0.672	0.024	0.669	0.023
Labor AR coeff. ρ_l	β	0.85	0.1	0.988	0.007	0.985	0.008
Invest. AR coeff. ρ_i	β	0.85	0.1	0.647	0.056	0.690	0.051
Govt. spend. AR coeff. ρ_g	β	0.85	0.1	0.971	0.012	0.971	0.012
Cap. tax AR coeff. ρ_{tk}	β	0.85	0.1	0.941	0.021	0.941	0.022
Labor tax AR coeff. ρ_{tl}	β	0.85	0.1	0.975	0.012	0.974	0.012
Cons. tax AR coeff. ρ_{tc}	β	0.85	0.1	0.929	0.023	0.929	0.023
Transfer AR coeff. ρ_z	β	0.85	0.1	0.934	0.022	0.935	0.022
Tech std. σ_a	IΓ*	1	4	0.616	0.031	0.620	0.031
Pref. std. σ_b	IΓ*	1	4	10.069	0.621	9.875	0.596
Labor std. σ_l	IΓ*	1	4	3.682	0.628	2.874	0.445
Invest. std. σ_i	IΓ*	1	4	8.432	0.808	8.536	0.897
Govt. spend std. σ_g	IΓ*	1	4	3.034	0.151	3.029	0.149
Cap. tax std. σ_{tk}	IΓ*	1	4	4.214	0.170	4.311	0.213
Labor tax std. σ_{tl}	IΓ*	1	4	2.862	0.143	2.868	0.145
Cons. std. σ_{tc}	IΓ*	1	4	4.036	0.199	4.046	0.201
Transfer std. σ_z	IΓ*	1	4	3.281	0.163	3.284	0.162

* The parameters for the Inverse Gamma distribution correspond to s and v, where $f(x|s,v) = v^s\Gamma^{-1}(s)x^{-s-1}exp\frac{-v}{x}$

**Results where γ is calibrated to .20

Table 3. Selected prior and posterior distributions

When γ is estimated, a beta distribution with mean .5 and standard deviation .1 is chosen for the prior, following Forni et al. (2009). Tables 2 and 3 show the prior distributions for the remaining parameters to be estimated. The prior distributions are those found commonly in the literature, and are chosen to reflect prior estimates from studies conducted LPT, Forni et al. (2009), and Smets and Wouters (2003) among others. Generally speaking, the priors are somewhat diffuse, allowing for a wide range of parameter estimates. The habit persistence parameter (h) is assumed to be distributed Beta, with mean .7 and standard deviation .2, following Forni et al. (2009). For the risk-aversion parameter ω and the inverse of the Frisch elasticity κ, a Gamma distribution is chosen with a mean of 2 and standard deviation of .5. The capital utilization adjustment parameter δ_2 is assumed to follow a Gamma distribution with mean .7 and standard deviation .2, centered more tightly around the estimates of Schmit-Grohe and Uribe (2007) than those used by LPT. With respect to the shock processes, Beta distributions are used for the autoregressive coefficients ($\rho's$), with a mean and standard deviation of .85 and .1 respectively, as in Smets and Wouters (2003). The standard deviations of the innovations are assumed to be distributed inverse gamma, while the investment adjustment coefficient *s"* has a Gamma distribution with a mean of 5 and standard deviation set to .25. The priors over the fiscal variables closely follow LPT, and are designed to cover the range of prior estimates found in Blanchard and Perotti (2002), Giorni et al. (1995), and Yang (2005), among others. A Gamma distribution was chosen for the parameters governing the response of fiscal variables to debt ($\gamma_i's$), with a mean of .4 and standard deviation of .2. The iscal response to changes in the output gap ($\varphi_i's$) are also distributed Gamma. The Blanchard and Perotti (2002) estimate of the elasticity of tax revenue with respect to output implies a value of unity for φ_{tk} and φ_{tl}.[8]. Leeper et al. (2010) estimate a value for φ_{tk} that ranges between 1.4 and 1.7, while φ_{tl} is estimated to be between .33 and .38. The lower value of φ_{tl} reflects the fact that Social Security taxes (which are capped and regressive) are incorporated in the labor tax revenue data. Accordingly, I set the labor tax rate elasticity to have a mean and standard deviation of 0.5 and 0.25, and the capital tax rate elasticity to have a mean and standard deviation of 1.25 and 0.3. The prior for the coefficient measuring the co-movement between output and government spending (φ_g) is assigned a mean of .07 and standard deviation .05 while the coefficient on transfers (φ_z) is assumed to have mean and standard deviation of .2 and .1 respectively. The parameter

[8] Blanchard and Perotti (2002) find that a 1% increase in output leads to a 2.08% increase in tax revenue for the period 1947Q1-1997Q4, which implies an increase of approximately 1% in the average tax rate

measuring the co-movement between the capital and labor tax rate shocks ($\emptyset_{kl}$) is assumed to have a Normal distribution with a mean of 0.25 and a standard deviation of 0.1. Yang (2005) estimates $\emptyset_{kl}$ to be 0.26, in line with the findings of LPT which range from .15 to .19. The parameters measuring the co-movement between the capital and consumption tax rate shocks and between the labor and consumption tax rate shocks ($\emptyset_{kc}$and $\emptyset_{lc}$) are assumed to have a Normal distribution with a mean of 0.05 and a standard deviation of 0.1. There is very little information to guide the choice of priors for $\emptyset_{kc}$ and $\emptyset_{lc}$, but the chosen values encompass the values estimated by LPT (.024 and -.028, in the best fitting model). Since consumption taxes are mainly used for special funds, the effect is expected to be small.

4. Results

4.1 Estimation Results

Tables 2 and 3 report the primary estimation results, including the means and standard deviations of the model's parameters. Nearly all of the parameters are meaningfully different from zero, with the interaction terms between consumption tax rates and capital/labor tax rates (φ_{kc} and φ_{lc} respectively) being the lone exceptions. Plots of the prior and posterior distributionsof the parameters can be found in appendix C. The prior and posterior plots corroborate the formal identification test, as shown by the fact that either the posterior distribution is not centered on the prior or it is centered but with a smaller dispersion for most of the parameters. When labor supply is equalized across household types, the fraction of non-Ricardians is estimated to be .207. This estimate is on the low end of what is found in the literature, but not unreasonable. When allowing for intratemporal optimization by non-Ricardian households, the fraction of non-Ricardians is estimated to be .70, a figure that is quite large compared to just previous findings[9]. To provide a meaningful comparison between the two model specifications, I therefore focus on the results when γ=.20 for both labor supply assumptions[10], and then explore how the results change as the fraction on non-Ricardians increases to .70. With respect to the remaining structural parameters, the parameter estimates are very similar across the two labor supply specifications. The intertemporal elasticity of substitution (1/ω) and the Frisch elasticity of labor supply (1/ κ) are similar to estimates generally found in the literature. The posterior means values of (1/ω) are .43 and .44 for the two specifications. The unrestricted model generated a somewhat larger value for the Frisch elasticity (.58 compared to .41) and a slightly smaller habit stock parameter (.59 compared to .64). Relative to the results of LPT, the external habit stock is larger[11] but similar to the 67% reported by Cogan et al. (2010) for a model that includes non-Ricardian consumers. Most of the shocks are quite persistent, with estimated AR(1) coefficients greater than .9. The general preference shock ($\rho_{b)}$ and the investment adjustment cost shock (ρ_i) are somewhat less persistent with AR(1) parameters estimates in the range of .65 to .7.

An inspection of the fiscal policy parameters reveals several interesting findings. Under both labor supply specifications, the fiscal policy estimates are nearly identical. The results indicate that historically an increase in government debt triggers several fiscal instruments to adjust. Capital taxes and transfers react most strongly to debt innovations, while government spending and labor tax adjustments are smaller but nontrivial. In contrast to the findings of LPT, the addition of non-Ricardian households leads distortionary capital taxes to react more strongly than transfers. The attenuated response of transfers to debt also results in a stronger response

[9] For both model specifications, several priors over the fraction of non-Ricardians were tested, including a uniform prior. Estimates did not differ significantly.

[10] For the unrestricted model, this entails fixing $\gamma = .20$ and estimating the remaining parameters.

[11] LPT estimated h to be .5 for all model specifications

from labor taxes, while government spending tends to decrease[12] less in the face of a debt buildup than found by LPT. Capital taxes are extremely procyclical, as evidenced by the large response to changes in aggregate output. Labor taxes and transfers are also procyclical, albeit less dramatically than taxes on capital, while government spending changes does not appear to be a significant automatic stabilizer. Transfers respond to output slightly less when labor supply is unrestricted. In comparison to the findings of LPT, capital taxes and transfers react more strongly to fluctuations in output while labor taxes are significantly less responsive. Additionally, exogenous changes to capital and labor tax rates tend to occur together, as the capital-labor tax comovement term is positive and different from zero. Meanwhile, there appears to be little or no comovement of consumption tax rates with either capital or labor taxes. As LPT point out, this seems to indicate that Congress jointly considers changes in labor and capital taxes while consumption taxes are little used in concert with other tax instruments to affect changes in the economy's fiscal disposition.

4.2 Impulse Responses

The impulse response functions for a one standard deviation shock to each fiscal instrument are plotted in figures 1-10. The solid line is the response generated using the posterior mean parameter values while the dashed lines give the response at the 5th and 95th percentile of the posterior. Each figure shows the path of nine endogenous variables following the fiscal shock. Time is measured on the x-axis in years.

Figures 1 and 2 illustrate the effect of a one standard deviation increase in government spending. Under both labor supply specifications the response of Ricardian households is

[12] Note that all of the fiscal policy parameters are positive since sign restrictions are imposed in the fiscal policy rules, equations (13)-(17).

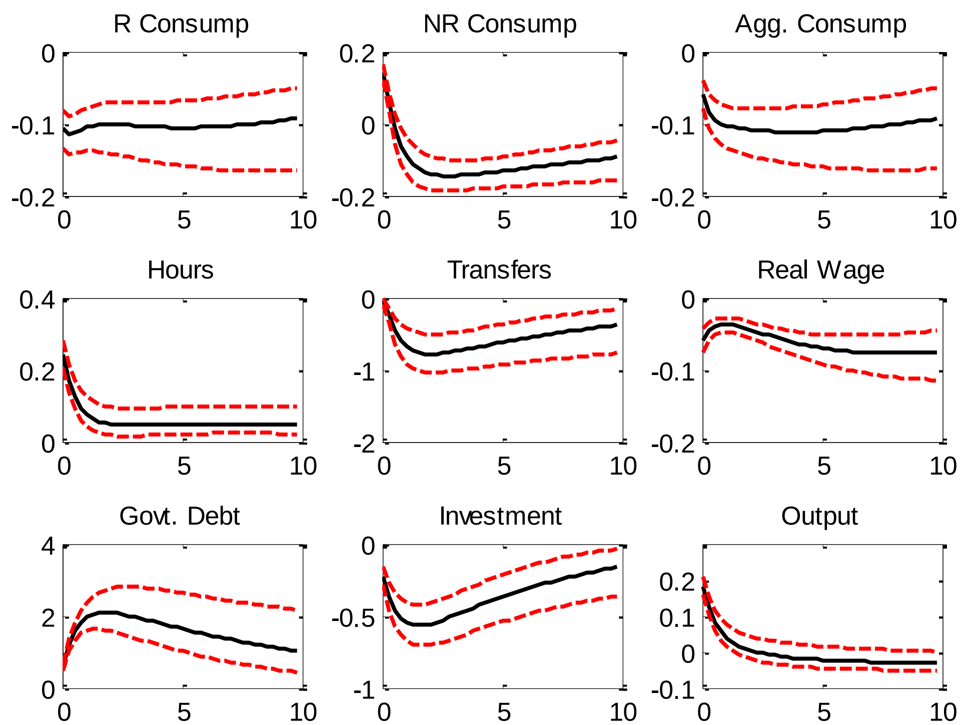

Figure 1. Estimated impulse responses to a one standard deviation increase in government spending, with restricted labor supply. The solid line is the mean response; the dashed lines represent the 5th and 95th percentile of the posterior distribution.

standard: an increase in government spending raises the interest rate and crowds out investment spending. Furthermore, the shock creates a negative wealth effect which induces households to compensate by increasing work effort. When labor supply is restricted, the increase in hours worked spans both types of households, leading to an increase in aggregate output. The response of output allows for a path that remains above steady-state for ten years, even as Ricardian households continue to reduce investment spending in response to higher capital taxes. The reduction in the expected present value of income also induces optimizing households to reduce consumption. In contrast, non-Ricardian households experience no such negative wealth effect on impact. The increased work effort leads to greater disposable income and higher consumption initially. This offsetting effect leads to a smaller reduction in aggregate

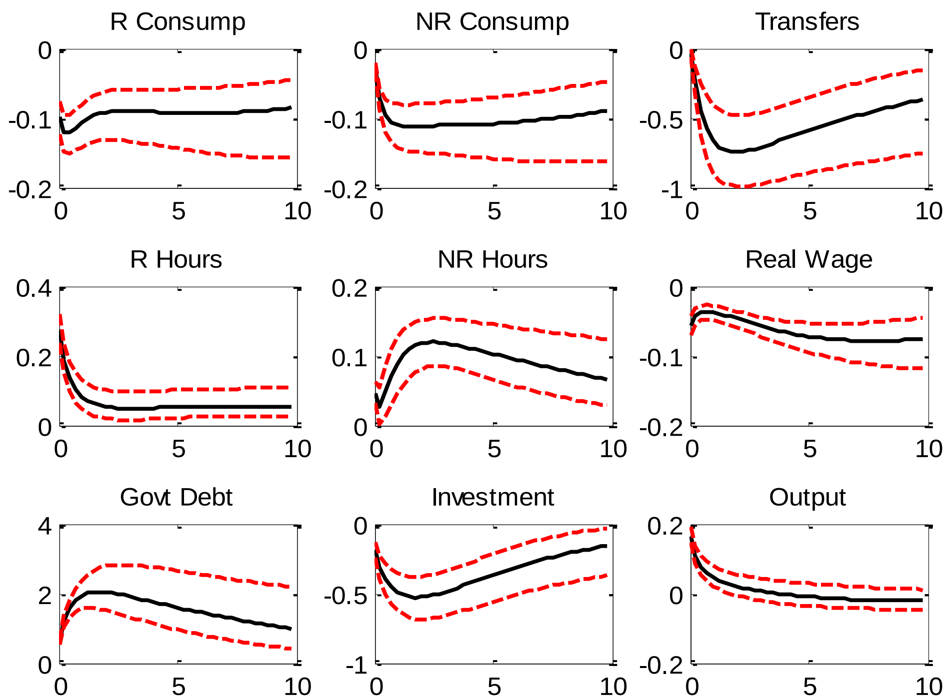

Figure 2. Estimated impulse responses to a one standard deviation increase in government spending, with unrestricted labor supply. The solid line is the mean response; the dashed lines represent the 5th and 95th percentile of the posterior distribution.

consumption than would be seen if all agents were fully rational. However, this effect is short lived. The increase in debt that results from the spending increase is financed in part by higher labor taxes, which reduces disposable income for non-Ricardians (an effect fully anticipated by Ricardians). Non-Ricardian income is further reduced as the part of the debt is retired by a decrease in transfer payments. After a few years, the paths of Ricardian and non-Ricardian consumption are very similar.In contrast, the behavior of non-Ricardians is markedly different when labor supply is unrestricted. Without inheriting the negative wealth effect of Ricardians, there is no immediate increase in hours worked. It is only after tax rates respond to the increased government debt that Ricardians respond to lower disposable income by decreasing consumption and increasing hours worked, at which time Ricardian hours are already returning to steady state.

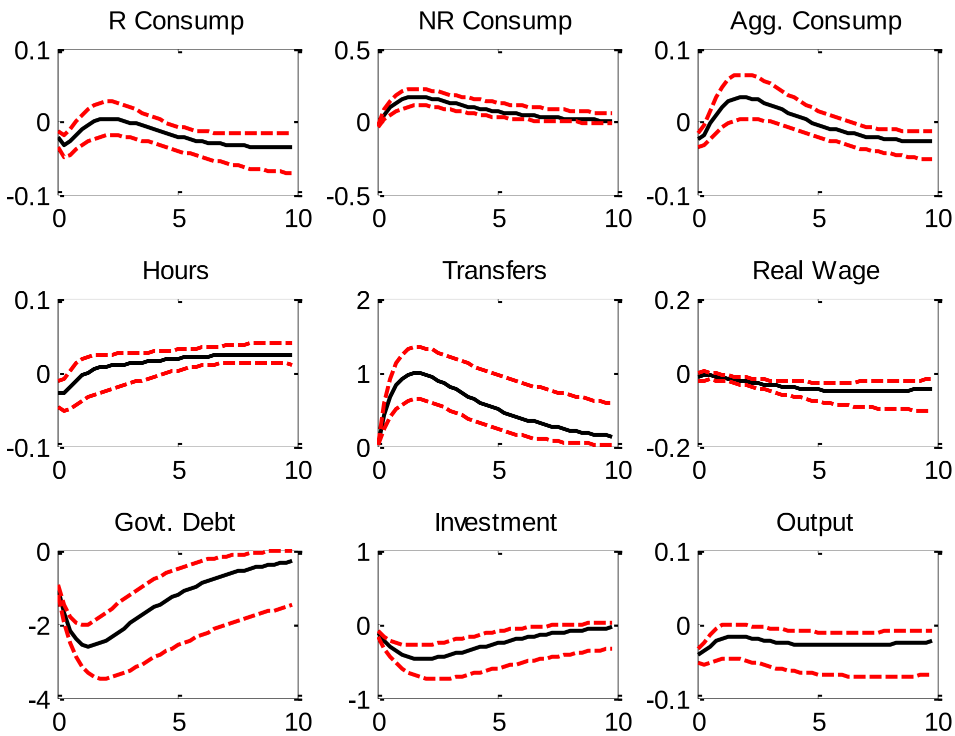

Figure 3. Estimated impulse responses to a one standard deviation increase in capital taxes, with restricted labor supply. The solid line is the mean response; the dashed lines represent the 5th and 95th percentile of the posterior distribution.

As a result, the path of aggregate hours is smoother than would be without the presence of non-Ricardians. Without the immediate boost in non-Ricardian hours worked and consumption, it follows that, upon impact, the aggregate demand effect of a government spending shock is weaker when labor supply is unrestricted.

Figures 3 and 4 present the effect of a one standard deviation increase in the capital tax rate. Established theory predicts a contemporaneous decrease in investment, labor hours, and output. The benefit of saving and investing is diminished, inducing optimizing households to trade current for future consumption. However, standard theory does not hold with heterogeneous households and the rich fiscal policy rules estimated in this paper. Since capital and labor taxes are positively related, the increase in capital taxes also ushers in higher labor taxes which reduces work effort in Ricardian households and causes a reduction in consumption on impact. As debt is retired and output lingers below steady state, Ricardian households expect a concomitant fall in capital and labor taxes. This increases work effort and investment after a few years, bringing output closer to its steady state value. With restricted labor supply, this effect is inherited by non-Ricardian households but is quickly offset as the reduction in government debt leads to an increase in transfer payments and a decrease in labor taxes that boosts disposable income. The result is an increase in non-Ricardian consumption that diminishes as debt returns to steady state, but remains positive throughout the transition period.

With unrestricted labor supply, non-Ricardians increase labor supply to compensate for lower income and consumption upon impact. This effect is reversed as transfers increase and capital and labor taxes decrease as a result of debt being retired. The subsequent increase in income causes non-Ricardians to consume more and work less. As debt returns to steady state, hours worked and consumption follow suit but stay below steady state for many years as output remains lower.

The effect of a one standard deviation increase in the labor tax rate is illustrated in figures 5 and 6. The response of Ricardian households, as expected, is to reduce hours worked which leads to lower income, consumption, and output on impact. In contrast, non-Ricardians increase consumption shortly after impact when labor supply is restricted. This is owed to the fact that hours begin to increase after a few periods and the reduction in after-tax labor income is offset by higher transfers. As debt is retired labor taxes begin to fall, transfers continue to increase, and output recovers, further boosting non-Ricardian consumption. The paths of investment and output allow for a variety of outcomes, reflecting the underlying uncertainty in the path of

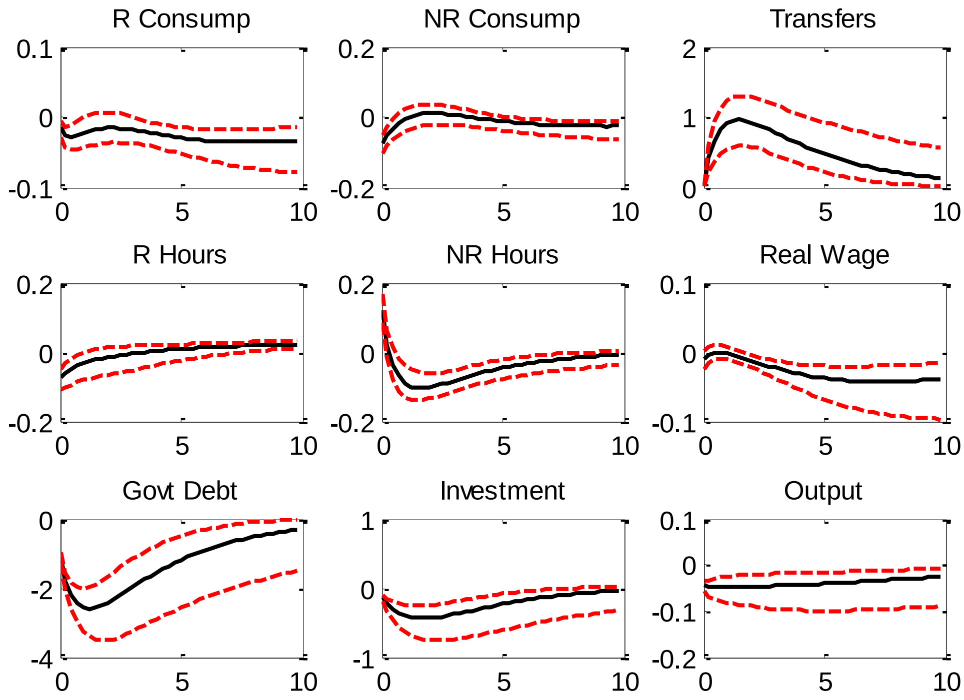

Figure 4. Estimated impulse responses to a one standard deviation increase in capital taxes, with unrestricted labor supply. The solid line is the mean response; the dashed lines represent the 5th and 95th percentile of the posterior distribution.

government debt. Unlike LPT, the impulse responses for the non-Ricardian model presented here allow for output to climb above steady state after a few periods. Standard theory predicts a decrease in investment with a reduction in labor supply as the returns to capital decline. This effect is enhanced in this model since capital and labor taxes are correlated and even further bolstered when output is above steady state, triggering an automatic stabilizer. However, in the model presented here investment can rise above or fall below steady state as several interconnected relationships play out. As debt decreases over several periods, capital taxes also decrease, stimulating investment. This effect is enhanced if output stays below steady state, which further reduces the capital tax and may lead to a substantial overall increase in investment.

