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New Keynesian versus old Keynesian government spending multipliers

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ABSTRACT

Renewed interest in fiscal policy has increased the use of quantitative models to evaluate policy. Because of modelling uncertainty, it is essential that policy evaluations be robust to alternative assumptions. We find that models currently being used in practice to evaluate fiscal policy stimulus proposals are not robust. Government spending multipliers in an alternative empirically estimated and widely cited new Keynesian model are much smaller than in these old Keynesian models; the estimated stimulus is extremely small with GDP and employment effects only one-sixth as large and with private sector employment impacts likely to be even smaller. We investigate the sensitivity of our findings with regard to the response of monetary policy, the zero bound on nominal interest rates and the inclusion of an empirically relevant degree of rule-of-thumb behaviour in the new Keynesian model. In addition, we relate our findings using estimated structural macroeconomic models to the recent literature using reduced-form regression techniques.

1. Introduction

In a recent paper[1] Christina Romer, Chair of the President's Council of Economic Advisers, and Jared Bernstein, Chief Economist of the Office of the Vice-President, provided numerical estimates of the impact of an increase in government spending on GDP and employment in the United States. Such estimates are a crucial input for the policy making process. They help determine the appropriate size and timing of countercyclical fiscal policy packages and they help inform members of the Congress and their constituents about whether a vote for a policy is appropriate. For packages approaching $1 trillion including interest, as in 2009, the stakes are enormous. The estimated economic impacts matter.

The Romer–Bernstein estimates are based on two particular quantitative macroeconomic models—one from the staff of the Federal Reserve Board and the other from an unnamed private forecasting firm. By averaging the impacts generated by these two models, they estimate that an increase in government purchases of 1 percent of GDP would induce an increase in real GDP of 1.6 percent compared to what it otherwise would be. Their results are shown in Fig. 1. Also shown in Fig. 1 are

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[1] See Romer and Bernstein (2009, Appendix 1, p. 12). Their paper was written during the transition period in early January before Christina Romer was sworn in as Chair of the Council of Economic Advisers. The first version of our paper was circulated immediately after a modified version of the Obama Administration's fiscal stimulus proposal was passed into law in February 2009 as NBER working paper 14782.

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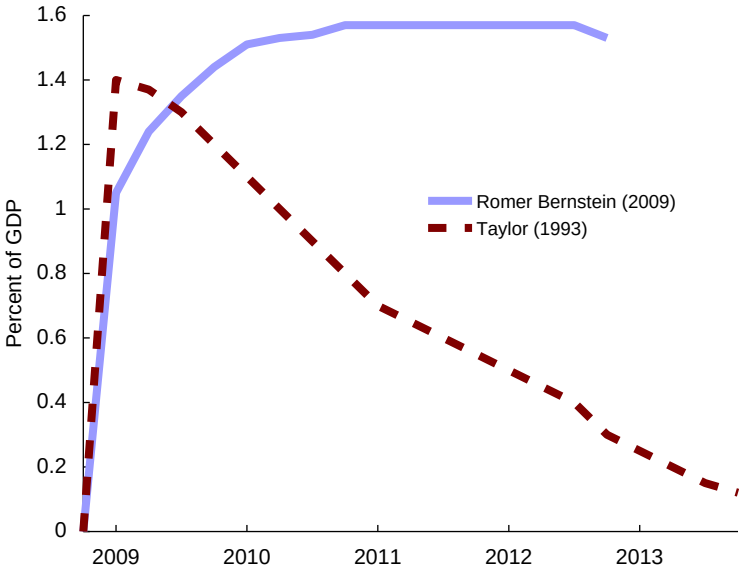

Fig. 1. Estimated impact on GDP of a permanent increase in government purchases of 1 percent of GDP.

the estimated effects of exactly the same policy change—a permanent increase in government purchases—as reported in another study published a number of years ago by one of us.[2]

It is clear from Fig. 1 that the results are vastly different between the different models. Perhaps the most important difference is that in one case higher government spending keeps on adding to GDP "as far as the eye can see," while in the other case the effect on GDP diminishes as non-government components are crowded out by government spending.

Macroeconomists remain quite uncertain about the quantitative effects of fiscal policy. This uncertainty derives not only from the usual errors in empirical estimation but also from different views on the proper theoretical framework and econometric methodology. Therefore, robustness is a crucial criterion in policy evaluation. Robustness requires evaluating policies using other empirically estimated and tested macroeconomic models. From this perspective Fig. 1 is a concern because it shows that the Romer–Bernstein estimates apparently fail a simple robustness test, being far different from existing published results of another model. For these reasons an examination of the Romer–Bernstein results is in order.