When the restriction on labor supply is removed, non-Ricardians again behave differently

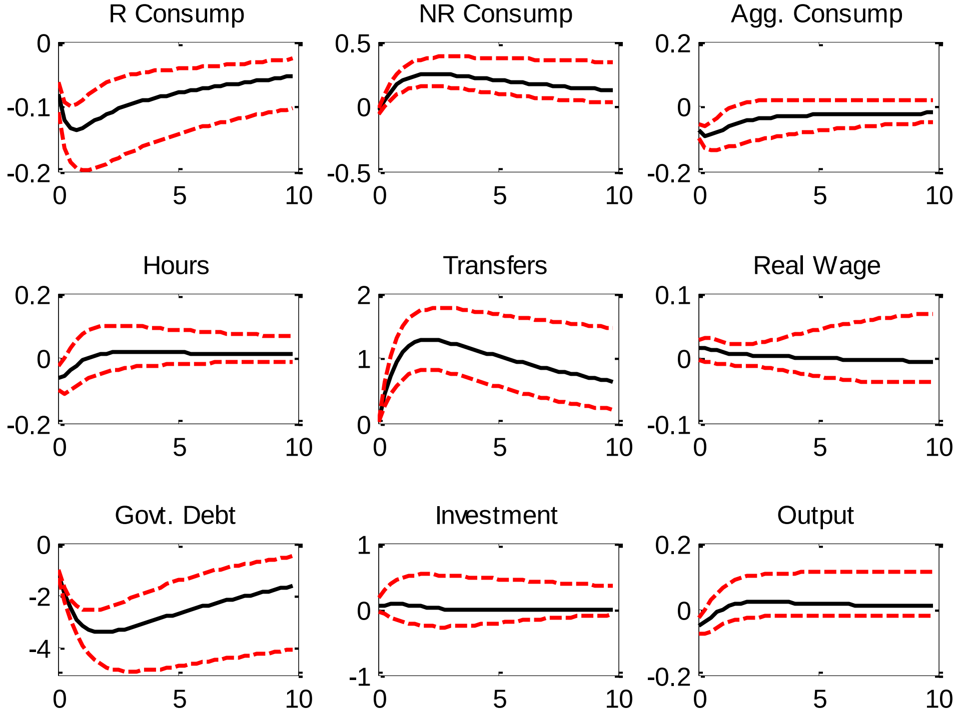

Figure 5. Estimated impulse responses to a one standard deviation increase in labor taxes, with restricted labor supply. The solid line is the mean response; the dashed lines represent the 5th and 95th percentile of the posterior distribution.

than in the restricted model. As one might expect, the labor tax shock causes non-Ricardian consumption to be lower on impact. However, labor hours actually *increase* after an increase in labor taxes. All else equal, non-Ricardian labor supply is inversely related to both consumption and the labor tax rate. It must be that the increased marginal utility of consumption is enough incentive to increase hours worked, even in the face of rising taxes. The resulting aggregate labor impulse response function is remarkably smooth as the labor supply decisions of the two household types cancel each other out. As with the capital tax innovation, as debt is retired both capital and labor taxes fall which boosts disposable income and consumption.

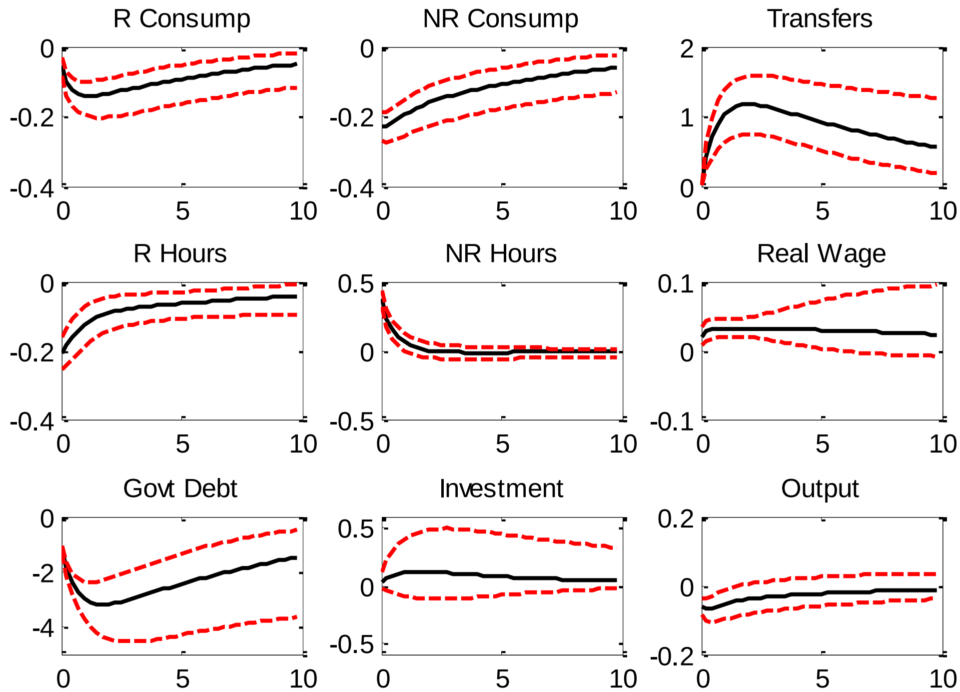

Figure 6. Estimated impulse responses to a one standard deviation increase in labor taxes, with unrestricted labor supply. The solid line is the mean response; the dashed lines represent the 5th and 95th percentile of the posterior distribution.

Figures 7 and 8 show the impulse response resulting from a one standard deviation increase in transfer payments. Similar to a government spending innovation, the increase in transfers creates a negative wealth effect, inducing an increase in hours worked for Ricardians. Since transfer payments enter directly into the consumption function of non-Ricardian households, these agents display an increase in consumption that is amplified significantly by the increase in hours worked inherited from Ricardians. Contrary to the fully rational model of LPT, the effect creates a much larger response of aggregate consumption in the short run, enough to push output above steady state upon impact. The mild stimulus is reversed shortly thereafter though as the transfers are financed by higher debt that must be retired via capital and labor

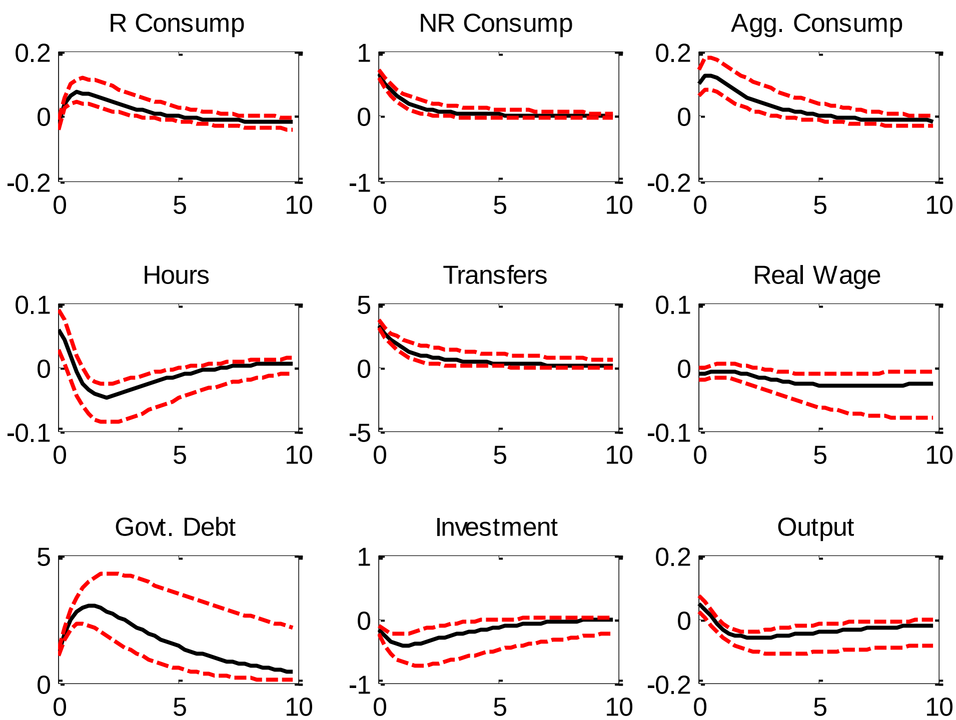

Figure 7. Estimated impulse responses to a one standard deviation increase in transfers, with restricted labor supply. The solid line is the mean response; the dashed lines represent the 5th and 95th percentile of the posterior distribution.

taxes. This eventually induces a reduction in hours worked and investment spending, causing output to fall below steady state. When labor supply is not restricted, the increase in transfers boosts non-Ricardian consumption, but by a much smaller amount. The increase in current disposable income leads non-Ricardians to trade off consumption for leisure rather than increasing hours worked like Ricardians. Even though aggregate consumption rises, output falls below steady state for many years after the innovation as investment is crowded out upon impact and further reduced as debt is retired in part through higher capital taxes.

Finally, the responses to an increase in the consumption tax rate are displayed in figures 9

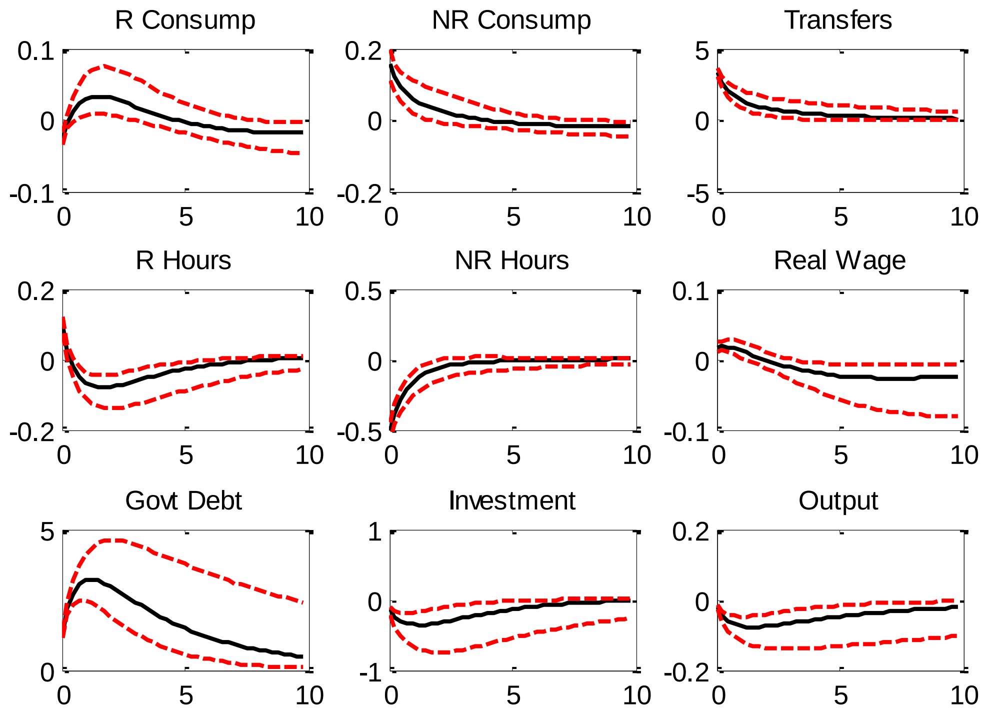

Figure 8. Estimated impulse responses to a one standard deviation increase in transfers, with unrestricted labor supply. The solid line is the mean response; the dashed lines represent the 5th and 95th percentile of the posterior distribution.

and 10. Since consumption taxes represent such a small percentage of tax revenue collected, all effects are mild. As expected, Ricardian consumption is reduced in the face of an increase in consumption taxes. Investment rises as consumers save more, spend less, and enjoy reduced capital taxes. When labor supply is restricted, non-Ricardian consumption actually rises slightly above steady-state after an increase in consumption taxes. This is owed to an increase in transfer payments and a reduction in labor taxes that results from paying down government debt, coupled with an increase in work effort induced by the negative wealth effect experienced by Ricardians. In the unrestricted model, the effect is similar to the response after a labor tax shock in that consumption decreases in the face of lower after-tax income, inducing greater work effort.

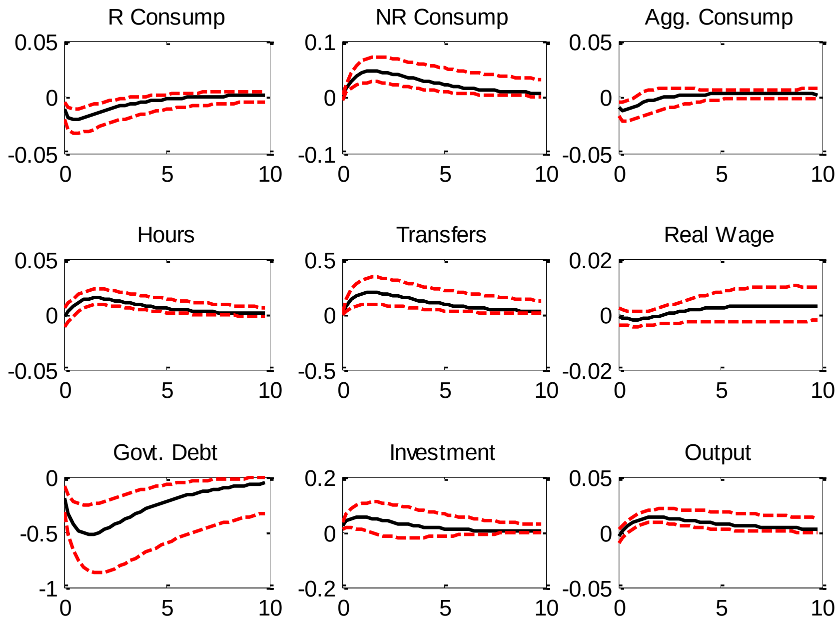

Figure 9. Estimated impulse responses to a one standard deviation increase in consumption taxes, with restricted labor supply. The solid line is the mean response; the dashed lines represent the 5th and 95th percentile of the posterior distribution.

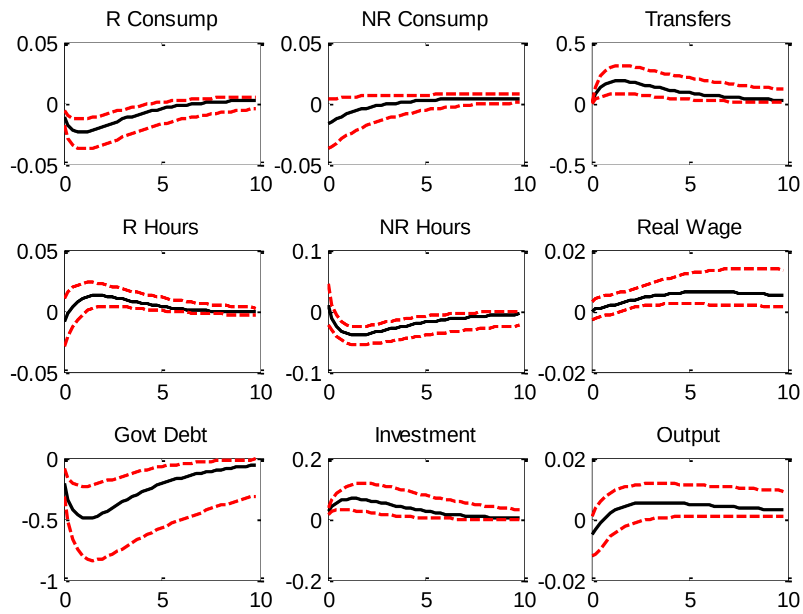

Figure 10. Estimated impulse responses to a one standard deviation increase in consumption taxes, with unrestricted labor supply. The solid line is the mean response; the dashed lines represent the 5th and 95th percentile of the posterior distribution.

4.3 Present-Value Multipliers

Throughout the fiscal policy literature, the quantitative effects of fiscal adjustments are commonly reported via Keynesian-style multipliers. It is less common though to report multipliers in terms of present discounted value. Following Mountford and Uhlig (2008) and LPT, I report present-value multipliers, which provide a more accurate assessment of the costs and benefits of fiscal adjustments that affect the economy well into the future. Present-value multipliers represent the present value of the change in a model variable over a k-period horizon that is induced by a change in a fiscal instrument (in this case, a one standard deviation shock). For instance, the present value of the change in output in response to a change in government spending is calculated as:

$$\frac{E_t \sum_{j=0}^{k} \left(\prod_{i=0}^{j} R_{t+i}^{-1} \right) \Delta Y_{t+j}}{E_t \sum_{j=0}^{k} \left(\prod_{i=0}^{j} R_{t+i}^{-1} \right) \Delta G_{t+j}}$$

Results are reported in tables 4 and 5. The impact multiplier is given for $k = 0$, while the cumulative, or long-run effect is given as k approaches infinity. In addition to point estimates for the multipliers, I also report the 5th and 95th percentile of the posterior distribution. This practice provides a more accurate characterization of the uncertainty inherent in the estimation process[13].

Generally speaking, the multipliers reported here are similar to those found by LPT, with a few noteworthy differences. As is typical with real business cycle models (see Uhlig (2010) for another example), the government spending present-value multipliers for output reported in both studies tend to be somewhat smaller than typically found in the empirical literature. With restricted labor supply, I find the multiplier ranges from .63 to .76 upon impact; however, unlike those reported by LPT, the mean multiplier turns negative in the long run as the increased gov-

[13] A special thanks to Nora Traum for a useful comment regarding this matter.

	Impact	5 quarters	10 quarters	25 quarters	∞		Impact	5 quarters	10 quarters	25 quarters	∞
Government spending present-value multipliers						*Labor tax present-value multipliers*					
	0.577	0.299	0.133	-0.013	-0.303		-0.226	-0.303	-0.317	-0.329	-0.352
ΔY	**0.634**	**0.386**	**0.232**	**0.133**	**-0.064**	ΔY	**-0.159**	**-0.186**	**-0.177**	**-0.158**	**-0.135**
	0.701	0.491	0.349	0.289	0.167		-0.102	-0.087	-0.052	0.012	0.125
	-0.289	-0.409	-0.445	-0.531	-0.822		-0.231	-0.382	-0.444	-0.481	-0.491
ΔC	**-0.242**	**-0.342**	**-0.364**	**-0.436**	**-0.670**	ΔC	**-0.175**	**-0.296**	**-0.340**	**-0.365**	**-0.355**
	-0.194	-0.276	-0.291	-0.350	-0.527		-0.134	-0.232	-0.265	-0.281	-0.242
	-0.155	-0.336	-0.452	-0.558	-0.530		-0.015	-0.034	-0.052	-0.074	-0.067
ΔI	**-0.124**	**-0.272**	**-0.361**	**-0.431**	**-0.395**	ΔI	**0.015**	**0.040**	**0.054**	**0.063**	**0.058**
	-0.089	-0.194	-0.254	-0.295	-0.263		0.055	0.137	0.194	0.246	0.238
Capital tax present-value multipliers						*Transfers present-value multipliers*					
	-0.212	-0.366	-0.508	-0.790	-1.250		-0.068	-0.251	-0.411	-0.670	-1.031
ΔY	**-0.159**	**-0.247**	**-0.327**	**-0.514**	**-0.791**	ΔY	**-0.045**	**-0.191**	**-0.324**	**-0.521**	**-0.704**
	-0.125	-0.168	-0.207	-0.328	-0.504		-0.031	-0.150	-0.266	-0.425	-0.519
	-0.113	-0.185	-0.225	-0.365	-0.807		0.008	0.025	0.031	-0.022	-0.254
ΔC	**-0.076**	**-0.104**	**-0.102**	**-0.176**	**-0.495**	ΔC	**0.015**	**0.064**	**0.104**	**0.094**	**-0.059**
	-0.048	-0.037	0.000	-0.037	-0.297		0.028	0.111	0.185	0.218	0.131
	-0.125	-0.366	-0.591	-0.861	-0.878		-0.094	-0.254	-0.397	-0.579	-0.605
ΔI	**-0.084**	**-0.253**	**-0.421**	**-0.624**	**-0.602**	ΔI	**-0.059**	**-0.166**	**-0.260**	**-0.355**	**-0.340**
	-0.059	-0.177	-0.302	-0.459	-0.427		-0.040	-0.108	-0.157	-0.185	-0.169

Table 4. Present-value multipliers for various time horizons. Estimates at the 5th percentile (top row), mean (bold type), and 95th percentile (bottom row) of the posterior. For the case of unrestricted labor supply.

	Impact	5 quarters	10 quarters	25 quarters	∞		Impact	5 quarters	10 quarters	25 quarters	∞
Government spending present-value multipliers						*Labor tax present-value multipliers*					
	0.627	0.318	0.146	-0.070	-0.374		-0.195	-0.195	-0.165	-0.153	-0.200
ΔY	**0.684**	**0.405**	**0.248**	**0.068**	**-0.156**	ΔY	**-0.131**	**-0.077**	**-0.018**	**0.029**	**0.036**
	0.755	0.517	0.382	0.241	0.091		-0.067	0.058	0.158	0.265	0.389
	-0.223	-0.352	-0.429	-0.574	-0.869		-0.197	-0.271	-0.281	-0.271	-0.290
ΔC	**-0.171**	**-0.285**	**-0.352**	**-0.474**	**-0.732**	ΔC	**-0.146**	**-0.179**	**-0.160**	**-0.133**	**-0.136**
	-0.114	-0.215	-0.276	-0.381	-0.581		-0.112	-0.104	-0.055	-0.006	0.034
	-0.184	-0.383	-0.494	-0.580	-0.558		-0.023	-0.061	-0.104	-0.161	-0.157
ΔI	**-0.145**	**-0.311**	**-0.400**	**-0.458**	**-0.424**	ΔI	**0.014**	**0.029**	**0.026**	**0.007**	**-0.0003**
	-0.104	-0.224	-0.286	-0.319	-0.286		0.075	0.166	0.212	0.244	0.232
Capital tax present-value multipliers						*Transfers present-value multipliers*					
	-0.203	-0.265	-0.322	-0.497	-0.900		0.058	-0.057	-0.206	-0.460	-0.797
ΔY	**-0.157**	**-0.162**	**-0.173**	**-0.294**	**-0.585**	ΔY	**0.112**	**0.027**	**-0.112**	**-0.324**	**-0.512**
	-0.127	-0.094	-0.081	-0.164	-0.348		0.169	0.100	-0.045	-0.249	-0.357
	-0.103	-0.092	-0.056	-0.098	-0.490		0.116	0.200	0.225	0.180	-0.041
ΔC	**-0.071**	**-0.014**	**0.069**	**0.080**	**-0.232**	ΔC	**0.178**	**0.296**	**0.333**	**0.301**	**0.148**
	-0.048	0.052	0.179	0.235	-0.045		0.250	0.402	0.449	0.423	0.320
	-0.119	-0.347	-0.564	-0.841	-0.882		-0.096	-0.262	-0.401	-0.559	-0.585
ΔI	**-0.087**	**-0.262**	**-0.442**	**-0.669**	**-0.666**	ΔI	**-0.065**	**-0.186**	**-0.285**	**-0.370**	**-0.358**
	-0.066	-0.197	-0.334	-0.507	-0.482		-0.044	-0.128	-0.190	-0.215	-0.195

Table 5. Present-value multipliers for various time horizons. Estimates at the 5th percentile (top row), mean (bold type), and 95th percentile (bottom row) of the posterior. For the case of restricted labor supply.

ernment debt is retired in part by levying distortionary taxes. The discrepancy is due to slightly more crowding out of investment and consumption expenditures. Even with the increased crowd out of consumption in the long run, the consumption multiplier upon impact is less negative than found by LPT, bringing the model's findings closer to empirical results that generally put the multiplier slightly above zero. Whether or not a larger fraction of Ricardian consumers can bring the consumption multiplier above zero will be examined below. In the unrestricted model, the initial effect upon aggregate demand is smaller and the consumption multiplier more negative since non-Ricardians do not experience a negative wealth effect, and only increase hours worked gradually over time. The long-run government spending multipliers vary little with the specification of labor supply.

The mean capital and labor tax multipliers on output have the expected negative signs upon impact. In each case the tax multiplier for output is modest upon impact, significantly smaller than the government spending multipliers. The long-run capital tax multiplier is much larger in absolute value than the impact multiplier, reflecting the harmful effect the taxation has on investment and capital accumulation over a longer time horizon. In the restricted model the long-run effect on output is smaller than reported by LPT, as the presence of rule of thumb consumers dampened consumption crowd out substantially. The unrestricted model produced multipliers that are nearly identical to those found by LPT. The consumption multiplier is more strongly negative, which leads to a long-run output multiplier of nearly -.8.

In both labor supply scenarios the long-run labor tax multiplier is slightly positive at the mean, but not significantly different from zero as displayed by the 95% confidence set. This result stands in contrast to the findings of LPT who report a long-run multiplier of -.21. When non-Ricardians are allowed to optimize intratemporally, the long-run mean multiplier on output turns negative as more consumption is lost. In both cases there appears to be a small amount of crowding-in of investment following a labor tax shock, which keeps output close to its steady state value. In each case the decrease in government debt that accompanies the tax shock triggers more wealth redistribution in the form of transfer payments, off-setting the decrease in disposable income and stimulating non-Ricardian consumption.

Perhaps the most interesting results are found in the transfers multipliers. In the case of restricted labor supply, non-Ricardian consumers increase consumption dramatically with the increase in current disposable income, causing aggregate consumption to increase in the short and long run. The effect is large enough to create a positive output multiplier upon impact. However, the stimulus is short lived; the increase in debt created by larger transfer payments triggers an increase in distortionary taxation and a decrease in government spending that brings the output multiplier below zero after ten quarters, and markedly negative in the long run. Since the data indicate that capital taxes react most strongly to debt, investment and capital accumulation suffer in the long run. In the unrestricted specification, consumption is not boosted nearly as much since non-Ricardians choose to work fewer hours with the increase in income. As a result, the output multiplier is negative on impact and more strongly negative in the long run.

4.4 Fraction of non-Ricardian Consumers

As mentioned above, previous estimates of the fraction of non-Ricardians vary substantially. In this paper, when labor supply is restricted the estimate is 20% while the unrestricted specification yields an estimate of 70%. Therefore, it is important to explore how the results change as the fraction on non-Ricardians varies. Of particular interest in previous

Fraction of NR (γ)	0.2		0.3		0.4		0.5		0.6		0.7	
	impact	LR	impact	LR	impact	LR	impact	LR	impact	LR	impact	LR
Government spending present-value multipliers												
ΔY	0.68	-0.16	0.72	-0.15	0.77	-0.14	0.82	-0.13	0.88	-0.12	0.95	-0.11
ΔC	-0.17	-0.73	-0.12	-0.73	-0.07	-0.73	-0.004	-0.72	0.07	-0.72	0.16	-0.71
ΔI	-0.15	-0.42	-0.16	-0.42	-0.17	-0.42	-0.18	-0.41	-0.19	-0.41	-0.20	-0.40
Capital tax present-value multipliers												
ΔY	-0.16	-0.58	-0.16	-0.52	-0.16	-0.45	-0.16	-0.37	-0.17	-0.28	-0.17	-0.19
ΔC	-0.07	-0.23	-0.07	-0.12	-0.08	0.00	-0.08	0.13	-0.09	0.27	-0.10	0.41
ΔI	-0.09	-0.67	-0.08	-0.71	-0.08	-0.77	-0.08	-0.82	-0.08	-0.87	-0.08	-0.92
Labor tax present-value multipliers												
ΔY	-0.13	0.04	-0.12	0.11	-0.11	0.19	-0.10	0.28	-0.08	0.38	-0.06	0.49
ΔC	-0.15	-0.14	-0.15	-0.04	-0.14	0.07	-0.14	0.18	-0.13	0.31	-0.12	0.44
ΔI	0.01	0.00	0.02	-0.02	0.03	-0.05	0.04	-0.08	0.05	-0.11	0.06	-0.14
Transfers present-value multipliers												
ΔY	0.11	-0.51	0.18	-0.49	0.27	-0.47	0.37	-0.44	0.49	-0.41	0.63	-0.42
ΔC	0.18	0.15	0.27	0.21	0.37	0.27	0.49	0.34	0.63	0.41	0.80	0.48
ΔI	-0.07	-0.36	-0.08	-0.40	-0.10	-0.44	-0.12	-0.47	-0.14	-0.51	-0.16	-0.54

Table 4. Present-value multipliers for various fractions of non-Ricardian consumers, with restricted labor supply. Evaluated at the posterior mean. For each fraction, both impact and long-run (k=∞) multipliers are given.

studies is the effect of government spending shocks on consumption and investment. Standard real business cycle analysis produces negative consumption and investment multipliers after a government spending shock, but this seems to be at odds with much of the empirical evidence.[14] Can a high enough proportion of non-Ricardians generate a positive consumption multiplier, even without nominal rigidities and/or central bank intervention? To what extent does the fraction of non-Ricardians affect investment crowd out and capital accumulation? To help answer these questions, tables 6 and 7 report fiscal multipliers for various values of γ, holding all other parameters constant at their estimated values based on the posterior mean.

As the fraction of rule-of-thumb consumers approaches 70% in the restricted model, the

[14] For a discussion of this topic, see Galí et al., 2007

Fraction of NR (γ)	0.2		0.3		0.4		0.5		0.6		0.7	
	impact	LR	impact	LR	impact	LR	impact	LR	impact	LR	impact	LR
Government spending present-value multipliers												
ΔY	0.634	-0.064	0.62	-0.05	0.61	-0.04	0.60	-0.03	0.58	0.00	0.55	0.03
ΔC	-0.242	-0.670	-0.24	-0.67	-0.24	-0.66	-0.24	-0.66	-0.24	-0.65	-0.24	-0.65
ΔI	-0.124	-0.395	-0.13	-0.39	-0.15	-0.38	-0.16	-0.37	-0.19	-0.35	-0.22	-0.32
Capital tax present-value multipliers												
ΔY	-0.159	-0.791	-0.15	-0.84	-0.14	-0.89	-0.13	-0.97	-0.12	-1.07	-0.10	-1.20
ΔC	-0.076	-0.495	-0.08	-0.51	-0.08	-0.53	-0.08	-0.55	-0.08	-0.58	-0.08	-0.63
ΔI	-0.084	-0.602	-0.08	-0.63	-0.07	-0.67	-0.06	-0.72	-0.04	-0.78	-0.02	-0.87
Labor tax present-value multipliers												
ΔY	-0.159	-0.135	-0.14	-0.11	-0.12	-0.09	-0.10	-0.06	-0.06	-0.03	0.00	0.01
ΔC	-0.175	-0.355	-0.18	-0.35	-0.18	-0.34	-0.18	-0.33	-0.18	-0.31	-0.17	-0.30
ΔI	0.015	0.058	0.03	0.07	0.05	0.09	0.08	0.10	0.12	0.12	0.17	0.15
Transfers present-value multipliers												
ΔY	-0.045	-0.704	-0.06	-0.74	-0.08	-0.78	-0.10	-0.84	-0.13	-0.91	-0.18	-0.99
ΔC	0.015	-0.059	0.02	-0.07	0.02	-0.08	0.02	-0.09	0.02	-0.11	0.02	-0.13
ΔI	-0.059	-0.340	-0.08	-0.36	-0.09	-0.38	-0.12	-0.40	-0.16	-0.42	-0.21	-0.42

Table 5. Present-value multipliers for various fractions of non-Ricardian consumers, with unrestricted labor supply. Evaluated at the posterior mean. For each fraction, both impact and long-run ($k=\infty$) multipliers are given.

output multiplier upon impact following a spending shock approaches unity. The increased stimulus is a result of less consumption crowd-out since non-Ricardians do not anticipate future tax increases to retire the new government debt. At a value of γ slightly higher than .5, roughly the fraction suggested by Campbell and Mankiw (1989), the consumption response does in fact become positive. This matters little though in the end: long-run multipliers vary only slightly as both consumer types eventually respond to the retirement of debt via distortionary taxes and reduced transfers. This effect is mirrored in the responses of consumption and output to a change in transfers. As the fraction of non-Ricardians increases, an increase in transfers will generate a larger short-run stimulus. The consumption multiplier peaks as .8 while the output multiplier reaches .63 upon impact, considerably larger than the baseline estimates. The long-run multiplier remains negative however, and varies little with changes in γ.

When labor supply is unrestricted, there are two surprising results after a government spending innovation. First, there is no tendency for the impact multiplier on consumption to increase with the fraction of non-Ricardians. This is the case since both Ricardians and non-Ricardians initially respond in essentially the same way to a spending shock, by reducing consumption. Second, the output multiplier after a capital tax shock tends to decrease as gamma increases. In the long-run, the output multiplier in the restricted model is nearly double that of the unrestricted model. This happens because the wealth effect is no longer inherited from Ricardians, leading aggregate hours to increase less after the shock. When the fraction of non-Ricardians reaches .70, the government spending multipliers are similar to those reported by LPT for the fully rational model.

The effect of a capital tax shocks also intensifies as the fraction of non-Ricardians increases in the unrestricted specification. The long-run investment multiplier approaches -.9, while the mean response of output to a capital tax innovation is -1.2 —significantly larger than both the restricted model in this paper and the fully rational model when all instruments adjust. The primary driver of this discrepancy is the consumption multiplier after the capital tax shock. In the unrestricted model, non-Ricardian consumption declines substantially in the long run. The long-run output multiplier after a transfers innovation is also larger, owed to more investment crowd-out throughout the transition period as capital taxes finance deficit spending. The multiplier approaches unity as the fraction of non-Ricardians reaches 70 percent.

4.5 Posterior Odds

The previous results considered a variety of model specifications that generated different impulse responses and fiscal multipliers. Which of these specifications is favored by the data? Additionally, the results reported by LPT suggest transfers are important for debt stabilization. Does this strong preference for transfer financing persist in the presence of non-Ricardian behavior? To answer these types of questions it is common to examine posterior model probabilities, which assess the degree of support for a particular specification (Koop, 2003). Generally comparisons are made between two competing models using the posterior odds ratio, which is simply the ratio of posterior model probabilities. When each model is assigned an equal probability of occurring the posterior odds ratio boils down to Bayes factor, which is calculated

Model Specification	Log-Marginal Likelihood	Bayes Factor relative to unrestricted labor supply, γ=.7
Unrestricted labor supply, γ=.7	-60	1.0
Unrestricted labor supply, γ=.2	-89	exp[29]
Restricted labor supply, γ=.2	-98	exp[38]
Unrestricted, , γ=.2, no transfers/debt response	-97	exp[37]
Fully rational, γ=0	-91	exp[31]

Table 6. Model Fit Comparisons

as the ratio of marginal likelihoods. I calculate the log-marginal likelihood and Bayes factor for various model specifications by applying Geweke's (1999) modified harmonic mean estimator[15] to the posterior simulation draws.

Results are reported in table 8 for several specifications of labor supply and gamma. For comparison, I also performed additional simulations for the fully rational model in which γ=0, and the unrestricted model in which the transfer response to debt has been turned off, i.e. γ_z=0. The data exhibit a strong preference for the unrestricted model in which the fraction of non-Ricardians is estimated to be .70. The unrestricted model in which gamma was fixed at .20 is

[15] Results are reported with a truncation parameter of .5. The results varied little with changes in the parameter.

only slightly favored over the fully rational specification of LPT. The data provide somewhat less support for both the restricted labor supply specification and the model in which the transfer-debt response has been eliminated. Taken together, the Bayes factors indicate support for household heterogeneity and unrestricted labor supply. That transfers response to debt is also important, though as expected, the preference is less dramatic than reported by LPT.

4.6 Present-value financing

I now repeat the present-value financing exercise performed by LPT for the unrestricted model where γ=.20. I calculate present-value decompositions of debt to determine what combination of adjustments in the expected paths of fiscal policy instruments and discount rates rationalize the observed value of government debt, and how these adjustments vary with the type of shock. In log-linearized form, the government's present-value relation is

$$\hat{B}_t = E_t \sum_{j=1}^{\infty} \beta^j \left[\left(\frac{T^k}{B}\right) \hat{T}^k_{t+j} + \left(\frac{T^l}{B}\right) \hat{T}^l_{t+j} + \left(\frac{T^c}{B}\right) \hat{T}^c_{t+j} - \left(\frac{G}{B}\right) \hat{G}_{t+j} - \left(\frac{Z}{B}\right) \hat{Z}_{t+j} - \left(\frac{1}{B}\right) \hat{R}_{t+j-1} \right]$$

where the unscripted variables represent steady state values and $\hat{T}^k_{t+j}$, $\hat{T}^l_{t+j}$, and $\hat{T}^c_{t+j}$ are real capital, labor, and consumption tax revenues respectively. This expression decomposes fluctuations in real debt into expected changes in the components of net-of-interest surpluses, at constant discount rates, and expected changes in real discount rates.

The results presented in table 9. The table shows the present-value components following an innovation to each exogenous process. Each shock is calibrated to raise or lower debt by one unit of the final good. When the components have the same sign as the change in

Variable	Shock								
	ε^a	ε^b	ε^l	ε^i	ε^g	ε^{tk}	ε^{tl}	ε^{tc}	ε^z
G	-7.84	7.19	11.90	2.21	-28.29	-1.78	-3.69	-1.81	1.98
T^k	10.00	4.07	-16.41	-4.57	10.16	5.14	-6.29	-2.35	3.56
T^l	16.25	-3.24	-25.74	-6.13	4.42	1.66	21.84	-3.88	1.25
T^c	2.38	-0.38	-3.93	-0.33	-0.50	0.02	-0.31	12.91	-0.01
Z	-25.20	23.60	38.19	7.04	15.95	-6.00	-12.37	-6.05	-5.66
R	3.42	-30.24	-3.01	2.77	-0.75	-0.04	-0.19	0.18	-0.11
Surplus	-4.42	31.24	4.01	-1.77	1.75	-0.96	-0.81	-1.18	1.11
ΔB	-1	+1	+1	+1	+1	-1	-1	-1	+1

Table 7. Present-value financing using the posterior mean for the unrestricted model, gamma=.2. Shocks normalized to raise or lower debt by one unit. The first five rows sum to the Surplus value in the seventh row. R and Surplus sum to the change in debt.

debt, the component is expected to stabilize debt; when the signs differ, the component pushes debt further from its steady state value. For example, after a government spending shock, capital and labor tax revenues increase, thereby helping stabilize debt, while consumption tax revenues move in the opposite direction. Overall, the present value of surpluses moves to support debt, but the discount rate does not. The increase in government spending forces the interest rate higher, leading to higher interest payments. Similar results hold for technology and preference shocks.

Generally speaking, the results are largely similar to those found by LPT. The fiscal dynamics vary significantly dependent upon which fiscal instrument is responsible for the initial change in debt. For both capital and labor taxes, the discount rate and surpluses each move to stabilize debt, though the discount rate plays a larger role after a labor tax shock. After a capital tax shock, labor and consumption tax revenues also increase, pushing debt further away from its steady state value. Government spending and transfers also rise though, eventually stabilizing the path of debt. After a consumption tax innovation, the present value of surpluses does most of the work stabilizing debt. A transfers innovation is also resolved solely by changes in the present value of surpluses while the discount rate is expected increase and push debt higher.

When compared to the findings of LPT, the model tested here produces a few discrepancies worth mentioning. The particular instruments that move to stabilize debt play different roles, with capital tax revenues generally bearing more of the debt stabilization burden. For example, after a government spending shock, capital and labor taxes adjust more and while transfers adjust less. Similarly, capital taxes play a larger role in stabilizing a labor tax shock while government spending and transfers are expected to adjust less. After a transfers innovation, both capital and labor taxes are expected to adjust more while government spending decreases less. Additionally, instead of decreasing to stabilize debt, the discount rate resists stabilization slightly after a transfers shock.

Figure 11 reports the present-value funding horizons of government debt innovations for the various fiscal shocks. The graph illustrates how long it takes for the present-value balance to be restored after the various fiscal policy shocks perturb government debt. Specifically, the figure reports the truncated sum over horizon *K*, denoted by $PV_t\,(K)$, and defined by:

$$PV_t(K) = E_t \sum_{j=1}^{K} \beta^j \left[\left(\frac{S}{B}\right) \hat{S}_{t+j} - \left(\frac{1}{\beta}\right) \hat{R}_{t+j-1} \right]$$

where *S* is the steady state net-of-interest surplus and $\hat{S}_{t+j}$ denotes percentage deviations of the surplus from the steady state. Time is measured on the x-axis in quarters.

The graph illustrates two main patterns. In the quarters directly following the shock, the path of debt continues to diverge since the shocks are serially correlated. After roughly eight quarters, the present-value balance is restored over a period of many years as the dynamics play out. It is clear that the horizon varies by fiscal instrument. Capital tax, consumption tax, and

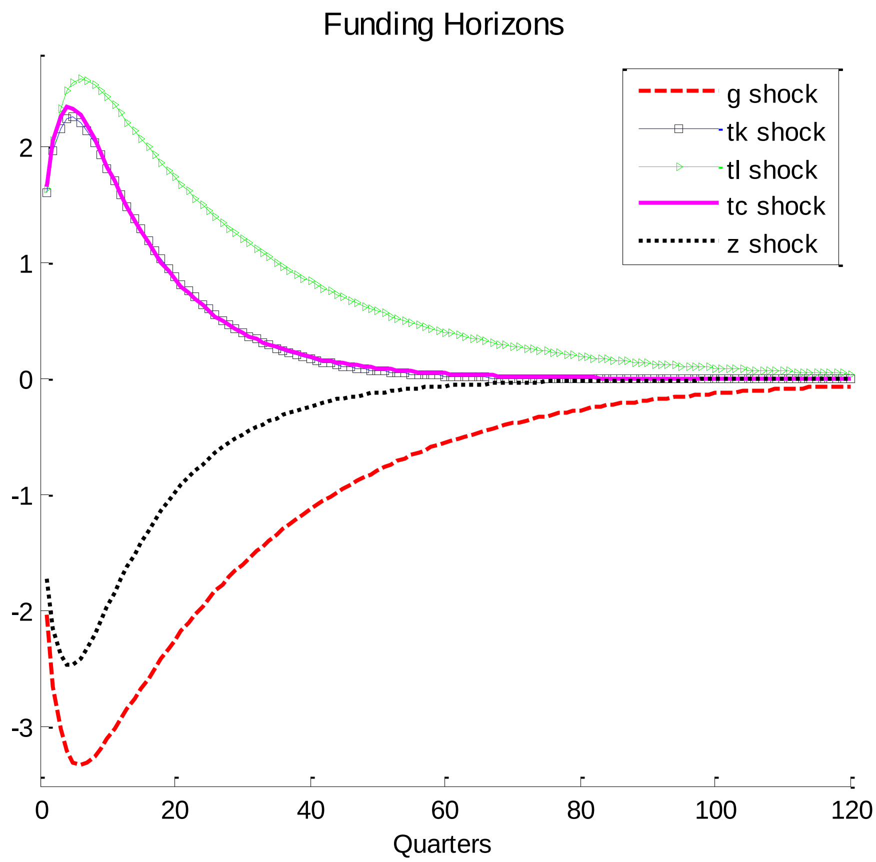

Figure 9. Government debt funding horizons for fiscal shocks. The x-axis units are quarters.

transfers shocks are completely financed after 15 to 20 years. In contrast, government spending and labor tax shocks take much longer to finance, in the range of 35 to 40 years. When compared to the fully rational model, government spending shocks create a larger debt perturbation that takes longer to resolve. The remaining funding horizons are similar.

5. Sensitivity analysis

5.1 Fiscal policy parameter estimates for various specifications of γ

Since the baseline results for the unrestricted labor supply specification were generated when γ was calibrated to .20, it is important to see how the remaining model parameters vary for different assumptions regarding the fraction of non-Ricardians. Table 10 presents the posterior

Parameter	Fraction of Non-Ricardians			
	20%	35%	50%	70%[1]
Risk aversion ω	2.13	2.18	3.99	3.41
Inverse Frisch elas. κ	1.60	1.99	5.31	4.09
Habit formation h	0.59	0.62	0.66	0.65
Capital util. costs δ_2	0.44	0.42	0.38	0.45
Investment adj. costs s''	5.65	5.61	5.30	5.22
Fraction of non-Ricardians, γ	-	-	-	0.70
Fiscal Policy				
Govt. spending debt coeff. γ_g	0.142	0.146	0.135	0.124
Capital tax debt coeff. γ_{tk}	0.468	0.475	0.464	0.453
Labor tax debt coeff. γ_{tl}	0.089	0.093	0.110	0.102
Transfer debt coeff. γ_z	0.360	0.366	0.395	0.356
Capital tax Y coeff. ψ_{tk}	2.207	2.205	2.252	2.233
Labor tax Y coeff. ψ_{tl}	0.267	0.261	0.213	0.182
Govt. spending Y coeff. ψ_g	0.031	0.030	0.029	0.027
Transfer Y coeff. ψ_z	0.157	0.158	0.152	0.133
Cap./Labor co-term φ_{kl}	0.203	0.203	0.203	0.202
Cap./cons. co-term φ_{kc}	0.029	0.029	0.029	0.029
Labor/cons. co-term φ_{lc}	-0.027	-0.027	-0.029	-0.031

1. Parameter values are those found when estimating γ from the data.

Table 8. Posterior modes for various calibrations of γ, variable labor supply.

modes for various specifications of γ under the assumption of unrestricted labor supply. The fourth column presents the posterior modes when gamma is estimated from the data. The results are largely similar across all specifications, but a couple of differences stand out. As the fraction increases, the Frisch elasticity and the elasticity of intertemporal substitution become smaller, reflecting the restrictions placed on the budget constraint of non-Ricardians. The response of labor taxes to output (γ_{tl}) is the only fiscal policy parameter that is substantially altered, demonstrating an inverse relationship with the value of γ.

5.2 Subsample estimates

In light of LPT's findings that some parameter estimates are sensitive to the time period under investigation, it is important to consider parameter stability by analyzing various subsamples. To this end I analyze five subsamples, each starting or ending with significant shifts in fiscal policy. The first subsample examines the entire postwar period before the financial crisis and recession of 2008-2009, which runs from 1960Q1-2007Q4. This sample is roughly equivalent to the baseline sample used by LPT. The next subsample looks at data from 1976Q1-2011Q4, thereby avoiding the recession of 1973-1975 and the tax reduction act of 1975 that offered stimulus in the form of a one-time tax rebate. The third subsample runs from 1989Q1-2011Q4 and avoids the first few years of the Tax Reform Act of 1986, which changed both personal and corporate income taxes. The fourth subsample, 1993Q1-1991Q1, starts after the recession of 1990-1991 and the implementation of the Omnibus Budget Reconciliation Act of 1993. The fifth and final subsample examines the short time series starting in 2002Q1 and running through 2011Q4, which begins after the passing of the Economic Growth and Tax Relief Reconciliation ACT of 2001.

Tables 11 and 12 present the posterior modes for each subsample, along with the full sample posterior mean for ease of comparison. In both labor supply scenarios, the structural parameters vary somewhat over time. Both the risk aversion parameter and the inverse Frisch elasticity tend to get smaller over time, bringing the estimates closer to those of Cogan et al (2010) derived from the model of Smets and Wouters (2003) augmented with rule of thumb consumers. Corroborating the findings of LPT and Smets and Wouters (2003), the habit formation parameter and the parameter relating depreciation to capacity utilization increase over time. In the restricted specification the fraction of non-Ricardian consumers is fairly stable, ranging from 21-25% of the population over the various subsamples. The fiscal policy parameters also exhibit some volatility over time, but appear to be more stable than reported by

Parameter	Full Sample Mean	1960Q1-2007Q4	1976Q1-2011Q4	1989Q1-2011Q4	1993Q1-2011Q4	2002Q1-2011Q4
Risk aversion ω	2.32	2.50	2.06	1.88	1.77	1.70
Inverse Frisch elas. κ	2.43	2.67	2.00	2.08	1.90	1.74
Fraction of non-Ricardians γ	0.21	0.22	0.25	0.24	0.24	0.22
Habit formation h	0.64	0.57	0.67	0.68	0.81	0.85
Capital util. costs δ_2	0.44	0.35	0.55	0.64	0.61	0.58
Investment adj. costs s''	5.64	5.48	5.52	5.42	5.34	5.18
Govt. spending debt coeff. γ_g	0.17	0.15	0.17	0.24	0.23	0.26
Capital tax debt coeff. γ_{tk}	0.47	0.36	0.38	0.73	0.73	0.44
Labor tax debt coeff. γ_{tl}	0.10	0.08	0.12	0.15	0.16	0.21
Transfer debt coeff. γ_z	0.38	0.35	0.22	0.19	0.22	0.35
Capital tax Y coeff. ψ_{tk}	2.21	2.19	2.24	2.29	2.09	2.20
Labor tax Y coeff. ψ_{tl}	0.30	0.23	0.24	0.33	0.33	0.30
Govt. spending Y coeff. ψ_g	0.06	0.03	0.04	0.03	0.04	0.03
Transfer Y coeff. ψ_z	0.24	0.16	0.22	0.21	0.22	0.20
Cap./Labor co-term φ_{kl}	0.20	0.23	0.15	0.19	0.20	0.12
Cap./cons. co-term φ_{kc}	0.03	0.03	0.03	0.05	0.06	0.03
Labor/cons. co-term φ_{lc}	-0.03	-0.02	0.03	-0.02	-0.03	-0.05

Table 9. Subsample posterior modes, restricted labor supply.