2. The need for an alternative assessment

We think it is best to start by conducting a fresh set of simulations with a macroeconomic model other than one of those used in Fig. 1. We focus on the Smets–Wouters model of the US economy.[3] The Smets–Wouters model is representative of current thinking in macroeconomics. It was recently published in the *American Economic Review* and is one of the best known of the empirically estimated "new-Keynesian" models. It is very similar to, and "largely based on" according to Smets and Wouters, another well-known empirically estimated new-Keynesian model developed by Christiano et al. (2005). The Smets–Wouters model was highlighted by Michael Woodford (2009) as one of the leading models in his review of the current consensus in macroeconomics.[4]

The term "new Keynesian" is used to indicate that the models have forward looking, or rational, expectations by individuals and firms, and some form of price rigidity, usually staggered price or wage setting. The term also is used to contrast these models with "old-Keynesian" models without rational expectations of the kind used by Romer and Bernstein.[5] New-Keynesian models rather than old-Keynesian models are the ones commonly taught in graduate schools because they capture how people's expectations and microeconomic behaviour change over time in response to policy

[2] See Taylor (1993, Figs. 5–8A, p. 166). This is a rational expectations model with staggered wage and price setting and thus could be described as "new Keynesian" as defined below.

[3] See Smets and Wouters (2007) for a complete review of their model. It determines 14 endogenous variables: output, consumption, investment, the price of capital, the capital stock, capital services, the capital utilization rate, labor supply, the interest rate, the inflation rate, the rental rate on capital, the wage rate, the marginal product of labor, and the marginal rate of substitution between work and consumption. The 14 equations include forward-looking consumption, investment, price and wage setting as well as several identities.

[4] See Woodford (2009), which also contains a useful survey of the whole "new Keynesian" literature.

[5] There is a rational expectations version of the Federal Reserve's FRB/US model. We simulated a permanent increase in government purchases in this version and found that the multipliers declined sharply over time unlike those reported by Romer and Bernstein (2009) but similar to the Taylor (1993) rational expectations model as shown in Fig. 1. We infer that the FRB/US model and the private sector model used by Romer and Bernstein are not new Keynesian models with rational expectations. Also, as explained below, new Keynesian models would not allow an assumption of a constant zero interest rate forever.

interventions and because they are empirically estimated and fit the data. They are therefore viewed as better for policy evaluation. In assessing the effect of government actions on the economy, it is important to take into account how households and firms adjust their spending decisions as their expectations of future government policy change.

We first show that the assumptions made by Romer and Bernstein about monetary policy—essentially an interest rate peg for the Federal Reserve—are highly questionable according to new-Keynesian models. We therefore modify that assumption and look at the impacts of a permanent increase in government purchases of goods and services in the alternative model. According to the alternative model the impacts are much smaller than those reported by Romer and Bernstein.

We then consider more realistic scenarios. We look at the impact when government spending follows the fiscal policy legislation enacted in February 2009 and we look at a scenario in which monetary policy is more responsive. For these scenarios the impact with the alternative model is even smaller.

3. The problem with an interest rate peg

Romer and Bernstein assume that the Federal Reserve pegs the interest rate—the federal funds rate—at the current level of zero for as long as their simulations run. Given their assumption that the spending increase is permanent, this means forever. In fact, such a pure interest rate peg is prohibited in new-Keynesian models with forward-looking households and firms because it produces calamitous economic consequences. As Thomas Sargent and Neil Wallace[6] pointed out more than 30 years ago, a pure interest rate peg will lead to instability and non-uniqueness in a rational expectations model. Inflation expectations of households and firms become unanchored and unhinged and the price level may explode in an upward spiral.

A permanent increase in government spending as a share of GDP would eventually raise the real interest rate. This is the mechanism by which other shares of spending (consumption, investment, and net exports) would be reduced to make room for the increased government share. With the Fed holding the nominal interest rate constant at the current value near zero, and thus below inflation, the lower real rate would cause inflation to rise and accelerate without limit. Thus the combination of a permanent increase in government spending and the Fed setting the interest rate at zero would lead to hyperinflation.

If the combination of a permanent government spending increase and a zero interest rate peg were assessed by the Smets–Wouters model or, for that matter, any of the new-Keynesian models, the economy's projected performance would reflect the aforementioned consequences. To achieve stability of output and inflation in such a model one must instead assume that, at some point, the federal funds rate is allowed to move above zero and respond to the state of the economy rather than be held fixed.

For the simulations presented here we therefore assume that the Federal Reserve only keeps the federal funds rate constant for a finite period of time after which it moves the interest rate depending on what is happening to the economy. We begin by assuming that it keeps the interest rate equal to zero and constant through 2009 and 2010 and then follows a standard monetary policy rule thereafter. Thus, in 2011, nominal interest rates will change somewhat and forward-looking households and firms will incorporate this monetary policy response in their decision making. Keeping interest rates constant for 2 years still does not seem very realistic and would likely result in an increase in inflation, but it is certainly more realistic than pegging the interest rates at zero forever, or even for 4 years.

4. Government spending multipliers: new Keynesian versus old Keynesian

Table 1 shows the response of real GDP to a permanent increase in government purchases of 1 percent of GDP in the new-Keynesian model and contrasts these with the average of the two models of Romer and Bernstein. The simulations are done using a new database of macroeconomic models designed explicitly with the purpose of doing such policy evaluation and robustness studies.[7] The increase in government spending is assumed to start in the first quarter of calendar year 2009. The forward-looking models require explicit assumptions about what household's and firms expect. Our assumption is that, as of the first quarter of 2009, people expect the government spending increase to continue permanently (as in the Romer–Bernstein policy specification), and that the spending increase is initially debt-financed. The Smets–Wouters model assumes that any increase in debt used to finance the increased government spending is paid off with interest by raising taxes in the future. We assume that these taxes are "lump sum" in the sense that they do not affect incentives to work, save or invest. They do, however, lower future after tax earnings and thereby wealth. If we took such incentive effects into account the increase in government spending would eventually reduce real GDP. Hence, our assumptions err on the side of overestimating the size of the impact of government spending on real GDP.