LPT. Government spending, capital taxes, and labor taxes tend to respond to debt more strongly over the course of the sample, while transfers seem to react to debt more strongly at the beginning and end of the sample. As pointed out by LPT, the increase in the responses of capital and labor taxes to debt over time can be explained at least in part by policy changes that occurred in the middle of the sample. The Omnibus Budget Reconciliation Act of 1993 raised personal and corporate income taxes with the goal of reducing deficits, a policy change that implies an increase in both $\gamma_{\tau k}$ and $\gamma_{\tau l}$ in the post 1993 period.

In the restricted model, the automatic stabilizer parameters are remarkably consistent across all subsamples. This finding runs against the results of LPT and Cohen and Follette (2000) that suggest capital tax automatic stabilizer should increase over time while labor tax

Parameter	Full Sample Mean	1960Q1-2007Q4	1976Q1-2011Q4	1989Q1-2011Q4	1993Q1-2011Q4	2002Q1-2011Q4
Risk aversion ω	2.262	2.39	2.20	2.00	1.93	1.92
Inverse Frisch elas. κ	1.726	1.94	1.45	1.70	1.57	1.56
Habit formation h	0.590	0.54	0.61	0.63	0.74	0.81
Capital util. costs δ_2	0.493	0.40	0.58	0.66	0.62	0.58
Investment adj. costs s''	5.651	5.50	5.53	5.42	5.33	5.17
Govt. spending debt coeff. γ_g	0.158	0.15	0.16	0.23	0.22	0.25
Capital tax debt coeff. γ_{tk}	0.481	0.37	0.39	0.74	0.74	0.45
Labor tax debt coeff. γ_{tl}	0.104	0.08	0.12	0.15	0.16	0.22
Transfer debt coeff. γ_z	0.364	0.34	0.21	0.18	0.20	0.34
Capital tax Y coeff. ψ_{tk}	2.217	2.17	2.22	2.29	2.08	2.18
Labor tax Y coeff. ψ_{tl}	0.311	0.24	0.24	0.34	0.35	0.30
Govt. spending Y coeff. ψ_g	0.060	0.03	0.04	0.03	0.04	0.03
Transfer Y coeff. ψ_z	0.197	0.13	0.18	0.18	0.20	0.19
Cap./Labor co-term φ_{kl}	0.202	0.23	0.15	0.19	0.20	0.12
Cap./cons. co-term φ_{kc}	0.029	0.03	0.03	0.05	0.06	0.03
Labor/cons. co-term φ_{lc}	-0.027	-0.02	0.03	-0.02	-0.03	-0.05

Table 10. Subsample posterior modes, unrestricted labor supply, γ=.20.

automatic stabilizer should decrease. The former results is owed to a decrease in the progressivity of labor tax rates over the sample period while the latter is suggested by increases in the elasticity of social insurance contributions with respect to its tax base. In both cases the labor tax automatic stabilizer actually increases over time, and the capital tax stabilizer, while fairly stable, does increase slightly in the samples beginning in 1976 and 1989 before decreasing after 1993. When the sample period is limited to pre-2008 data, the estimates from the unrestricted model more closely resemble those of LPT. The elasticity of intertemporal substitution, the Frisch elasticity, and the habit formation parameter all smaller than the full sample mean. The response of capital taxes is also smaller than the full sample mean, indicating

Variable	1960Q1-2011Q4	1960Q1-2007Q4	1976Q1-2011Q4	1989Q1-2011Q4	1993Q1-2011Q4	2002Q1-2011Q4
Government spending present-value multipliers						
ΔY	-0.156	-0.163	-0.174	-0.382	-0.348	-0.134
ΔC	-0.732	-0.742	-0.724	-0.785	-0.764	-0.787
ΔI	-0.424	-0.421	-0.450	-0.597	-0.584	-0.347
Capital tax present-value multipliers						
ΔY	-0.585	-0.594	-0.394	-0.202	-0.160	-0.096
ΔC	-0.232	-0.254	-0.187	-0.322	-0.171	0.024
ΔI	-0.666	-0.675	-0.588	-0.495	-0.559	-0.443
Labor-tax present-value multiplier						
ΔY	0.036	0.013	-0.126	-0.173	-0.215	-0.345
ΔC	-0.136	-0.143	-0.232	-0.306	-0.265	-0.267
ΔI	-0.0003	-0.030	-0.126	-0.102	-0.170	-0.305
Transfers present-value multipliers						
ΔY	-0.512	-0.527	-0.474	-0.407	-0.456	-0.321
ΔC	0.148	0.163	0.187	0.187	0.221	0.293
ΔI	-0.358	-0.345	-0.332	-0.312	-0.408	-0.282

Table 11. Long-run (k=∞) present-value multipliers. Subsample estimates. Evaluated at the posterior mode of each subsample. Unrestricted labor supply, γ=.20.

that some of the novelty in the estimated fiscal policy parameters is driven by recent trends in the data. Tables 13 and 14 display the long-run fiscal multipliers associated with the subsample estimates, calculated at the posterior modes of the various subsamples. Reflecting the moderate instability in the model parameters across the subsamples, the present-value multipliers also change over time. In the case of capital and labor tax shocks, the sign of the multiplier even differs across time periods. A couple of patterns emerge. Increases in government spending and labor taxes have become more costly over time in terms of forgone output. On the other hand, capital tax shocks were responsible for less consumption and investment crowd out in the later sample periods, leading to a much smaller decrease in aggregate output in the long run. This

Variable	1960Q1-2011Q4	1960Q1-2007Q4	1976Q1-2011Q4	1989Q1-2011Q4	1993Q1-2011Q4	2002Q1-2011Q4
Government spending present-value multipliers						
ΔY	-0.064	-0.116	-0.130	-0.400	-0.383	-0.108
ΔC	-0.670	-0.704	-0.703	-0.815	-0.814	-0.779
ΔI	-0.395	-0.412	-0.427	-0.585	-0.570	-0.330
Capital tax present-value multipliers						
ΔY	-0.791	-0.790	-0.613	-0.357	-0.406	-0.356
ΔC	-0.495	-0.511	-0.420	-0.576	-0.570	-0.294
ΔI	-0.602	-0.611	-0.556	-0.374	-0.386	-0.365
Labor-tax present-value multiplier						
ΔY	-0.135	-0.260	-0.421	-0.332	-0.478	-0.826
ΔC	-0.355	-0.681	-0.892	-0.892	-0.929	-1.040
ΔI	0.058	0.051	0.006	0.074	-0.002	-0.251
Transfers present-value multipliers						
ΔY	-0.704	-0.656	-0.670	-0.571	-0.685	-0.500
ΔC	-0.059	0.008	-0.063	-0.034	-0.080	-0.022
ΔI	-0.340	-0.321	-0.280	-0.247	-0.324	-0.125

Table 12. Long-run ($k=\infty$) present-value multipliers. Subsample estimates. Evaluated at the posterior mode of each subsample. Restricted labor supply.

finding is particularly important since the data suggest a stronger tendency to use capital taxes to retire debt in the more recent sample periods. Meanwhile, an increase in transfers also tends to be less onerous to unwind in more recent times as consumption is boosted more and investment is crowded out less in the later subsamples.

CHAPTER 4: FEDERAL RESERVE FORECASTS AS FISCAL NEWS: RESULTS FROM AN IDENTIFIED VECTOR AUTOREGRESSION AND STRUCTURAL MODEL

1. The VAR and Identification

The basic econometric framework is owed to Blanchard and Perotti (2002):

$$Y_t = A(L)Y_{t-1} + U_t$$

where Y_t consists of quarterly real per capita taxes, government spending, and GDP and $A(L)$ is the lag operator. Blanchard and Perotti spend a great deal of time exploring the identification of the model, using institutional information about taxes, spending, and transfer programs to construct parameters that quantify the contemporaneous relationships between taxes, spending, and GDP. After a thorough investigation, they find that government spending does not respond to GDP or taxes contemporaneously. This means that government spending shocks can be identified using a standard Choleski decomposition with government spending ordered first. The same identification scheme is used by a number of authors, including a 2007 investigation by Perotti that uses a seven variable system. This paper follows Ramey and Shaprio (1998) and Ramey (2011) by augmenting a similar VAR with the fiscal news variable ordered first, followed by government spending and a similar set of additional variables for purposes of comparison. In addition to the Federal Reserve forecasts, I will examine VAR's that contain the log of real capita quantities of total government spending, GDP, total hours worked, nondurable plus services consumption[16], private fixed investment, the Barro and Redlick (2010) tax rate, and the

[16] Chained non-durable and services consumption are aggregated using Whelan's (2000) method.

log of nominal compensation in private business divided by the deflator in private business[17]. I follow Ramey by using the total hours worked series based on unpublished BLS data, graciously provided on her website, based on the findings on Cavallo (2005) that suggest a significant portion of rises in government spending consists of increases in the government payroll. Ramey and Shapiro (1998) show that the product wage, rather than the consumption wage, is better suited for comparing model predictions form both an empirical and theoretical perspective. The rationale is based on the fact that defense spending tends to be concentrated in a few industries like manufactured goods. Ramey and Shaprio show that the relative price of manufactured goods rises significantly during a defense buildup, possibly leading to a situation where the consumption wage is unchanged or rising while the product wage is falling. For reasons to be discussed in section 3, I estimate two versions of the model. In both cases four lags of the variables are included; where they differ is in the treatment of the time trend. A complete account of data used is provided in appendix E.

2. Post-war Government Spending

Government spending is commonly broken down into three components: federal defense, federal non-defense, and state and local. What constitutes each type of spending? Defense spending is mostly self-explanatory, but a 2012 Congressional Budget Office report breaking down federal discretionary spending for 2011 indicates nearly 18% of the defense budget went toward research, development, testing, evaluation, atomic energy, and several "other" categories. Federal non-defense spending was dominated by education, training, employment, and social services (18% of discretionary non-defense spending), transportation (14%), income security

[17] Ramey's (2011) results are robust to using Alexander and Seater's (2009) update of the Seater (1982) and Stephenson (1998) average marginal tax rate. The Barro-Redlick (2010) tax rate includes state income taxes whereas the Alexander-Seater series only has federal income and social security taxes.

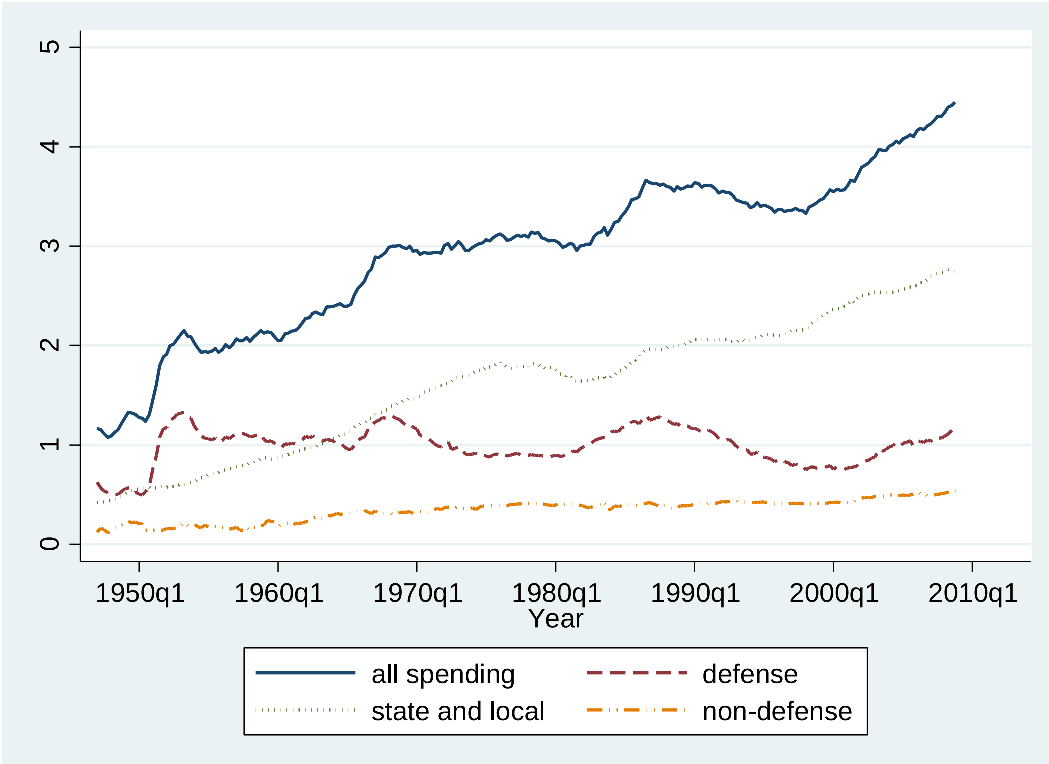

Figure 10. Real per-capita components of government spending, 1947-2008.

(11%), and health (10%)[18] over the same period. State and local governments spent most heavily on education, social services, transportation, and public safety[19].

Figure 12 illustrates the time series properties of each of these components in real, per-capita terms. It is clear that federal non-defense spending is a small portion of total spending and exhibits minimal volatility. The fluctuations in total spending then are primarily driven by a combination of defense and state and local spending. Prior to 1975, fluctuations in total spending appear to be driven almost entirely by defense purchases as state and local spending followed a smooth upward trend. Large military buildups during the Korean and Vietnam wars

[18] Other significant categories are veteran's benefits and services, administration of justice, and international affairs

[19] It is also worth noting that transfer payments are not included in measures of government spending. Dramatic increases in transfer payments for programs like Medicare and Social Security have been a key driver of rising government *outlays* in recent times.

are plainly evident in both the defense and total spending time series. After 1975, however, both components drive movements in total spending. The dramatic cuts in state and local spending that began in the early 1980's is particularly evident in the aggregate spending time series, even as cold war defense spending was on the upswing. After 1990, state and local spending resumed its steady upward march with some modest reductions evident during the Clinton administration.

At a lower frequency, the overall increase in real per-capita government spending is primarily a function of increasing state and local expenditures as defense spending exhibits no upward trend over time. In fact, as a share of GDP, defense spending has decreased from its 1952 third quarter peak of 15% to just over 5% in 2008. Meanwhile, state and local spending has climbed from 6.7% to 12.5% of GDP over the same time horizon.

Given these facts, what type of spending is best suited to identify the response of consumption to changes in government spending? What econometric challenges do these time series present? In response to the first question, most researchers have focused on defense spending since it is the component most likely to be exogenous with respect to most macroeconomic aggregates (see Hall (2009) for a nice survey of the government spending literature). It has been postulated that defense buildups are likely the result of various political and diplomatic exigencies outside the realm of domestic economic activity. Ramey (2011) points to two specific problems with non-defense spending in the context of this investigation. First, a large portion of non-defense spending is allocated to education. Educational spending is driven in large part by demographic changes (which also have a large impact on the economy) and creates human capital. Second, the efficient provision of public goods may actually have a positive wealth effect, blurring the distinction between New Keynesian and Classical model predictions. In summary, not only is defense spending responsible for most of the post-war

	ADF (4 lags)		ADF with Trend		DF-GLS ERS	
variable	10% Crit. Val.	t-stat	10% Crit. Val.	t-stat	10% Crit. Val.	t-stat
ln government spending	-2.575	-0.152	-3.141	-2.809	-2.667	-2.707
ln GDP	-2.575	-0.997	-3.141	-3.958*	-2.667	-3.016**
ln consumption	-2.575	-1.735	-3.141	-3.088	-2.667	-1.815
ln fixed investment	-2.575	-1.554	-3.141	-3.319*	-2.667	-2.32
ln total hours worked	-2.575	-1.424	-3.141	-1.706	-2.667	-1.839
ln product wage	-2.575	-0.363	-3.141	-1.955	-2.667	-2.032
Barro-Redlick tax rate	-2.575	-2.698*	-3.141	-2.021	-2.667	-0.65
Federal Reserve growth forecasts	-2.575	-2.328	-3.141	-2.328	-2.667	-1.50
Δ government spending	-2.576	-4.624***	-		-2.668	-2.827*
Δ ln GDP	-2.576	-5.102***	-		-2.668	-3.254**
Δ ln consumption	-2.576	-4.842***	-		-2.668	-4.688***
Δ ln fixed investment	-2.576	-4.451***	-		-2.668	-3.687***
Δ ln total hours worked	-2.576	-4.49***	-		-2.668	-4.259***
Δ ln product wage	-2.576	-4.592***	-		-2.668	-2.993**

* indicates significance at 10% level

** indicates significance at the 5% level

*** indicates significance at 1% level

Table 13. Stationarity tests. Unless otherwise stated, all variables are in real, per-capita terms.

variation in total government spending, it is also less likely to enter into the aggregate production function or interact with private consumption.

The two econometric issues that merit formal treatment are stationarity and cointegration. There is a clear upward trend in government spending and several other variables that will become part of the VAR analysis in subsequent sections. However, is the trend in the data best described by a deterministic or a stochastic process? Following the blueprint of Blanchard and Perotti (2002), I perform Augmented Dickey-Fuller tests[20] on the time series of interest. In addition, I perform an augmented Dickey-Fuller t-test in which the times series are transformed by a generalized least-squares regression. The critical values are interpolated from the tables constructed by Elliot, Rothenberg, and Stock (1996). Table 15 presents the results. When the

[20] Four lags of the first differences are included in the ADF tests.

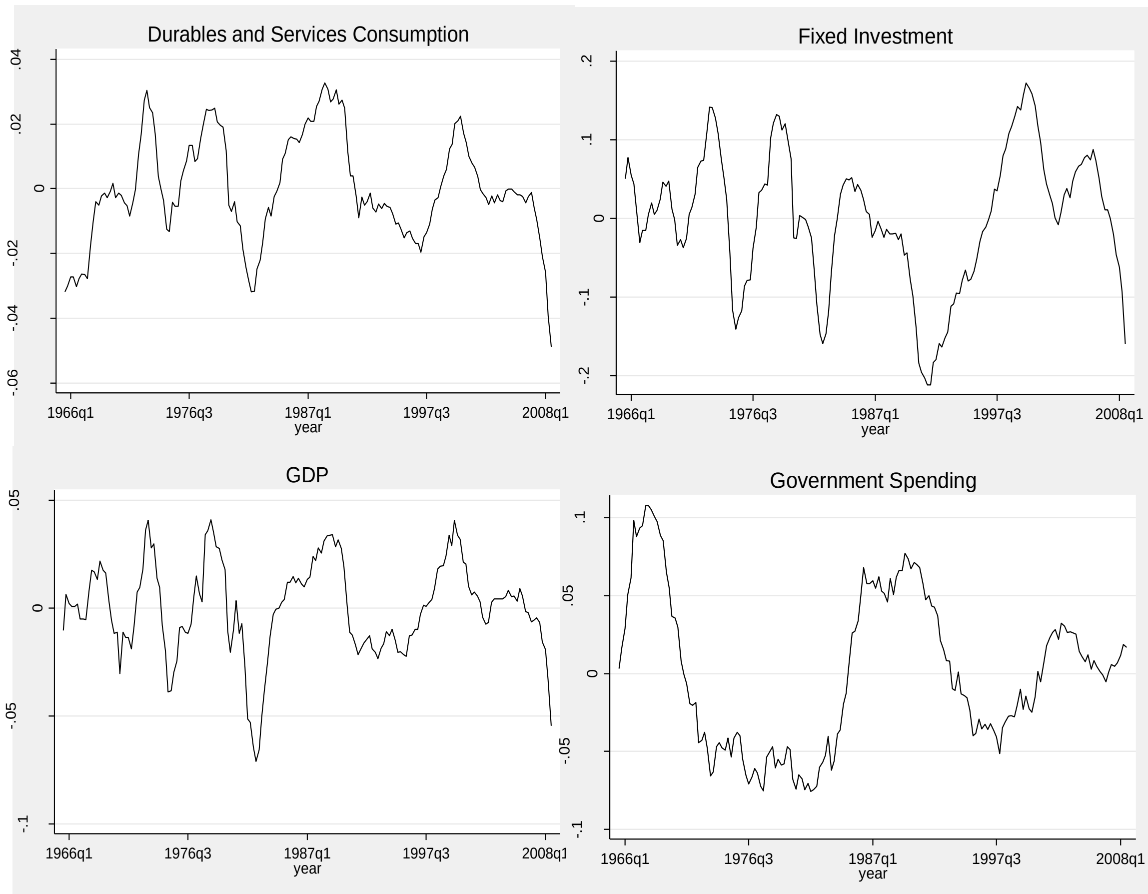

Figure 11. Linearly Detrended Time Series, 1965q1 - 2008q2.

variables are in levels, with the exception of the Barro-Redlick average marginal tax rate, the null hypothesis of a unit root cannot be rejected at the 10% level. The Federal Reserve forecasts fall just short of the critical value. When a deterministic time rend component is added to the test, only GDP and fixed investment appear stationary. In almost all cases though, the ADF tests do not offer overwhelming evidence in either direction.

Figure 13 presents the linearly detrended time series for durables and services consumption, fixed investment, GDP, and government spending for the period 1965q1 to 2005q2 for which the Federal Reserve forecast data is available. Visual inspection reveals no distinct trends and gives the appearance of stationarity, albeit with some persistence in quarterly fluctuations. In light of this finding, I will follow the two-pronged approach of Blanchard and Perotti (2002) by estimating two forms of the VAR. The first will follow the specification used by Ramey (2011) and include all variables in levels allowing for a deterministic, quadratic time trend[21]. The second form will allow for a stochastic trend. I take the first differences of each variable and account for the underlying drift by subtracting a changing mean, constructed as the arithmetic average of the past first differences with a decay parameter of 5% per quarter.

Blanchard and Perotti (2002) performed a battery of cointegration tests, including the relationship between taxes and the components of spending. Formal tests revealed no strong evidence for a cointegrating relationship between taxes and spending, rejecting the null of a unit root at about the 5 percent level but no lower. This finding is corroborated by several empirical studies, including Bohn (1998). Without clear direction from the data, Blanchard and Perotti decide to compare their benchmark results to the case where taxes and spending are cointegrated, reporting that the results are little changed. Given these findings, I leave the exploration of cointegrating relationships to future work.

3. Federal Reserve Forecasts

The Federal Reserve makes Federal Open Market Committee (FOMC) meeting materials available to the public with a five year lag. The Fed's website contains meeting minutes and policy documents dating back to 1936. Beginning with the June 17 meeting in 1964, the Fed also began archiving the "Green Book" in pdf format, a report prepared by the staff of the Board of Governors of the Federal Reserve System. The Green Book summarizes current economic

[21] The quadratic form is used to match the demographic –induced U-shape observed in the hours worked time series.

and financial conditions for meeting participants, and is still published to this day. Starting with the FOMC meeting in the second quarter of 1965, the Green Book contains quarterly forecasts of various macro aggregates in nominal terms, including government spending and its components. Over time, the forecast became more extensive and eventually the staff began projecting figures out several quarters into the future in terms of real growth rates. In the cases where only nominal forecasts are made, I convert the values into real terms using the forecasted value of the GDP deflator. From the archived Green Books I was able to construct a consistent, one quarter-ahead forecast for defense spending from 1965:2 to 2005:2. A four quarter-ahead forecast is available beginning in 1974:2. To my knowledge, this is the longest available time series for quarterly forecasts of defense spending. This allows me to incorporate the forecasts themselves in the VAR rather than using forecast errors[22] , which has a material effect on the impulse responses. One notable omission from this sample period is the Korean War buildup, the largest instances of post-WWII military spending. At first blush this would seem problematic; however, some authors have argued though that this period should be omitted from the analysis anyway since it is an outlier in the post 1947 time period.

The Fed forecasts will be used in a VAR framework as a new measure of “fiscal news” to explore the timing of government spending shocks and test the Ramey hypothesis. Are the Fed forecasts an appropriate instrument for such an investigation? Figure 14 plots the one quarter-ahead forecasts of defense spending growth along with actual defense spending growth for the sample period. The forecasts predict spending growth between periods t and t+1 using information available in period t. The series of forecasts is lagged one period so the predicted

[22] Ramey used Survey of Professional Forecasters forecast errors as a measure of fiscal news. The forecast error is calculated as the difference between predicted spending growth in period *t* using *t-1* information and actual spending growth in period *t*. Ramey uses the forecast errors rather than the forecasts themselves in order to be able to combine samples that use defense spending forecasts and federal spending forecasts.

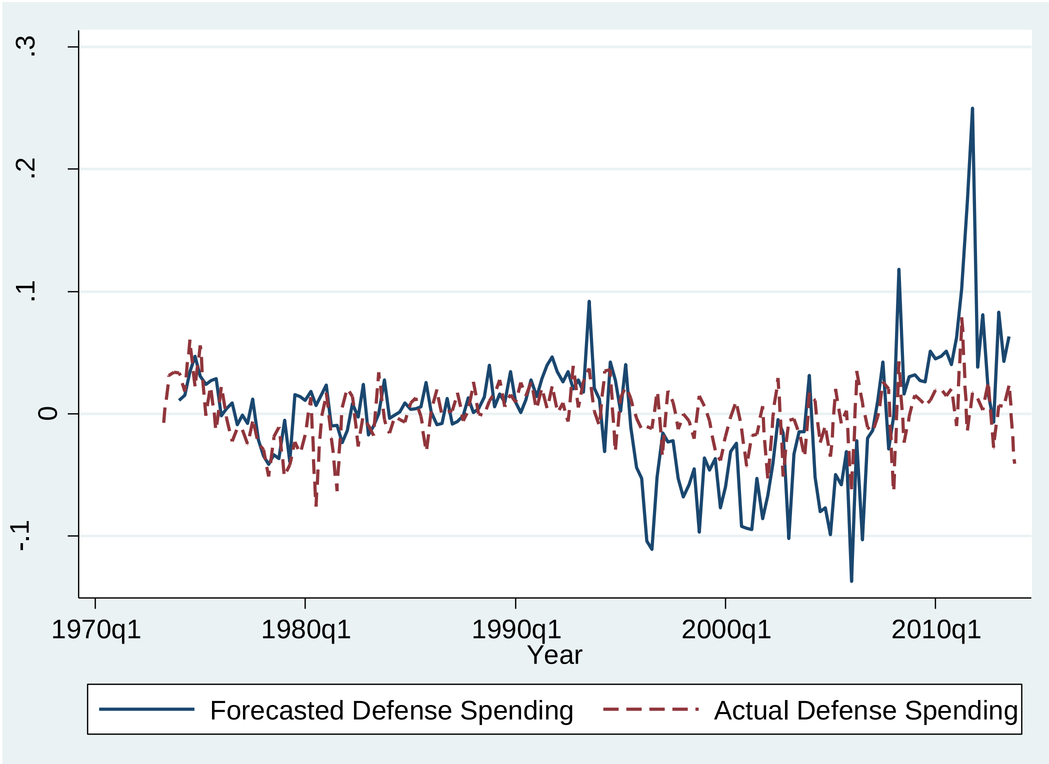

Figure 12. Actual defense spending growth vs. Federal Reserve Forecasts of growth next period, 1965-2005.

value lines up with the actual measured value. While far from perfect, there several instances where the forecasts accurately predict changes in defense spending such as the early to mid-1990's and early 2000's. The forecasts are particularly poor in the early 1980's, which is perhaps explained by heightened uncertainty regarding domestic and foreign policy stemming from the Volcker disinflation and Cold War diplomacy. It is also clear that the volatility of the forecasts is much higher after the mid 1990's, exhibiting a tendency to overshoot the measured value substantially. Formal statistical tests indicate that the forecasts are a valid instrument, though not as powerful as the Survey of Professional Forecasters presented by Ramey. Table 16 presents several regression-based tests for both the full sample period and a subsample starting in 1985 where there appears to be a shift in volatility. R-squared values and F-statistics are reported when federal or defense spending in periods *t* or *t+1* are regressed on the one or two

Forecast	Full Sample* R-squared	F-Statistic	Marginal F-Statistic	1985-2006 R-squared	F-Statistic	Marginal F-Statistic
1 Period-ahead, All federal spending	0.114	20.18	14.7	0.1783	17.58	14.15
2 period-ahead, All federal spending	0.06	9.28	7.87	0.0318	2.7	1.27
1 period-ahead defense spending	0.16	29.9	16.68	20.66	21.09	18.04
2 period-ahead, defense spending	0.114	18.15	12.11	0.1272	11.95	7.62

* for 1 period ahead forecasts full sample period is 1965 Q3 - 2005 Q2. For 2 period-ahead forecasts the full sample period is 1969 Q4 - 2005 Q2

Table 14. Explanatory power of Fed forecasts.

step-ahead forecasts made in period *t-1*. Marginal F-statistics on the exclusion of the forecast variables in a regression that includes four lags of the following additional variables: log real per capita federal or defense spending, log real GDP, the 3-month T-bill rate, and the Barro-Redlick average marginal tax rate. As Staiger and Stock (1997) discuss, a first-stage F-statistic under 10 could be an indicator of a weak instrument problem. As Ramey points out, most macro shocks used in the literature, including monetary and oil price shocks have F-statistics well below 10, but that is not the case here. As expected, the one period-ahead forecasts have more predictive value than their two period-ahead counterparts with F-statistics either near or exceeding 20. R-squared values are on the low side however, with one period ahead forecasts explaining 11-16 percent of the variation in the dependent variable. These results are larger than the R-squared values of Ramey's defense news variable computed using post-1955 data, but significantly lower than the survey of professional forecasters data which yielded an R-squared of .60 and F-statistics exceeding 200. While the two period-ahead forecasts are less informative, defense spending forecasts made two periods in advance still yield an F-statistic over 10 and an R-squared of .127. Generally speaking, the post-1985 subsample yields higher R-squared values in spite of greater volatility, consistent with improved forecasting methods over time.

Hypothesis tests		p-value
Do 1 period-ahead Fed forecasts of federal spending Granger-cause VAR shocks?	Yes	0.0475
Do 1 period-ahead Fed forecasts of defense spending Granger-cause VAR shocks?	Yes	0.049
Do VAR shocks Granger-cause 1 period-ahead Fed forecasts of federal spending?	No	0.657
Do VAR shocks Granger-cause 1 period-ahead Fed forecasts of defense spending?	No	0.213

Table 15: Granger causality tests

While the forecasts appear to be useful instruments, this investigation is most concerned with the timing of information flows. Specifically, are unexplained innovations in the VAR framework actually predicted by the Federal Reserve forecasters? I answer this question by once again following the procedure used by Ramey. I first compute the series of VAR shocks by estimating the baseline VAR specification given in section 2 and collecting the residuals. I then perform Granger causality tests to explore the timing with the p-values reported in table 3. The results are clear: both federal and defense spending forecasts Granger cause the VAR shocks but the opposite is not true. In other words, I find corroborating evidence for the Ramey's premise: variations that appear to be random shocks from the econometrician's perspective are able to be forecasted.

4. Vector Autoregression Results

4.1 Baseline VAR

In order to provide a basis for comparison, figure 15 illustrates the dynamic response of several macro variables to a government spending shock, identified using the standard Choleski decomposition with government spending ordered first. The VAR, consisting of government spending, GDP, total hours worked, nondurable plus services consumption, private fixed investment, the Barro-Redlick (2010) tax rate, and the manufacturing product wage, is typical of the government spending studies in the literature. All variables are in levels and each equation

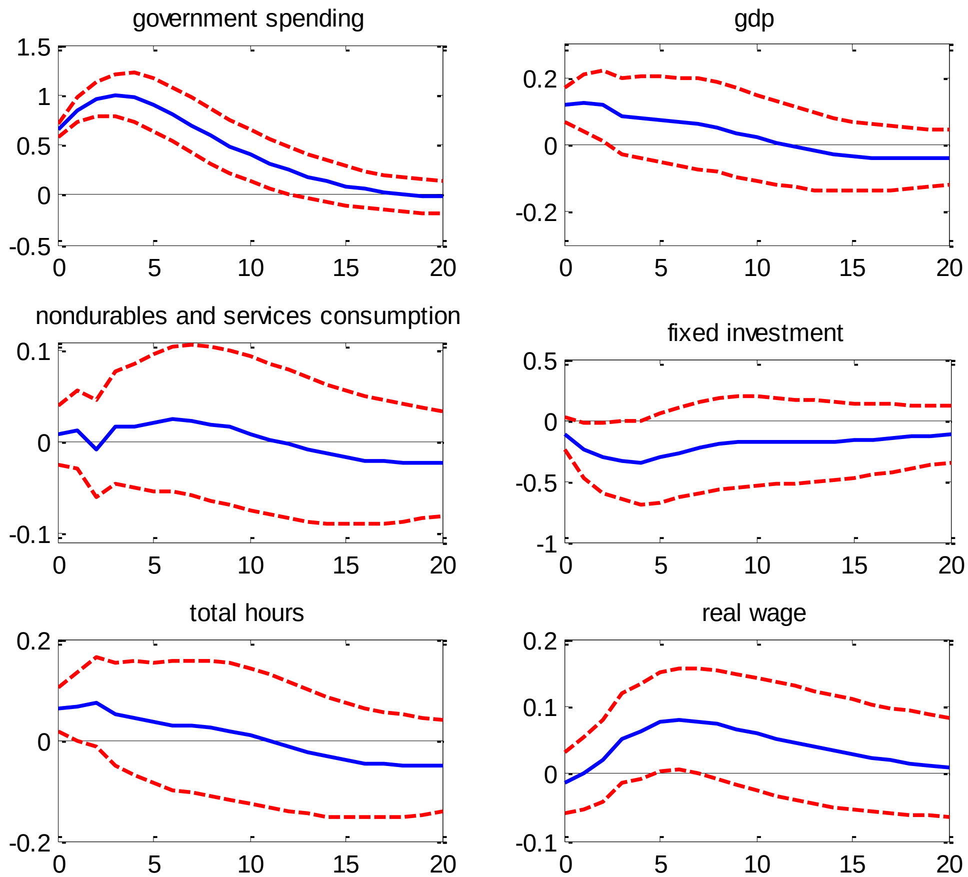

Figure 13. Baseline VAR

contains a quadratic time trend. The figure traces the mean response and the 95% confidence bands[23] for a period of twenty quarters. Throughout this section shocks are normalized so that the log change of government spending after a shock to the news variable is unity at its peak.

Qualitatively, the responses are typical for the literature. The positive government spending shock causes GDP to rise initially and stay positive for several quarters. The mean response of consumption of nondurables and services is also positive for roughly twelve quarters

[23] It is common to report 68% confidence bands in the fiscal policy literature, though there is no theoretical justification for this choice. Instead, I show the 95% bands common in the monetary policy literature.

	1 qrt	4 qtrs	8 qtrs	12 qtrs	20 qtrs	**peak**	cumulative irf
			Deterministic trend				
GDP	0.126	0.080	0.052	-0.008	-0.037	0.126	0.567
consumption*	0.013	0.017	0.020	-0.003	-0.024	0.025	0.010
fixed investment	-0.249	-0.346	-0.192	-0.177	-0.114	-0.346	-4.255

* Nondurables and services consumption

Table 16. Standard dynamic response to a government spending shock.

before turning negative. Total hours and the real wage also tend to rise while investment falls as government spending crowds out some private activity. Fiscal multipliers are summarized in table 18.

4.2 The Fiscal News VAR

One of the primary questions this paper seeks to answer is how these responses change when anticipation effects are accounted for. To answer this question I now examine several model specifications involving Federal Reserve forecasts as a measure of fiscal news. I follow Ramey by using the approach of Burnside, Eichenbaum, and Fisher (2004), which utilizes a set of fixed variables while rotating in other variables of interest one at a time. While this method requires re-estimating the VAR multiple times, it allows me to examine the effect on several variables while maintaining a relatively parsimonious specification. The fixed set of variables includes the Federal Reserve forecasts, the log of real per capita government spending and the log of real per-capita GDP. To control for monetary and tax policy, the three-month T-bill rate and the Barro-Redlick average marginal income tax rate are also included in the fixed set. The extra variables considered are total hours, the manufacturing product wage, the real BAA bond rate (with inflation defined by the CPI), along with the components of consumption and investment spending. This exercise is completed twice, once utilizing a deterministic time

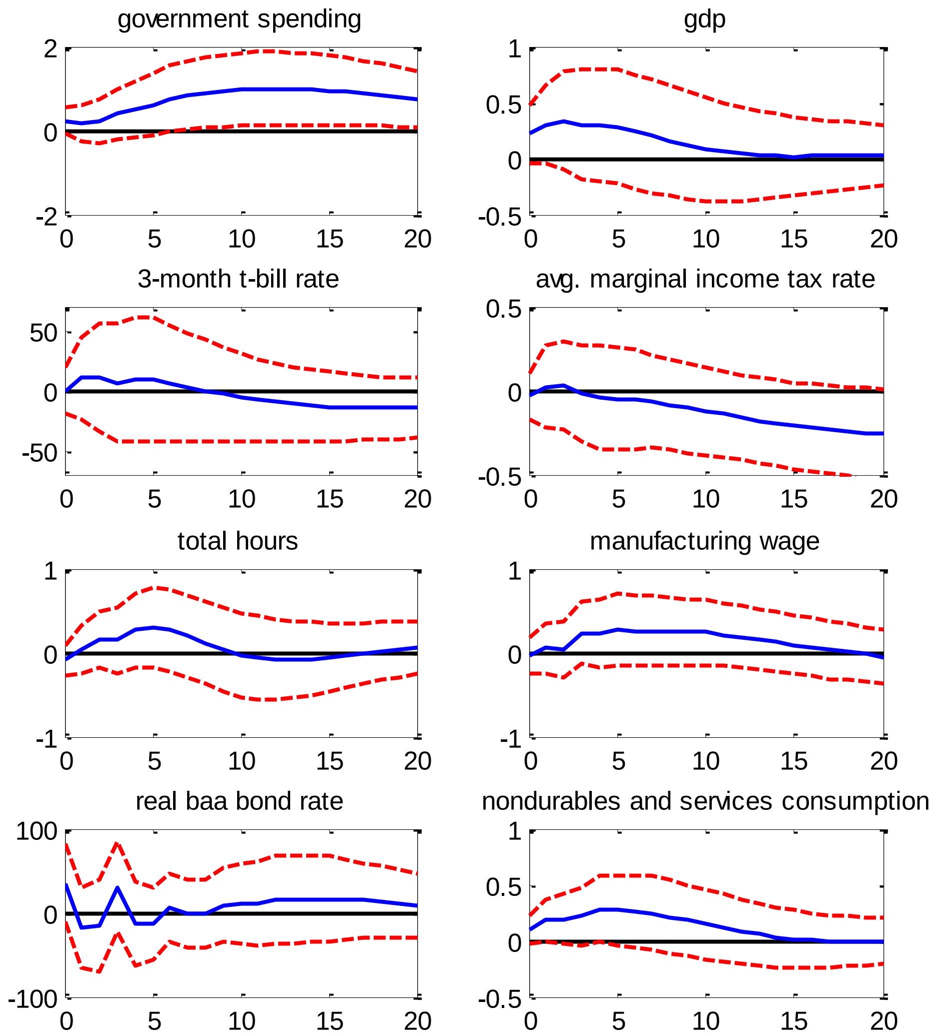

Figure 14. Impulse to expected defense spending

trend (DT) and second time a stochastic trend (ST) as described above. Finally, I examine the effect of using forecast errors rather the forecasts themselves as a measure of fiscal news. A summary of the multipliers can be found in tables 19 and 20.

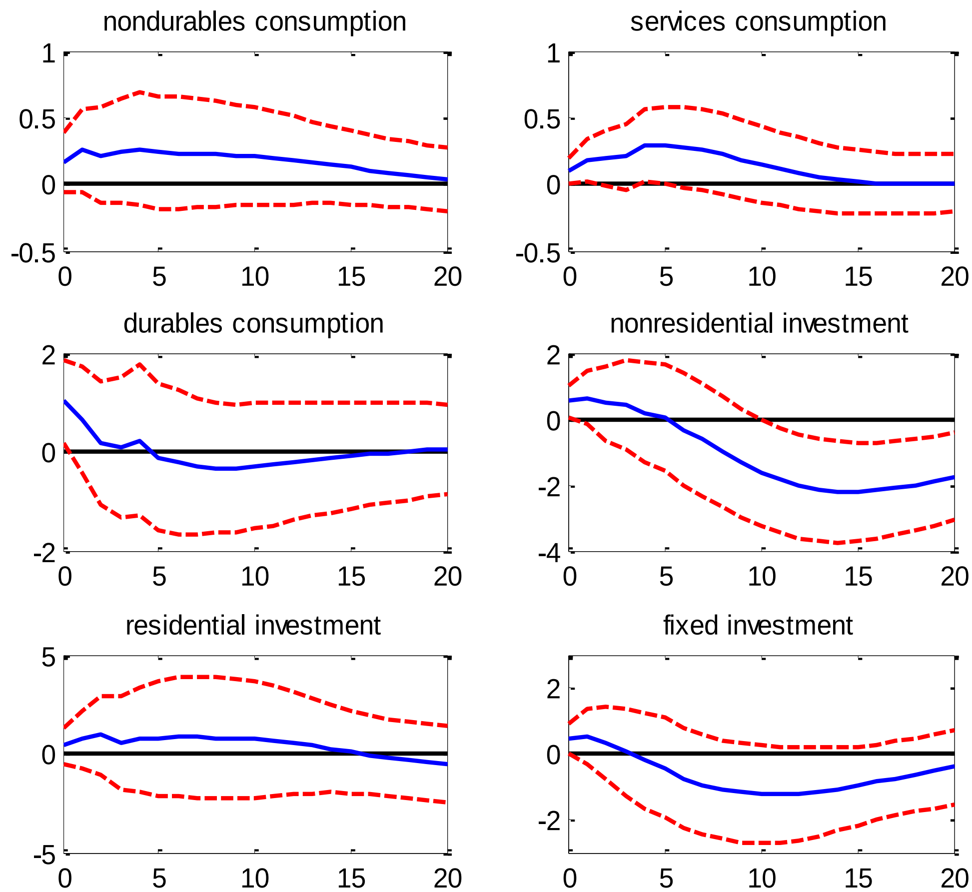

Figure 15. Impulse to expected defense spending.

4.3 Deterministic Trend Results

Figures 16 and 17 illustrate the response to a shock to the news variable assuming a deterministic trend. As before, the responses are normalized so that the response of government spending peaks at unity. The response of government spending peaks later and is significantly more persistent than the baseline, remaining positive for more than five years. GDP rises upon impact, peaking after five quarters at a value of .5 before turning negative after eleven quarters. The stimulus is more than twice as large as the baseline estimate and significantly larger than

	1 qrt	4 qtrs	8 qtrs	12 qtrs	20 qtrs	**peak**	cumulative irf
			Deterministic trend				
GDP	0.313	0.496	0.079	-0.064	0.043	0.496	2.459
consumption*	0.157	0.303	0.221	0.093	0.008	0.303	2.790
fixed investment	0.782	0.367	-0.518	-0.896	-0.544	-0.910	-7.209
			Stochastic trend				
GDP	1.049	-0.071	-0.049	0.016	0.008	1.055	2.068
consumption*	0.256	0.142	0.032	0.045	0.031	0.256	1.346
fixed investment	3.392	0.043	-0.392	-0.247	-0.118	3.392	3.326

* Nondurables and services consumption

Table 17. Dynamic response to a fiscal news shock, using actual forecasts for period t+1.

that reported by Ramey who found the news shock to be contractionary when using the SPF forecasts as a measure of fiscal news[24]. The cumulative impulse response after five years is 2.46. Interestingly, the response of consumption is largely positive, in stark contrast to the Ramey hypothesis. The response of non-durables and services consumption is positive and persistent, peaking after five quarters at .30. Durables consumption also rises upon impact before turning negative after four quarters. Hours and the real wage increase in a qualitatively similar fashion to the baseline estimate, while investment first rises before falling and remaining negative for several quarters. Taken as a whole, the evidence supports the much of the existing identified VAR literature that predicts a rise in GDP, hours, the real wage, and consumption after a government spending shock.

4.4 Stochastic Trend Results

Figures 18 and 19 depict the impulse responses when the deterministic trend is replaced with a stochastic trend. With the exception of the manufacturing wage, the effects are qualitatively similar. GDP, hours, and consumption all tend to rise after the shock while the

[24] Ramey reported a peak GDP response of .23 when using a narrative approach.

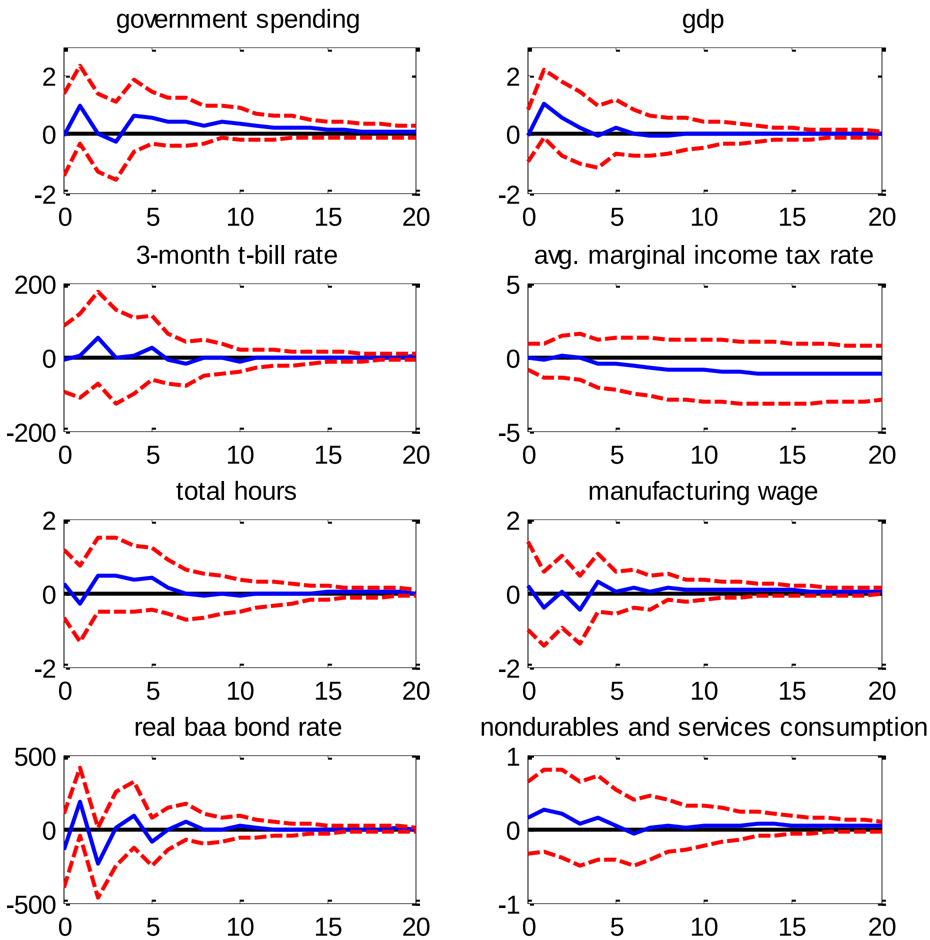

Figure 16. Response to fiscal news shock, stochastic trend.

wage is depressed initially before increasing. GDP peaks soon after the shock at 1.05 and quickly returns to zero. The cumulative response is slightly smaller than the deterministic trend at 2.07. The response of consumption to a change in expected defense spending is again positive, with all components rising for roughly five quarters after impact. The real wage in contrast displays a net negative response after the first year with a slight rise thereafter. All components of investment display the same pattern of rising before falling, although the cumulative effect is less negative in the long run.

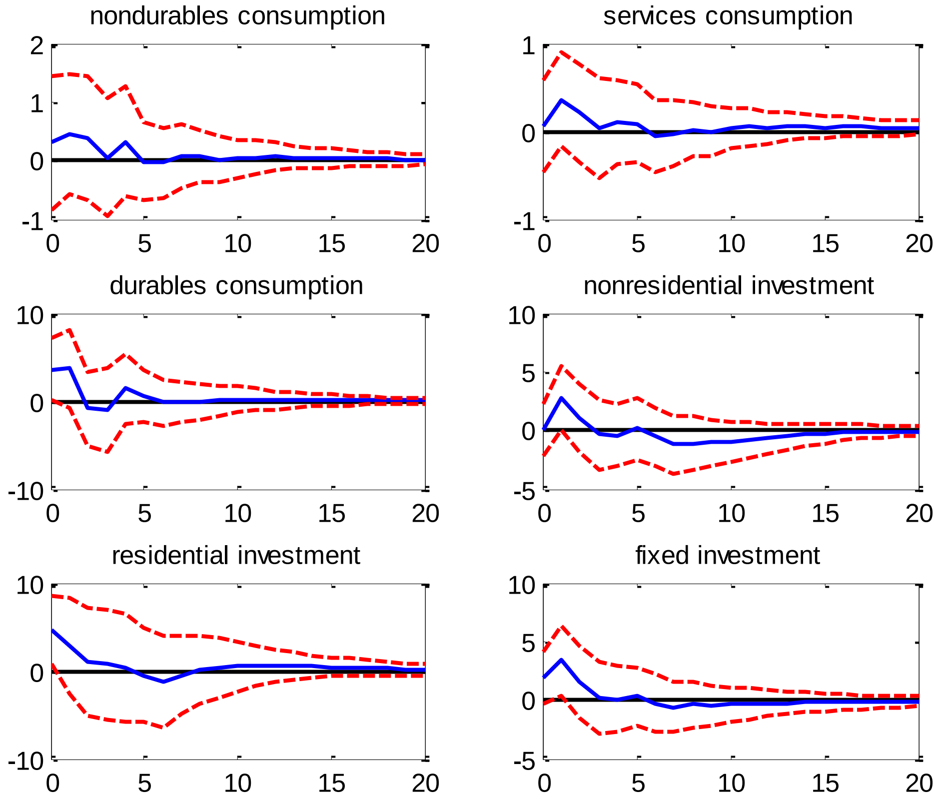

Figure 17. Response to fiscal news shock using actual forecasts, stochastic trend.

4.5 Forecast Error Results

I now turn to the question how the forecast data should be incorporated in the VAR. In particular, does the use of forecast errors in place of the raw forecasts change the results? To answer this question I incorporate the Federal Reserve forecast error defined as the difference between forecasted defense spending growth from period *t-1* to *t* made with period *t-1* information, and actual growth from period *t-1* to *t*. The impulse responses following a shock to the forecast errors, shown in figures 20 and 21, tell a dramatically different story. A fiscal news shock is now highly contractionary with output peaking at -.17 and remaining below zero for

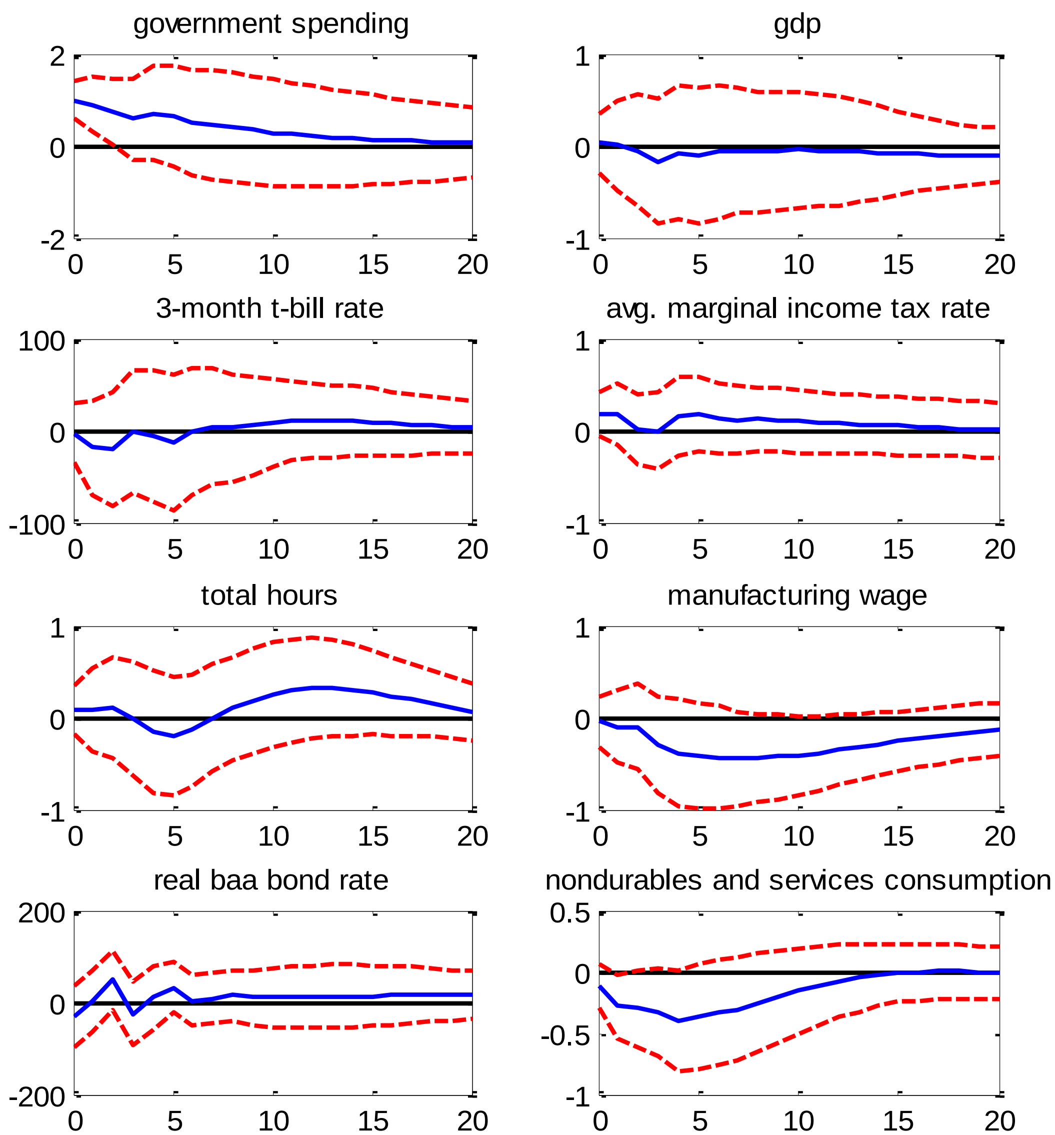

Figure 18. Impulse to expected defense spending using forecast error.

several years after impact. Nondurables and services consumption also decrease after the shock, peaking at -.26 and -.38 respectively. Only durables consumption shows any tendency to increase after the shock, though this component still decreases upon impact before recovering for

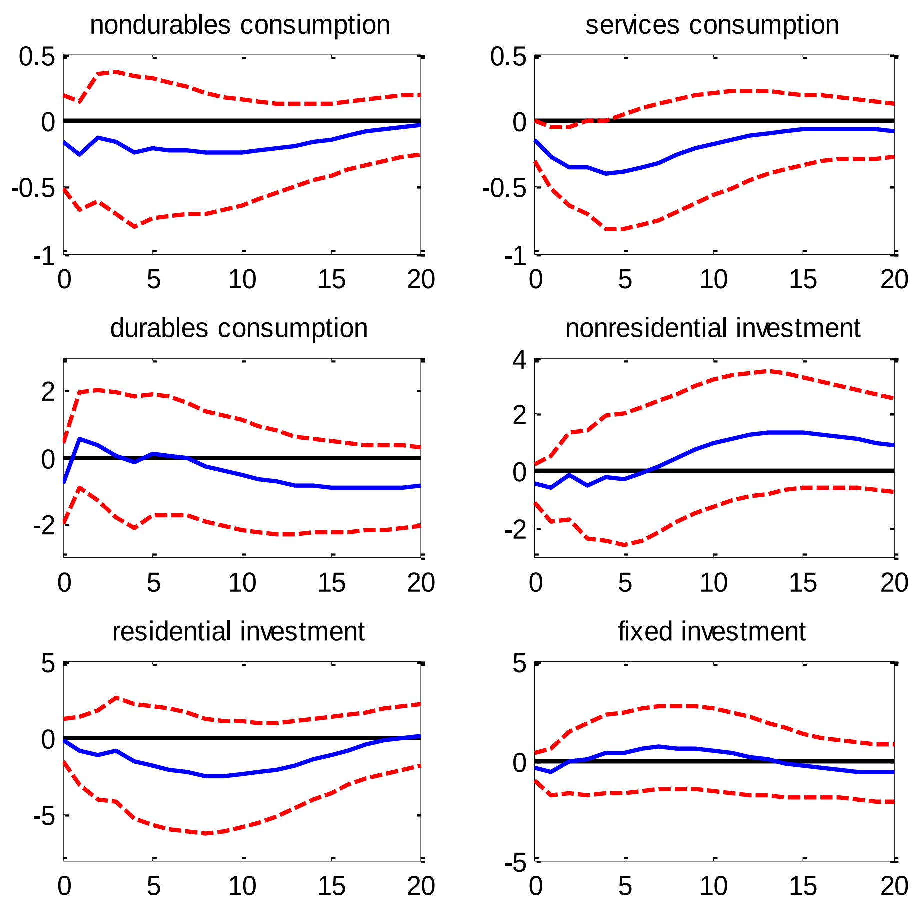

Figure 19. Impulse to expected defense spending using forecast error.

several quarters and then eventually decreasing again. The path of the real wage has also changed, now showing a substantial drop in response to the shock. Residential investment declines for four years while nonresidential declines for five quarters before eventually rising. Complete multiplier results are presented in tables 19 and 20.

5. DSGE Model Simulation Results

What if the Granger causality results reported above are the result of misspecification of the time series representation of the data or the omission of important variables from the VAR?

	1 qrt	4 qtrs	8 qtrs	12 qtrs	20 qtrs	**peak**	cumulative irf
			Deterministic trend				
GDP	0.005	-0.073	-0.064	-0.059	-0.098	-0.172	-1.470
consumption*	-0.283	-0.399	-0.253	-0.078	-0.010	-0.399	-3.347
fixed investment	-0.535	0.330	0.612	0.188	-0.635	0.612	0.327
			Stochastic trend				
GDP	0.008	0.038	0.040	0.003	0.000	0.121	0.100
consumption*	-0.011	0.028	0.022	-0.003	0.000	-0.034	0.086
fixed investment	-0.410	-0.602	-0.080	-0.034	0.010	-0.602	-1.056

* Nondurables and services consumption

Table 18. Dynamic response to a fiscal news shock, using forecast errors.

Another approach to testing the validity of the Fed forecasts as measure of fiscal news is to analyze a structural model of the economy. In theory, the structural model does not suffer from the same frailties as a reduced-form statistical model and is therefore an appealing source of corroborating evidence. Specifically, I investigate whether or not the Federal Reserve forecasts Granger cause the DSGE model residuals for the consumption and hours worked variables? If so, then this lends further credence to the hypothesis that changes in government spending are anticipated by agents and should therefore be modeled formally in a structural setting. If not, then this would cast doubt on the ability of the identified VAR to fully capture the macroeconomic dynamics of anticipated fiscal policy.

5.1 Model overview

This section provides a brief overview of the structural model employed here. The model is the best-fitting specification presented in chapter three of this work, closely following the neoclassical growth model presented in Leeper, Plant and Traum (2010). The primary distinctive feature is the presence of consumer heterogeneity in the form of two types of representative household. The first household type displays optimizing behavior by maximizing an intertemporal utility function, referred to as a *Ricardian* agent. The second type of representative agent exhibits rule-of-thumb, or *non-Ricardian* behavior. The model also contains a representative firm and the government, featuring a rich specification of fiscal policy rules. The model economy is buffeted by nine temporary innovations: shocks to government spending, capital, labor, and consumption taxes, transfer payments, technology, investment adjustment costs, and preferences. For further details, please see appendix A.

5.2. *Ricardian Households*

A fraction of the population $\gamma \in [0,1]$ is non-Ricardian. The remaining $(1-\gamma)$ of households is Ricardian and maximizes expected utility. Preferences, common to *all* households, are described by the following separable utility function:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t u_t^b \left[(1-\omega)^{-1} (c_t^J - hC_{t-1})^{1-\omega} - u_t^l (1+\kappa)^{-1} (l_t^J)^{1+\kappa} \right]$$

for $J \in \{r, nr\}$. Utility is derived from consumption, c_t^J , relative to a habit stock defined as a fraction $h \in [0,1]$ of the previous period's aggregate consumption, C_{t-1}. Hours worked, l_t^J , yield disutility. The utility function contains two preference shocks, one general (u_t^b) and one specific to labor supply (u_t^l). The parameters $\omega, \kappa \geq 0$ represent the coefficient of risk aversion and the inverse of the Frisch labor supply elasticity respectively, and $\beta \in [0,1]$ is the discount factor. The shocks u_t^b and u_t^l evolve according to the AR(1).

Maximization for Ricardian agents is subject to a flow budget constraint,

$$(1+\tau_t^c)c_t^r + i_t^r + b_t^r = (1-\tau_t^l)w_t^r l_t^r + (1-\tau_t^k)R_t^k v_t K_{t-1}^r + R_{t-1}b_{t-1}^r + z_t^r$$

Ricardians have at their disposal after-tax labor and capital income, interest on government bonds held the previous period, and lump-sum transfer payments from the government, z_t^r. Income is consumed, invested in physical capital, or used to purchase government debt. Capital income is computed as the rental rate of capital, R_t^k, multiplied by the effective quantity of capital employed by Ricardian households in period *t*, $v_t K_{t-1}^r$. The variable v_t is a household control variable that measures the utilization rate of the capital stock. R_{t-1} is the return on one-year government debt owned by Ricardian households, b_t^r. The tax rates on consumption, labor income, and capital income are given by τ_t^c, τ_t^l, and τ_t^k respectively. It should be emphasized that only Ricardian households save and invest in physical capital and consider an intertemporal resource allocation decision.

5.3. *Non-Ricardian Households*

A fraction $\gamma \in [0,1]$ of households lack access to financial and capital markets and must consume all current disposable income. Income is derived from working (taxed at rate τ_t^l) and lump-sum transfers from the government, z_t^{nr}. Consumption expenditures are subject to taxation at rate τ_t^c. The non-Ricardian budget constraint is therefore given as:

$$(1+\tau_t^c)c_t^{nr} = (1-\tau^l)w_t^{nr} l_t^{nr} + z_t^{nr}$$

I allow for different levels of consumption and labor supply for Ricardians and non-Ricardians. The formulation is similar that of Galí et al. (2007), where non-Ricardians cannot optimize intertemporally, but can still adjust hours to solve a static optimization problem taking their budget constraint as given. Temporarily ignoring taxes, the problem becomes:

$$\max \ U(c^{nr}, 1 - l^{nr})$$

$$s.t. \ \ c^{nr} = \ w l^{nr} + z^{nr}$$

The intratemporal Euler equation for non-Ricardians then takes the form:

$$U_c / U_l = \frac{1}{w}$$

In equilibrium, the optimality condition for non-Ricardians is identical to that of Ricardians except for the levels of consumption and labor supply. Thus, the only way labor supply will be equalized across households is if the equilibrium level of consumption is also the same for both Ricardians and non-Ricardians.

5.4. *Government Sector*

As the focus of this paper is fiscal policy, several salient features of the model are found in the government sector formulation, taken from LPT. The government faces a flow budget constraint:

$$B_t + \tau_t^k R_t^k v_t K_{t-1} + \tau_t^l w_t L_t + \tau_t^c C_t = R_{t-1} B_{t-1} + G_t + Z_t$$

where G_t and Z_t are government spending and transfer payments respectively. In addition to issuing debt, the government sources funds by levying capital, labor, and consumption taxes. Funds are used to service debt, purchase final goods and services, and redistribute wealth via lump-sum transfer payments.

Fiscal instruments behave according to a rich specification that allows for a response to the state of the economy. The fiscal rules capture two important policy considerations: business cycle stabilization and debt stabilization. First, contemporaneous co-movement with output allows fiscal instruments to behave as automatic stabilizers, acting to bring the economy closer to potential GDP. Second, fiscal instruments are allowed to respond to the level of the federal debt. Higher government debt in period *t* will trigger fiscal responses in period *t+1* that tend to bring debt back to its steady state level. Linearized, in terms of log-deviations from the steady state, the policy rules are:

$$\hat{G}_t = -\varphi_g \hat{Y}_t - \gamma_g \hat{B}_{t-1} + \hat{u}_t^g$$

$$\hat{u}_t^g = \rho_g \hat{u}_{t-1}^g + \sigma_g \varepsilon_t^g, \qquad \varepsilon_t^g \sim N(0,1)$$

$$\hat{\tau}_t^k = \varphi_{tk} \hat{Y}_t + \gamma_{tk} \hat{B}_{t-1} + \phi_{kl} \hat{u}_t^{tl} + \phi_{kc} \hat{u}_t^{tc} + \hat{u}_t^{tk}$$

$$\hat{u}_t^{tk} = \rho_g \hat{u}_{t-1}^{tk} + \sigma_k \varepsilon_t^{tk}, \qquad \varepsilon_t^{tk} \sim N(0,1)$$

$$\hat{\tau}_t^l = \varphi_{tl} \hat{Y}_t + \gamma_{tl} \hat{B}_{t-1} + \phi_{kl} \hat{u}_t^{tk} + \phi_{lc} \hat{u}_t^{tc} + \hat{u}_t^{tl}$$

$$\hat{u}_t^{tl} = \rho_l \hat{u}_{t-1}^{tl} + \sigma_{tl} \varepsilon_t^{tl}, \qquad \varepsilon_t^{tl} \sim N(0,1)$$

$$\hat{\tau}_t^c = \phi_{kc}\hat{u}_t^{tk} + \phi_{lc}\hat{u}_t^{tl} + \hat{u}_t^{tc}$$

$$\hat{u}_t^{tc} = \rho_{tc}\hat{u}_{t-1}^{tc} + \sigma_{tc}\varepsilon_t^{tc}, \qquad \varepsilon_t^{tc} \sim N(0,1)$$

$$\hat{Z}_t = -\varphi_z\hat{Y}_t - \gamma_z\hat{B}_{t-1} + \hat{u}_t^z$$

$$\hat{u}_t^z = \rho_z\hat{u}_{t-1}^z + \sigma_z\varepsilon_t^z, \qquad \varepsilon_t^z \sim N(0,1)$$

where $\varphi_i \geq 0\ for\ i = \{g, k, tl\}$ captures the fiscal response to deviations in output from potential GDP and $\gamma_i \geq 0\ for\ i = \{g, k, tl, z\}$ models the response to government debt. The consumption tax rate, largely capturing movement in excise taxes on gasoline, tobacco, and the like, is assumed to be an exogenous process. Since excise taxes are used mainly for special funds, it is reasonable to believe they do not respond to changes in economic conditions.

Additionally, each fiscal instrument is subject to persistent, random shocks, represented in the model by the u_t's. The coefficients on the lagged shocks ($\rho_i \in [0,1]\ for\ i = \{g, tk, tl, tc, z\}$) measure the degree of persistence of an exogenous change in policy. Furthermore, exogenous changes in one tax instrument are allowed to affect the remaining tax instruments. This response is quantified by the parameter $\phi_i\ for\ i = \{kl, kc, tc\}$.

Aggregate quantities of household variables are weighted averages of Ricardian and non-Ricardian components:

$$C_t = (1-\gamma)C_t^r + \gamma C_t^{nr}$$

$$L_t = (1-\gamma)L_t^r + \gamma L_t^{nr}$$

A complete characterization of the system of equations and steady state used to solve the model can be found in appendix A.

5.5.Methodology and Results

The parameters of the structural model are estimated using Bayesian techniques. Prior distributions are similar to those widely used in the literature. I use quarterly data for nine time series: consumption, investment, hours worked, government debt, government spending, capital tax revenues, labor tax revenues, consumption tax revenues, and government transfers. The data are converted to real terms by dividing by the GDP deflator for personal consumption expenditures. To make the data stationary, I linearly detrend the natural logarithm of each time series independently. After estimating the parameters of the model, the one period-ahead DSGE model forecast errors are computed using the Kalman filter and the time series data. I then test the forecast errors generated by the DSGE model for Granger causality with the Federal Reserve forecasts. Answering the question, do the Federal Reserve forecasts of government spending Granger cause the DSGE model residuals for consumption and hours worked?

I employ two approaches to compute the DSGE forecast errors. In the first, I use the entire data set available to produce a single estimate for the structural parameters, calculated as the mean of the posterior distribution. The posterior distribution is simulated using a random walk Metropolis-Hastings algorithm. However, this approach may bias model predictions by incorporating into the model parameters ex post information about future fiscal policies that was not available to forecasters in real time. To mitigate this concern, I create a series of one step-ahead DSGE forecasts by re-estimating the parameter vector each quarter using only the data available up until that time period. The downside of this approach is that it is very costly from a computational standpoint. To ease this burden, I use the posterior mode as the estimate of the parameter vector rather than simulating the posterior each quarter and calculating the mean. This is similar to the "plug-in" approach described by Del Negro and Schorfheide (2012).

Complete Granger causality tests were performed using one period-ahead Federal Reserve forecasts of defense spending and Ramey's time series of one period-ahead government spending forecast errors computed from the Survey of Professional Forecasters. I test for causality in both directions between the measures of fiscal news and the DSGE model residuals for consumption and hours worked. I perform this battery of tests for both parameter estimation methods described above. In all cases four lags of each dependent variable are incorporated into the regressions. Full results are presented in table 21. The results are consistent across the numerous tests, regardless of which variable is used as a measure of fiscal news. There is no statistical evidence that forecasted changes in government spending improve the DSGE model forecasts of consumption and hours worked. The results are also consistent across both parameter estimation methodologies.

6. Discussion

The results presented in section 5 lead to diametrically opposed conclusions depending on which measure of fiscal news is utilized. When the raw forecasts are used to identify changes in the present discounted value of defense spending, the VAR results corroborate much of the existing literature that finds GDP, consumption, hours, and the real wage to rise after a government spending shock, even when the changing in spending is anticipated. However, if forecast errors are used as the measure of fiscal news then the classical model's predictions

Hypothesis tests: Single Parameter Estimates		p-valu
Do 1 period-ahead Fed forecasts of defense spending Granger-cause DSGE Consumption forecast errors?	No	0.587
Do 1 period-ahead Fed forecasts of defense spending Granger-cause DSGE Labor Supply forecast errors?	No	0.905
Do 1 period-ahead SPF forecasts Granger-cause DSGE Consumption forecast errors?	No	0.410
Do DSGE Consumption forecast errors Granger-cause 1 period-ahead Fed forecasts of defense spending?	No	0.920
Do DSGE Labor Supply forecast errors Granger-cause 1 period-ahead Fed forecasts of defense spending?	No	0.224
Do DSGE Labor Supply forecast errors Granger-cause 1 period-ahead SPF forecasts?	No	0.695
Hypothesis tests: Rolling Parameter estimates		**p-valu**
Do 1 period-ahead Fed forecasts of defense spending Granger-cause DSGE forecast errors?	No	0.589
Do 1 period-ahead Fed forecasts of defense spending Granger-cause DSGE Labor Supply forecast errors?	No	0.322
Do 1 period-ahead SPF forecasts Granger-cause DSGE Consumption forecast errors?	No	0.756
Do DSGE Consumption forecast errors Granger-cause 1 period-ahead Fed forecasts of defense spending?	No	0.909
Do DSGE Labor Supply forecast errors Granger-cause 1 period-ahead Fed forecasts of defense spending?	No	0.967
Do DSGE Labor Supply forecast errors Granger-cause 1 period-ahead SPF forecasts?	No	0.537

Table 19. Granger Causality Tests

mostly ring true: an anticipated government spending shock leads to a reduction in the present value of future income streams, reducing consumption and increasing work effort. This leads to higher output in the short run (a very small increase initially in this study) and a lower marginal product of labor that depresses wages. In the former scenario fiscal stimulus may make some sense as a short-run policy option, while in the latter there is much less incentive to use it as a countercyclical maneuver.

Which measure of news is more appropriate? If testing the merit of the classical model versus the New Keynesian model is the ultimate goal, then the best measure of news is that which immediately captures changes in the present discounted value of future income and tax streams. Since the forecast error incorporates news that arrived last period (the forecast is made in period *t-1*), the raw forecasts made in period *t* would appear to be a superior measure. Since news arrived last period it is not clear that the timing of agents' decision making is accurately captured when forecast errors are used. Additionally, there may be an econometric case for preferring the raw forecasts over the errors. Since defense and total government spending are highly correlated, it is possible the forecast error, by incorporating the difference between actual and forecasted defense spending, biases the regression results. In any case, the disparate results indicate great care must be taken when incorporating forecast data in a fiscal policy VAR.

The structural model results suggest that perhaps more fundamental questions should be asked. Why do the data fail to speak with a single voice? Is anticipated government spending an important driver of household behavior? A separate but related question is whether or not professional forecasts are a useful proxy for fiscal news. If anticipated fiscal policy were an important part of the data generating process and effective proxies for fiscal news are utilized, then one would expect to find a systematic relationship between the structural model forecast errors and the fiscal news variable. Using a DSGE model designed to capture the complex interactions between the various fiscal instruments used by the government and households, I find little evidence that measures of fiscal news improve the structural model's forecasts. One can conclude that either anticipated fiscal policy is not a visible component of household behavior, or the particular measures of fiscal news used here are not adequately capturing the anticipation effects.

CHAPTER 5: CONCLUSION

Fiscal policy is among the most pertinent topics in contemporary macroeconomics. Countercyclical fiscal policy, intended to mitigate the harmful effects of recessions on output and employment, has been used extensively in recent times. The American Recovery and Reinvestment Act was designed to pump nearly $800 billion of fiscal stimulus into the economy to combat the Great Recession. Long-run fiscal planning is also at the forefront of current public policy. In both the US and Europe governments are grappling with the proper mix of sensible spending, debt reduction, and taxation while simultaneously fostering an environment that enhances the prospects for long-run growth. Given the complexities of the macro economy and the realities of the modern political system that drives fiscal policy, understanding the ramifications of accruing debt and the fiscal adjustments required to keep the economy on a sustainable fiscal path is a daunting yet crucial task.

This paper has added to the growing body of literature by conducting theoretical and empirical investigations into the inner workings of fiscal policy. In chapter three, I explore how a particular departure from full rationality, justified by a plethora of microeconomic evidence, affects fiscal adjustments under two different labor supply assumptions. Leeper, Plante, and Traum (2010) found that the US time series data prefer rich fiscal policy rules and that debt financed fiscal adjustments have long lasting effects that can stand in stark contrast to those of conventional models. I build upon their work by exploring household heterogeneity, inspired by the savers and spenders theory of fiscal policy of Mankiw (2000). The contributions are two-fold. First, by allowing transfer payments to affect disposable income and therefore the consumption bundless of non-Ricardian households, the time series data are viewed through a more flexible lens. This modification directly affects the estimation of model parameters. Transfers respond more weakly to debt while capital and labor taxes become more important. Capital taxes and transfers also have stronger roles as automatic stabilizers of output. Second, household heterogeneity changes the way in which fiscal adjustments are perceived and reacted to by consumers, thereby changing the economic impact of these adjustments. These effects are studied for two labor supply specifications. In aggregate, households are less able to respond to expected future policy adjustments by modifying their behavior immediately. Both of these implications have tangible effects on the impulse responses and present-value multipliers generated by the model, particularly in the short run. The restricted model allows for transfers to create some modest short-run stimulus and implies less short-run crowding out of consumption in the face of an increase in government spending. Provided the fraction of non-Ricardian consumers is in the neighborhood of the 50% suggested by Campbell and Mankiw (1989), it is even possible for a real model to exhibit crowding in of consumption after a government spending shock, which would bring the theoretical predictions more in line with the bulk of empirical evidence. When non-Ricardians optimize intratemporally however, the consumption multiplier after a spending shock is definitively negative, while spending and transfers multipliers yield less short-run stimulus as agents demand more leisure when disposable income increases. As the fraction of non-Ricardian households increases to the .70 in the specification most favored by the data, the discrepancy between the two labor supply specifications widens. In particular, capital taxes and transfers become very costly in the long run in terms of forgone output.

Measures of model fit provide additional insight. The data favor an economy populated by both spenders and savers, and intratemporal optimization is preferred to an economy where hours worked are artificially equalized across household types. Models where transfers respond to debt are still preferred, though less dramatically than reported previously.

Regardless of household composition, it remains clear that long-run effects are markedly different from short-run effects. The larger short-run stimulus created by the presence of non-Ricardian households is ephemeral. Eventually, debt financed fiscal adjustments require costly future adjustments to retire the debt. When debt is retired using distortionary taxes, the cumulative effect of these adjustments is small, and in most cases, negative.

In chapter four I seek to understand how government spending affects macroeconomic aggregates when policy changes are anticipated. This question is important since many policy actions are debated in congress and discussed in popular news outlets before being enacted. If agents are rational, they will incorporate news about future spending changes before they are enacted. Specifically, for a rational, forward-looking agent in the classical model a change in the present discounted value of lifetime income will induce a negative wealth effect. This decrease in wealth causes agents to devote more time to work and reduce consumption. However, much of the current empirical literature finds just the opposite to be true: a rise in government spending causes output, hours, consumption, and the real wage to increase. This finding is typically thought to lend credence to dynamic stochastic general equilibrium models with sticky prices and various degrees of market imperfections, of the type exemplified by Smets and Wouters (2007). However, Ramey and other proponents of the narrative approach to identifying government spending shocks provide evidence that the increase in consumption following an increase in defense spending is rather a reflection of the fiscal shocks being anticipated, and therefore mistimed by the econometrician.

When Federal Reserve forecasts are used to identify government spending shocks I find that consumption, hours, wages, and output all increase following the shock. The output multiplier measured as the peak response is around .5 using a deterministic trend and around unity using a stochastic trend. The responses are qualitatively similar to those found by authors using the standard Choleski decomposition to identify government spending shocks. One the other hand, if forecast errors are used in place of the forecasts themselves, the results are quite similar to those found by authors using the narrative approach of Shapiro and Ramey (1998) and Ramey (2011). Hours increase following a shock while consumption and wages decrease. Over the five year response period the shock causes output to contract. It stands to reason that the raw forecasts are a better measure of changes in the present discounted value of disposable income. If this is the case, then the results of this paper would tend to support sticky price models of the macro economy over the classical paradigm.

In the second part of chapter four, I use the best-fitting structural model developed in chapter three to see if the Federal Reserve forecasts are able to improve the forecasts of the structural model. If not, then it is possible that the reduced form statistical model is suffering from misspecification and that the granger causality between the standard VAR residuals and the Federal Reserve forecasts found to be present in the sample is misleading. The structural model is designed to capture the complex interactions between households and the various fiscal instruments used by the government, perhaps addressing interactions missing in the VAR. In fact, I find little evidence that measures of fiscal news would improve the structural model's fit to the time series data. The results suggest that perhaps some fundamental questions need to be addressed. Why do the data fail to speak with a single voice when forecasts are incorporated into the VAR in slightly different ways? Is anticipated government spending an important driver of household behavior? A separate but related question is whether or not professional forecasts are a useful proxy for fiscal news. If anticipated fiscal policy is an important part of the data generating process and effective proxies for fiscal news are utilized, then one would expect to find a systematic relationship between the structural model forecast errors and the fiscal news variable. The structural model exercise seems to suggest that either anticipated fiscal policy is not a visible component of household behavior, or the particular measures of fiscal news used here are not adequately capturing anticipation effects.

In the end, it is clear that more work must be done to understand the crucial question of how government spending affects the economy. Possible extensions of this work are numerous. From a theoretical standpoint, the model presented in chapter three can be extended to include monetary policy and a variety of market imperfections. The degree of monetary accommodation and the interaction between fiscal and monetary policy can influence fiscal multipliers, especially in the short run. Priority should also be given to formally modeling anticipation effects in a structural setting. Formal modeling may not only give insight into anticipation effects, but also help researchers develop and interpret reduced-form statistical models that are less likely to be misspecified.

APPENDIX A

Model solution for the case of unrestricted labor supply

1. Solving the household problem using dynamic programming

After subbing equation (5) into (4), the Bellman equation takes the form:

$$V(k_{t-1}^r, b_{t-1}^r, i_{t-1}^r) = u_t^b \left\{ (1-\omega)^{-1} (c_t^J - hC_{t-1})^{1-\omega} - u_t^l (1+k)^{-1} (L_t^J)^{(1+\kappa)} \right\} +$$

$$\beta E_t V(k_t^r, b_t^r, i_t^r) + \lambda_t \left[(1-\tau_t^k) R_t^k v_t k_{t-1}^r + (1-\tau_t^l) w_t l_t^r + R_{t-1} b_{t-1}^r + z_t^r - (1+\tau_t^c) c_t^r - i_t^r - b_t^r \right] +$$

$$\mu_t \left\{ -k_{t-1}^r + \left[1 - (\delta_o + \delta_1 (v_t - 1) + \frac{\delta_2}{2} (v_t - 1)^2 \right] k_{t-1}^r + [1 - s(\cdot)] i_t^r \right\}$$

for $J \in \{r, nr\}$.

Household first order conditions:

$$c_t^r \; : \; u_t^b (c_t^r - hC_{t-1})^{-\omega} = (1+\tau_t^c)\lambda_t \Rightarrow$$

$$u_{t+1}^b (c_{t+1}^r - hC_t)^{-\omega} = (1+\tau_{t+1}^c)\lambda_{t+1}$$

$$l_t^J \; : \; u_t^b u_t^l (l_t^J)^{\kappa} = \lambda_t (1-\tau_t^l) w_t$$

for $J \in \{r, nr\}$.

$$b_t^r \;:\; \beta E_t \frac{dv}{db_t^r} = \lambda_t$$

envelope theorem $\Rightarrow \beta E_t (R_t \lambda_{t+1}) = \lambda_t$

$$k_t^r \;:\; \beta E_t \frac{dv}{dk_t^r} = \mu_t$$

envelope theorem $\Rightarrow \beta E_t \left\{ \lambda_{t+1}(1-\tau_t^k) R_t^k v_t + \mu_{t+1}[(1-\delta(v_{t+1})] \right\} = \mu_t$

$$i_t^r \;:\; \beta E_t \frac{dv}{di_t^r} + \mu_t \left\{ [1-S_t(\cdot)] - S_t' \frac{u_t^i i_t^r}{i_{t-1}^r} \right\} = \lambda_t$$

envelope theorem $\Rightarrow \mu_{t+1} \beta E_t S_{t+1}' u_{t+1}^i (\frac{i_{t+1}^r}{i_t^r})^2 + \mu_t \left\{ [1-S_t(\cdot)] - S_t' \frac{u_t^i i_t^r}{i_{t-1}^r} \right\} = \lambda_t$

$$v_t \;:\; \lambda_t (1-\tau_t^k) R_t^k = \mu_t [\delta_1 + \delta_2 (v_t - 1)]$$

2. System of equations (unrestricted labor supply)

Define: $q_t = \dfrac{\mu_t}{\lambda_t}$

(1) $$\frac{u_t^b (C_t^r - hC_{t-1})^{-\omega}}{(1+\tau_t^c)} = \beta E_t \frac{u_{t+1}^b R_t (C_{t+1}^r - hC_t)^{-\omega}}{(1+\tau_{t+1}^c)}$$

(2) $$u_t^l (L_t^r)^{\kappa} L_t (1+\tau_t^c) = (C_t^r - hC_{t-1})^{-\omega} (1-\tau_t^l)(1-\alpha) Y_t$$

(3) $u_t^l (L_t^{nr})^{\kappa} L_t (1+\tau_t^c) = (C_t^{nr} - hC_{t-1})^{-\omega} (1-\tau_t^l)(1-\alpha) Y_t$

(4) $q_t = \beta E_t \dfrac{u_{t+1}^b R_t (C_{t+1}^r - hC_t)^{-\omega} (1+\tau_t^c)}{u_t^b (C_t^r - hC_{t-1})^{-\omega} (1+\tau_{t+1}^c)} \text{ x } \left\{ \dfrac{\left(1-\tau_{t+1}^k\right)(1-\alpha) Y_{t+1}}{K_t} + q_{t+1}\left(1-\delta\left(v_t\right)\right) \right\}$

(5) $q_t \left[\delta_1 + \delta_2 (v_t - 1)\right] = \dfrac{\left(1-\tau_t^k\right)\alpha Y_t}{v_t K_{t-1}}$

(6) $1 = \beta E_t \left\{ \dfrac{\lambda_{t+1}}{\lambda_t} q_{t+1} S'_{t+1}(\cdot) u_{t+1}^i \left(\dfrac{I_{t+1}^r}{I_t^r} \right)^2 \right\} + \; q_t \left\{ \left[1 - S_t(\cdot)\right] - S'_t(\cdot) \dfrac{u_t^i I_t^r}{I_{t-1}^r} \right\}$

(7) $Y_t = C_t + I_t + G_t$

(8) $K_t^r = (1-\delta(v_t)) K_{t-1}^r + \left[1 - S\left(\dfrac{u_t^i I_t^r}{I_{t-1}^r} \right) \right] I_t^r$

(9) $B_t + T_t^k + T_t^l + T_t^c = R_{t-1} B_{t-1} + G_t + Z_t$

(10) $T_t^k = \tau_t^k \alpha Y_t$

(11) $T_t^l = \tau_t^l (1-\alpha) Y_t$

(12) $T_t^c = \tau_t^c C_t$

(13) $Y_t = u_t^a (v_t K_{t-1})^{\alpha} L_t^{1-\alpha}$

(14) $(1+\tau_t^c) C_t^{nr} = (1-\tau_t^l) L_t^{nr} (1-\alpha) Y_t L_t^{-1} + Z_t$

(15) $C_t = (1-\gamma) C_t^r + \gamma C_t^{nr}$

(16) $L_t = (1-\gamma)L_t^r + \gamma L_t^{nr}$

(17) $K_t = (1-\gamma)K_t^r$

(18) $I_t = (1-\gamma)I_t^r$

(19) $B_t = (1-\gamma)B_t^r$

These equations, along with the fiscal policy rules (14) - (18) from the text, and the additional shock processes given by (1), (2), (6), and (10) from the text characterize the model's equilibrium. When labor supply is restricted equations (3) and (15) are no longer needed, and the labor variables drop out of equation (13).

3. Log-linearized system of equations

(1) $$\frac{\omega C^r}{C^r - hC} E_t \hat{C}_{t+1}^r - \frac{\omega hC}{C^r - hC} \hat{C}_t + \frac{\tau^c}{1+\tau^c} E_t \hat{\tau}_{t+1}^c - E_t \hat{u}_{t+1}^b$$
$$= \hat{R}_t + \frac{\omega C^r}{C^r - hC} \hat{C}_t^r - \frac{\omega hC}{C^r - hC} \hat{C}_{t-1} + \frac{\tau^c}{1+\tau^c} \hat{\tau}_t^c - \hat{u}_t^b$$

(2) $$\frac{\omega C^r}{C^r - hC} \hat{C}_t^r - \hat{Y}_t + \frac{\tau^l}{1-\tau^l} \hat{\tau}_t^l + \frac{\tau^c}{1+\tau^c} \hat{\tau}_t^c + \kappa \hat{L}_t^r + \hat{L}_t + \hat{u}_t^l = \frac{\omega hC}{C^r - hC} \hat{C}_{t-1}$$

(3) $$\frac{\omega C^{nr}}{C^{nr} - hC} \hat{C}_t^{nr} - \hat{Y}_t + \frac{\tau^l}{1-\tau^l} \hat{\tau}_t^l + \frac{\tau^c}{1+\tau^c} \hat{\tau}_t^c + \kappa \hat{L}_t^{nr} + \hat{L}_t + \hat{u}_t^l = \frac{\omega hC}{C^{nr} - hC} \hat{C}_{t-1}$$

(4) $$\frac{\omega C^r}{C^r - hC} E_t \hat{C}^r_{t+1} - \frac{\omega hC}{C^r - hC} \hat{C}_t - \beta(1-\delta_0) E_t \hat{q}_{t+1} + \beta\delta_1 E_t \hat{v}_{t+1} + \alpha\beta\tau^k \frac{Y}{K} E_t \hat{\tau}^k_{t+1}$$

$$- \alpha\beta(1-\tau_k) \frac{Y}{K} E_t \hat{Y}_{t+1} - E_t \hat{u}^b_{t+1} \frac{\tau^c}{1+\tau^c} + E_t \hat{\tau}^c_{t+1}$$

$$= \frac{\omega C^r}{C^r - hC} \hat{C}^r_t - \frac{\omega hC}{C^r - hC} \hat{C}_{t-1} - \hat{q}_t - \alpha\beta(1-\tau_k) \frac{Y}{K} \hat{K}^r_t + \frac{\tau^c}{1+\tau^c} \hat{\tau}^c_t - \hat{u}^b_t$$

(5) $$\left(1 + \frac{\delta_2}{\delta_1}\right) \hat{v}_t - \hat{Y}_t + \frac{\tau^k}{1-\tau^k} \hat{\tau}^k_t + \hat{q}_t = -\hat{K}^r_{t-1}$$

(6) $$\beta E_t \hat{I}^r_{t+1} + \beta E_t \hat{u}^i_{t+1} = (1+\beta)\hat{I}^r_t - \hat{I}^r_{t-1} - \left(\frac{1}{S''(1)}\right) \hat{q}_t + \hat{u}^i_t$$

(7) $$Y\hat{Y}_t - C\hat{C}_t - G\hat{G}_t - I\hat{I}_t = 0$$

(8) $$\hat{K}^r_t + \delta_1 \hat{v}_t - \delta_0 \hat{I}^r_t = (1-\delta_0)\hat{K}^r_{t-1}$$

(9) $$B\hat{B}_t + \alpha\tau_k Y(\hat{\tau}^k_t + \hat{Y}_t) + \tau_l(1-\alpha)Y(\hat{\tau}^l_t + \hat{Y}_t) + \tau^c C(\hat{\tau}^c_t + \hat{C}_t) -$$

$$G\hat{G}_t - Z\hat{Z}_t = \frac{B}{\beta}\hat{R}_{t-1} + \frac{B}{\beta}\hat{B}_{t-1}$$

(10) $$\hat{Y}_t - \hat{u}^a_t - \alpha\hat{v}_t - (1-\alpha)\hat{L}_t = \alpha\hat{K}^r_{t-1}$$

(11) $$(1+\tau^c)C^{nr}\hat{C}^{nr}_t + \frac{\tau^c}{1+\tau^c}\hat{\tau}^c_t + \mathrm{Y}(1-\alpha)\tau^l \left({L^{nr}}/{L}\right)\hat{\tau}^l_t - (1-\tau_l)(1-\alpha)Y\left({L^{nr}}/{L}\right)\hat{Y}_t$$

$$+ (1-\tau_l)(1-\alpha)Y\left({L^{nr}}/{L}\right)\hat{L}_t - (1-\tau_l)(1-\alpha)Y\left({L^{nr}}/{L}\right)\hat{L}^{nr}_t - Z\hat{Z}_t = 0$$

(12) $C\hat{C}_t - (1-\gamma)C^r\hat{C}_t^r - \gamma C^{nr}\hat{C}_t^{nr} = 0$

(13) $L\hat{L}_t - (1-\gamma)L^r\hat{L}_t^r - \gamma L^{nr}\hat{L}_t^{nr} = 0$

(14) $\hat{u}_t^b = \rho^b\hat{u}_{t-1}^b + \sigma_b\varepsilon_t^b$

(15) $\hat{u}_t^l = \rho^l\hat{u}_{t-1}^l + \sigma_l\varepsilon_t^l$

(16) $\hat{u}_t^i = \rho^i\hat{u}_{t-1}^i + \sigma_i\varepsilon_t^i$

(17) $\hat{u}_t^a = \rho^a\hat{u}_{t-1}^a + \sigma_a\varepsilon_t^a$

(18) $\hat{u}_t^g = \rho_g\hat{u}_{t-1}^g + \sigma_g\varepsilon_t^g$

(19) $\hat{u}_t^{tk} = \rho_{tk}\hat{u}_{t-1}^{tk} + \sigma_{tk}\varepsilon_t^{tk}$

(20) $\hat{u}_t^{tl} = \rho_{tl}\hat{u}_{t-1}^{tl} + \sigma_{tl}\varepsilon_t^{tl}$

(21) $\hat{u}_t^{tc} = \rho_{tc}\hat{u}_{t-1}^{tc} + \sigma_{tc}\varepsilon_t^{tc}$

(22) $\hat{u}_t^z = \rho_z\hat{u}_{t-1}^z + \sigma_z\varepsilon_t^z$

The five fiscal policy rules given in (13) – (17), definitions of aggregate tax revenues, and identities comprise the remaining eleven equations in a 33 equation system solved using the gensys algorithm.

4. Finding the steady-state

Table 1. Calibrated parameters

Parameter	Value
α	0.3
β	0.99
δ_0	0.025
G/Y	0.087
B/Y	0.34
τ^k	0.212
τ^l	0.191
τ^c	0.0256

$$q = v = 1$$

$$S(1) = S'(1) = 0; \quad S'' > 0$$

$$R = \frac{1}{\beta}$$

$$R^k = \frac{\frac{1}{\beta} - (1 - \delta_0)}{1 - \tau^k}$$

$$\delta_1 = R^k \left(1 - \tau^k\right)$$

$$I^r = \delta_0 K^r$$

$$I = (1 - \gamma) I^r$$

$Y, K, K^{r}, C, C^r, C^{nr}, L, L^r, L^{nr}, and\ Z$ can be solved for using the following relations:

$$Y\left(1 - s_g\right) = C + \delta_0 K$$

$$Y = K^{\alpha} L^{1-\alpha}$$

$$R^k = \frac{\alpha Y}{K}$$

$$\left(1 + \tau^c\right)(L^r)^{1+\kappa} = \left(C^r - hC\right)^{-\omega}\left(1 - \tau^l\right)(1 - \alpha)Y$$

$$\left(1 + \tau^c\right)(L^{nr})^{1+\kappa} = \left(C^{nr} - hC\right)^{-\omega}\left(1 - \tau^l\right)(1 - \alpha)Y$$

$$(1 + \tau^c)\, C^{nr} = \left(1 - \tau^l\right)(1 - \alpha)Y + Z$$

$$C = (1 - \gamma)C^r + \gamma C^{nr}$$

$$L = (1-\gamma)L^{r} + \gamma L^{nr}$$

$$Z = \tau^{k}\alpha Y + \tau^{l}(1-\alpha)Y + \tau^{c}C - Y\left(s_{g} + \frac{(1-\beta)}{\beta}s_{b}\right)$$

$$K = (1-\gamma)K^{r}$$

where $s_g = G/Y \in (0,1)$ and $s_b = B/Y \in (0,1)$

Define total tax revenue:

$$T = T^{k} + T^{l} + T^{c}$$

$$T^{k} = \tau^{k}\alpha Y$$

$$T^{l} = \tau^{l}(1-\alpha)Y$$

$$T^{c} = \tau^{c}C$$

APPENDIX B

Model Identification

Original Model (gamma estimated): A(33,33), B(33,9), C(9,33)							
Found n_X = 14; rank(CC)= 14; rank(OO)=14							
Transformed Model: A(14,14); B(14,9); C(9,14)							
n_theta = 35	n_x=14	n_eps=9					
Order condition: n_theta=35		n_delta 297					
Tolerance	DL	DT	DU	LT	LU	LTU	Pass?
1.0E-02	35	196	81	231	116	312	Yes
1.0E-03	35	196	81	231	116	312	Yes
1.0E-04	35	196	81	231	116	312	Yes
1.0E-05	35	196	81	231	116	312	Yes
1.0E-06	35	196	81	231	116	312	Yes
1.0E-07	35	196	81	231	116	312	Yes
1.0E-08	35	196	81	231	116	312	Yes
1.0E-09	35	196	81	231	116	312	Yes
1.0E-10	35	196	81	231	116	312	Yes
2.2E-12	35	196	81	231	116	312	Yes
Required:	35	196	81	231	116	312	

Table 20. Ng and Komunjer (2011) parameter identification test,for the case where gamma is estimated.

Original Model (gamma calibrated): A(33,33), B(33,9), C(9,33)							
Found n_X = 14; rank(CC)= 14; rank(OO)=14							
Transformed Model: A(14,14); B(14,9); C(9,14)							
n_theta = 34	n_	x= 14	n_ep	s = 9			
Order condition:	n_theta=34 n_delta 297						
Tolerance	DL	DT	DU	LT	LU	LTU	Pass?
1.0E-02	34	196	81	230	115	311	Yes
1.0E-03	34	196	81	230	115	311	Yes
1.0E-04	34	196	81	230	115	311	Yes
1.0E-05	34	196	81	230	115	311	Yes
1.0E-06	34	196	81	230	115	311	Yes
1.0E-07	34	196	81	230	115	311	Yes
1.0E-08	34	196	81	230	115	311	Yes
1.0E-09	34	196	81	230	115	311	Yes
1.0E-10	34	196	81	230	115	311	Yes
2.2E-12	34	196	81	230	115	311	Yes
Required:	34	196	81	230	115	311	

Table 21. Ng and Komunjer (2011) parameter identification test, for the case where gamma is calibrated.

APPENDIX C

Prior vs. Posterior Distribution Plots

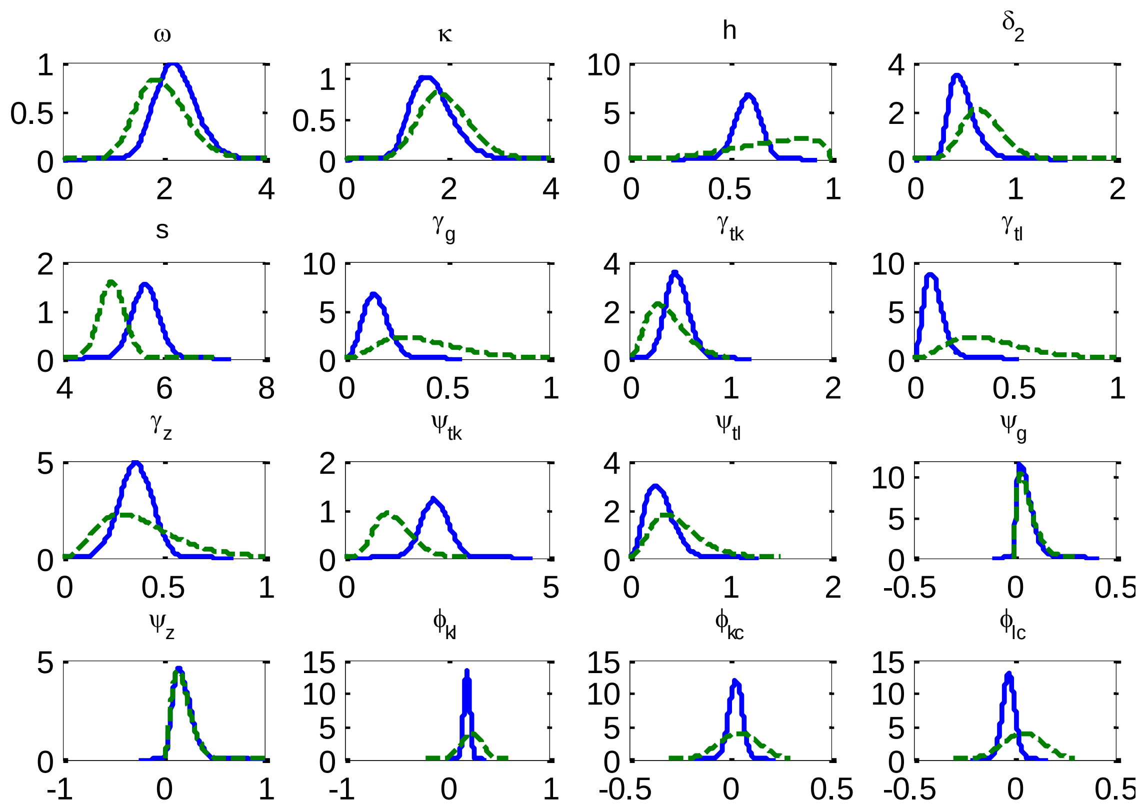

Figure 20. Posterior (solid line) vs. prior (dashed) distributions. Unrestricted labor supply.

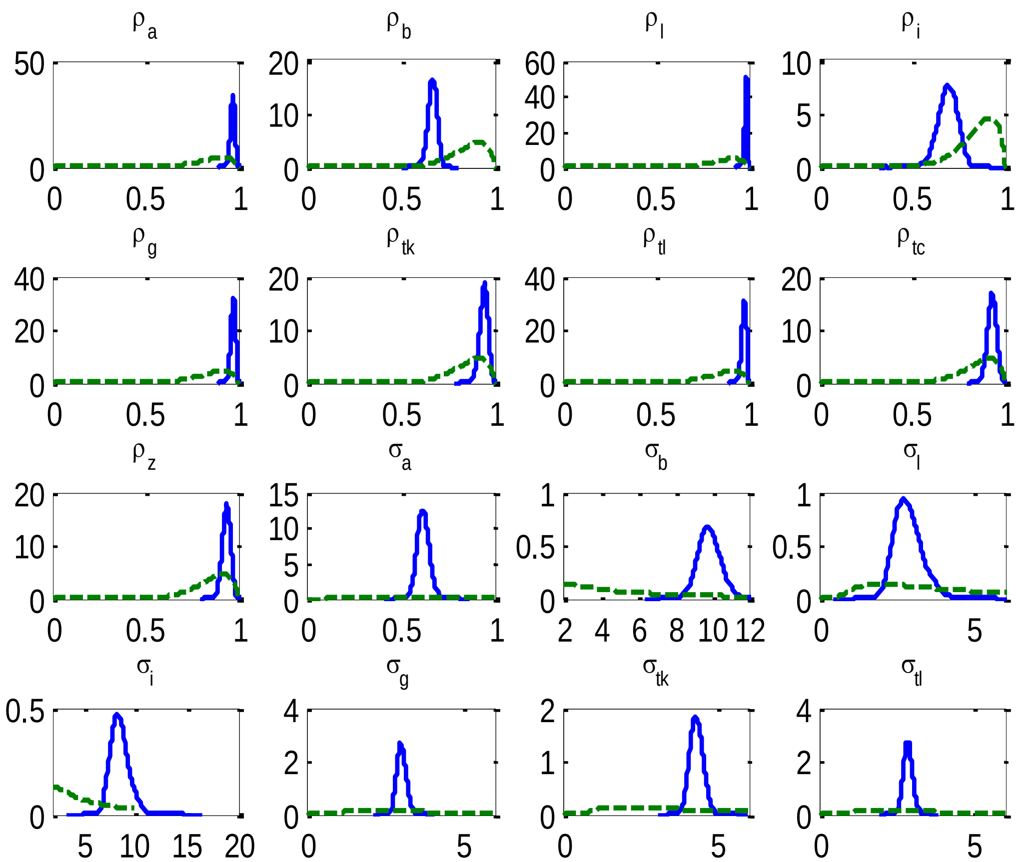

Figure 21. Posterior (solid line) vs. prior (dashed) distributions. Unrestricted labor supply.

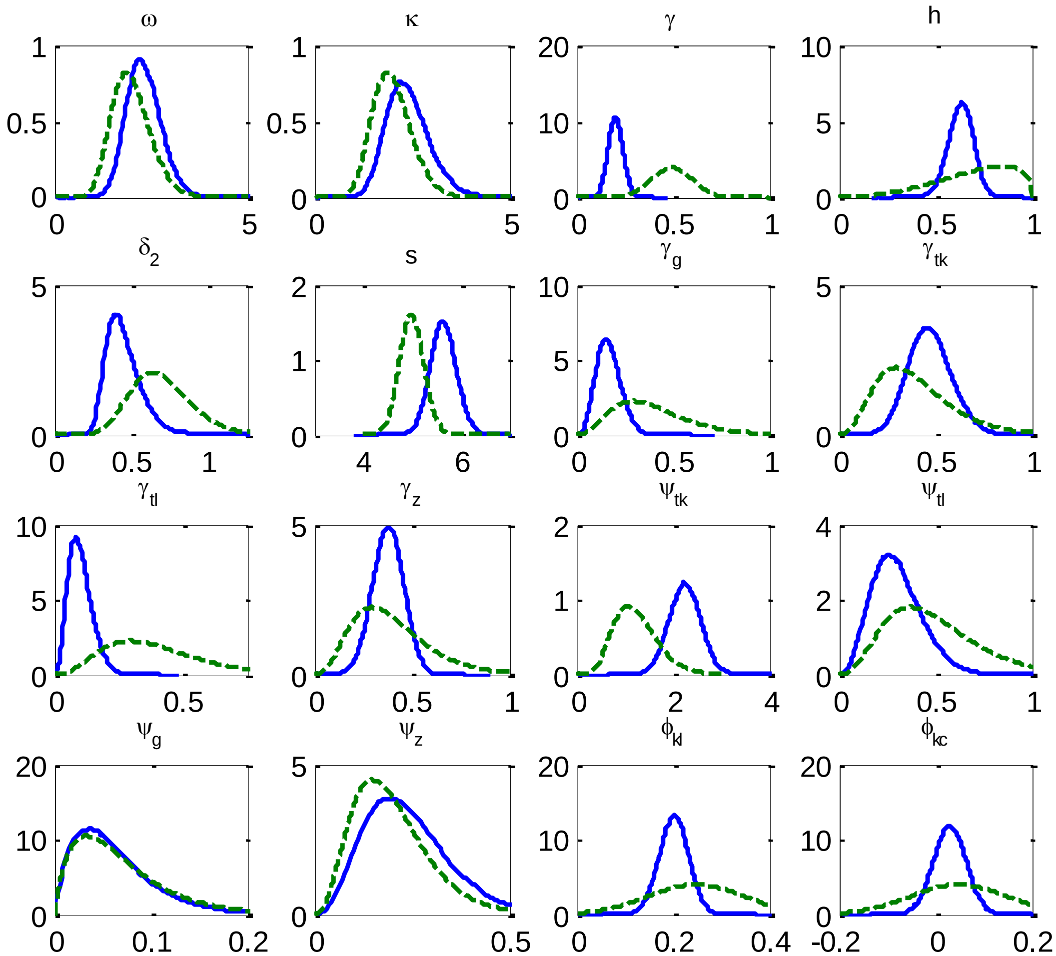

Figure 22. Posterior (solid line) vs. prior (dashed) distributions. Restricted labor supply.

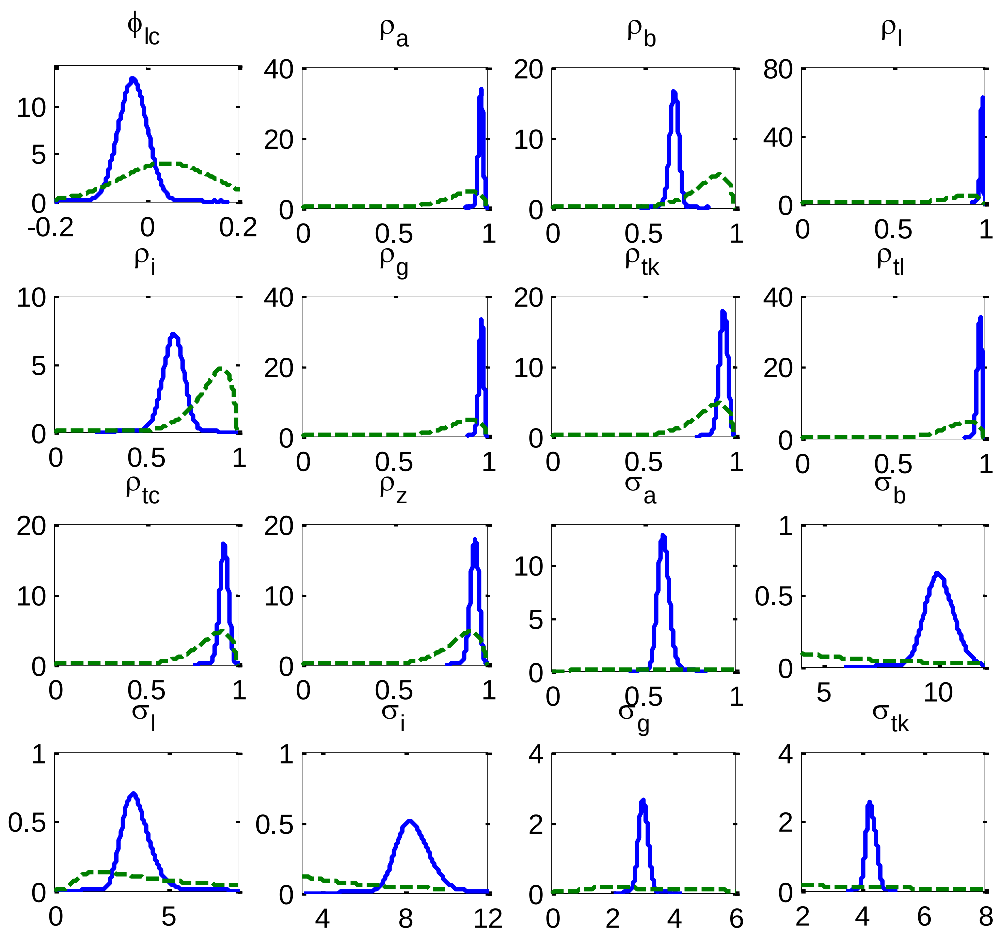

Figure 23. Posterior (solid line) vs. prior (dashed) distributions. Restricted labor supply.

APPENDIX D

Chapter 3 Data

Fiscal variables are constructed following Leeper et al. (2010) and Jones (2002). The majority of the time series are from the Buereau of Economic Analysis' NIPA, or NIPA data downloaded from the St. Louis Fed's Fred database. The few exceptions are noted below. Data were extracted in nominal terms and converted to real terms as described in the text.

Consumption (C): defined as personal consumption expenditure on nondurable goods (NIPA Table 1.1.5 line 4) and on services (Table 1.1.5 line 5).

Investment (I): defined as personal consumption expenditure on durable goods (Table 1.1.5 line 3) and gross private domestic investment (Table 1.1.5 line 6).

Consumption tax revenues (T^c): defined as excise taxes and customs duties (lines 5 and 6 in NIPATable 3.2).

Consumption tax rates: The average consumption tax rate is

defined as

$$\tau^c = \frac{T^c}{C - T^c - T_s^c}$$

where T_s^c is state and local sales taxes (Table 3.3 line 12).

Capital and labor tax rates: Following Jones (2002), first the

average personal income tax rate is computed:

$$\tau^p = \frac{IT}{W + \frac{PRI}{2} + CI}$$

where IT is personal current tax revenues (Table 3.2 line 3), W is wage and salary accruals (Table 1.12 line 3), PRI is proprietors' income (Table 1.12 line 3), and CI is capital income. Capital income is defined as rental income (Table 1.12 line 12), corporate profits (Table 1.12 line 13), interest income (Table 1.12 line 18), and PRI/2.

The average labor income tax rate is computed as:

$$\tau^{l} = \frac{\tau^{p}\left(W + \frac{PRI}{2}\right) + CSI}{EC + PRI/2}$$

where CSI is contributions for government social insurance (Table 3.2 line 11) and EC is compensation of employees (Table 1.12 line 2). The average capital income tax rate is calculated as:

$$\tau^{k} = \frac{\tau^{p} CI + CT}{CI + PT}$$

where CT is taxes on corporate income (Table 3.2 line 7) and PT is property taxes (Table 3.3 line 8). Capital and labor tax revenues. The capital and labor tax revenues are constructed by multiplying the average tax rate and tax base.

Government expenditure (G): defined as government consumption expenditure (Table 3.2 line 20), government gross investment (Table 3.2 line 41), and government net purchases of non-produced assets (Table 3.2 line 43), minus government consumption of fixed capital (Table 3.2 line 44).

Transfers (TR): defined as net current transfers, net capital transfers, and subsidies (Table 3.2 line 31), minus the tax residual. Net current transfers are defined as current transfer payments (Table 3.2 line 21) minus current transfer receipts (Table 3.2 line 15). Net capital transfers are defined as capital transfer payments (Table 3.2 line 42) minus capital transfer receipts (Table 3.2 line 38). The tax residual is defined as current tax receipts (Table 3.2 line 2), contributions for government social insurance (Table 3.2 line 11), income receipts on assets (Table 3.2 line 12), and the current surplus of government enterprises (Table 3.2 line 18), minus total tax revenue, T (consumption, labor, and capital tax revenues).

Government debt (B): defined as $B_t = NB - Seigniorage + B_{t-1}$

where Seigniorage is defined as $M_t - M_{t-1}$, M is the St. Louis Fed's adjusted monetary base, and NB is net borrowing. Net borrowing is computed using the NIPA deficits concept, specifically as G + INT + TR - T, where INT is interest payments (Table 3.2 line 28).[25]

Hours worked: Hours worked is constructed from the following variables:

H: Nonfarm business, all persons, average weekly hours duration: index, 1992 D 100, seasonally adjusted. (From US Department of Labor, PRS85006023.)

Emp: Civilian employment: 16 years and over, measured in thousands, seasonally adjusted. (From US Department of Labor, Bureau of Labor Statistics, CE16OV.) Turned into an index where 1992:3 = 100. Hours worked are then defined as:

$$N = \frac{H * Emp}{100}$$

[25] Following Leeper et al. (2010) I calculate the debt series starting from 1947, so that the starting value will not be too sensitive to the initial value. To initialize the debt series, I use the 1947Q1 value of the Cox and Hirschhorn (1983) market value of debt. The Cox-Hirschhorn debt series is not used in general since the series is not consistent with NIPA's net borrowing definition.

Definition of observable variables

An observable variable X is converted to log per-capita terms by transforming variable x in the following way:

$$X = \ln\left(\frac{\mathrm{x}}{\mathrm{Popindex}}\right) * 100$$

where Popindex in an index of Population, constructed so that 1992:3 = 1. Pop is the civilian noninstitutional population, ages 16 years and over, seasonally adjusted, number in thousands (from US Bureau of La of Labor Statistics), LNS10000000.

x = [consumption, investment, hours worked, government

spending, labor tax revenues, capital tax revenues, consumption

tax revenues, government debt, and transfers].

APPENDIX E

<u>Chapter 4 data</u>

The Federal Reserve forecasts are described in detail in chapter four. All other data was graciously made available on Valerie Ramey's website. Below are the descriptions from Ramey (2011).

1. Data for 1965–2005

Data on nominal GDP, quantity indexes of GDP, and price deflators for GDP and its components were extracted from bea.gov on August 2009. The combined category of real consumption of nondurables plus services was created using Wheelan's (2000) method. The nominal wage and price indices for business were extracted August 2009 from the bls.gov productivity program. The total hours data used in the baseline post-WWII regressions is from unpublished data from the BLS, kindly provided by Shawn Sprague.

2. Hours: Historical series 1939–2008

1939:1–1947:2: Ramey interpolates Kendrick's (1961) annual civilian nonfarm, farm, and military hours series using monthly and quarter series published in various issues of the *Statistical Abstract*. An advantage of Kendrick's civilian series is that it includes hours worked by "emergency workers" as part of the WPA, etc. Various issues of the *Statistical Abstract* (available online through census.gov) report quarterly or monthly data on employed persons and average weekly hours of employed persons for farm and nonfarm civilians from1941:3 through 1945. These are based on the household survey. In 1946, ranges of hours were reported, so that

Average weekly hours could be constructed. Thus, total hours series for (nonemergency) farm and nonfarm civilians were constructed from these numbers from1941:3to 1946:4. The numbers of employed farm and nonfarm civilians from the household survey were reported from1940:2 on, but average hours were not reported. For 1939:1 to1940:1, the only available series was the establishment based civilian nonfarm employment (available from bls.com). As there was no significant seasonality in the average weekly hours series for civilian nonfarm workers, Ramey used the employment series to extend the civilian nonfarm worker total hours back to 1939:1.
There was, however, significant seasonality in the average weekly hours for farm workers. Ramey estimated seasonal hours factors for farm workers using data from1941:3–1947:3 and then applied those to the employment numbers to create total hours back to 1939:1.

1947:3–2008:4: Because the earlier series were based on household data and because the match with Kendrick's series was better, Ramey spliced the earlier data CPS household series from1947on. The seasonally unadjusted CPS monthly data were collected by Cociuba, Prescott, and Ueberfeldt (2009). Ramey then seasonally adjusted the entire series using the Census' X12 program, allowing for outliers due to roving Easters and Labor Days. However, because there was a noticeable permanent change in the seasonality of hours from1946 through1948, theX12 program led to a few anomalous quarters, 1947:3, 1948:2, and1948:4. I smoothed these quarters by averaging with the surrounding quarters. The military hours series was available quarterly from unpublished BLS data from 1948 on. As noted above, the initial baseline regression uses the establishment-based hours series rather than the household series for comparability with the rest of the literature.

3. Tax Series

Barro and Redlick (2010) provide an update for the Barro and Sahasakul (1983) average marginal tax rate series from 1912 through 2006. Ramey had previously updated Alexander and Seater's (2009) series through 2007 using their programs. The annual tax series are converted to quarterly assuming that the tax rate in each quarter of the year was equal to the annual rate for that year.

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ABSTRACT

ESSAYS IN FISCAL POLICY

by

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Major: Economics

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Fiscal policy is investigated in two settings. First, a fully identified neoclassical growth model with rich fiscal policy rules is augmented with non-Ricardian consumers and fit to post-war U.S. data using Bayesian techniques. Allowing transfer payments to directly affect the consumption choices of rule-of-thumb agents permits a new interpretation of time series evidence regarding which fiscal instruments have historically financed government debt. The economic impact of fiscal adjustments is studied for two labor supply specifications. The first specification restricts labor supply by equalizing hours worked across household types. The second relaxes this assumption, allowing for intratemporal optimization by non-Ricardian households. With respect to previous findings, capital and labor taxes are more important for debt stabilization while transfers play a smaller role. Capital taxes and transfers play a larger role in output stabilization.

Second, I explore the effects of anticipated policy changes. If agents are rational, they will incorporate news about future spending changes before they are enacted. I collected Federal Reserve forecasts for the period 1965 – 2005 from online archives of FOMC meetings. I incorporate the forecasts as a measure of anticipated military spending to identify government spending shocks in a VAR. When the raw forecasts are used I find that GDP, hours, wages, and consumption all rise following a shock to the news variable. When I instead incorporate forecast errors in the VAR I find just the opposite: hours increase while wages and consumption fall after a government spending shock, as is typical with the narrative approach to identifying government spending shocks, pioneered Ramey and Shapiro (1997). Thus, the way in which the forecast data is incorporated into the VAR becomes crucially important to the results. Corroborating evidence is sought using a structural model designed to study fiscal policy.

AUTOBIOGRAPHICAL STATEMENT

I hail from Grand Rapids, MI. I attended the University of Oklahoma on a National Merit Scholarship, graduating with dual B.A. degrees in Letters and Spanish in 2001. I went on to earn an MBA from Grand Valley State University in 2003. I earned my Economics PhD in 2014 from Wayne State University in Detroit, MI. My fields are macroeconomics and health economics. I currently reside in Pittsburgh, PA where I work as an assistant professor of economics at California University of Pennsylvania. I live with my wife, Briget, and my three children, Anna, Ella, and Alexander.