Observe that the Smets–Wouters model predicts a much smaller boost to GDP than the estimates reported by Romer and Bernstein. The Smets–Wouters multiplier is smaller throughout the whole simulation period, and by 2011 is only

[6] See Sargent and Wallace (1975). Though the Sargent and Wallace model assumes perfectly flexible prices the same results hold in models with sticky prices.

[7] The model database is described in Wieland et al. (2009) and used in a model comparison exercise by Taylor and Wieland (2009).

Table 1
Impact of a permanent increase in government spending by 1 percent of GDP (federal funds rate set to zero throughout 2009 and 2010).

	Percentage increase in real GDP				
	2009Q1	2009Q4	2010Q4	2011Q4	2012Q4
Romer/Bernstein	1.05	1.44	1.57	1.57	1.55
Smets/Wouters	1.03	0.89	0.61	0.44	0.40

about one-third the size of the Romer–Bernstein multiplier. The Smets–Wouters model also shows a rapid reduction in the size of the impact over time. Overall the Smets–Wouters impacts are very similar in size and timing to those found in the Taylor (1993) model shown in Fig. 1. In sum, the Romer–Bernstein estimates are much more optimistic in their GDP estimates than the alternative model considered here.

The Smets–Wouters model predicts that the increase in GDP by the end of 2009 is smaller than the increase in government expenditures itself; that is, the multiplier is less than one. Thus, the model predicts that government "stimulus" quickly produces a permanent contraction in private sector investment and/or consumption. Note that the magnitude of the contraction grows over time. By the end of 2012, for each dollar of "stimulus", the flow of goods and services purchased by the private sector falls by 60 cents.

5. Alternative assumptions about monetary policy

Table 2 shows what would happen if the length of time for which the federal funds rate is anticipated to remain constant is shorter and extends only through the end of 2009. In other words we now assume that the Fed starts following its feedback rule for policy starting in 2010 rather than waiting until 2011.

The impacts in Table 2 are uniformly smaller through 2011 than those in Table 1 because interest rates can begin to increase earlier (in 2010 rather than 2011) accelerating the crowding-out process in the new-Keynesian model. Note that the differences between the Smets–Wouters simulations in Tables 1 and 2 are not nearly as large as the differences between either of these and the Romer–Bernstein impacts. In what follows we will continue with the assumption that the Fed can start to increase interest rates if necessary in 2010.

6. A more realistic path for government purchases

Although a permanent increase in government purchases of goods and services is a good way to understand the properties of a model, it is not a realistic description of the fiscal policy packages under consideration in the United States and other countries recently nor of the final $787 billion fiscal stimulus package enacted and signed into law[8] on February 17, 2009. For example, about half of that fiscal stimulus package consists of transfer payments for unemployment assistance, nutritional aid, and health and welfare payments, and temporary tax cuts. In addition, the package does not provide for an immediate *permanent* increase in government purchases of goods and services. Most of the purchases authorized by the law are one-time and phased in, with the lion's share of the purchases completed within 4 years.

Table 3 shows the US fiscal stimulus package's impact on the federal deficit and federal government purchases in billions of dollars. The government purchases column corresponds to the permanent increase in government purchases simulated and reported in Tables 1 and 2 except of course that it is not permanent. Observe that $21 billion or just 2.6 percent of the total $787 billion increase in the deficit spending occurs in fiscal year 2009, which is when the economy is expected to be weakest.[9] Federal purchases then increase in 2010, stay relatively steady for 2 years, and then begin to decline again in 2012. Since the stimulus bill is a mixture of increased transfer payments, tax refunds, and higher government purchases, the path for the deficit is different from the path of the increase in government purchases.

One component of federal government transfers—certain transfers going to state and local governments—is similar to federal purchases in that the funds are to be used by the states to purchase goods and services. These intergovernmental transfers, which consist mainly of funds for education and public safety activities, are shown in the third column of Table 3. During the first 3 years, these government transfers exceed federal purchases. It is difficult to determine how much of the transfers to states and localities will ultimately result in an increase in spending on goods and services. States and localities might use some or all of the funds to avoid raising taxes or increasing borrowing. To the extent that they do, the transfer would not produce a net increase in government purchases of goods and services. Romer and Bernstein (2009) assume that 60 percent of these transfers go to purchases of goods and services. In keeping with that assumption, we consider in what follows the impact on GDP of an increase in government purchases equal to column 2 plus 60 percent of column 3 in Table 3. We assume that the path of purchases is constant for all the quarters within a fiscal year and that, as assumed Romer and Bernstein (2009), there is a one quarter lag in the effect of the increase of transfers to states and localities on

[8] The official name of the legislation is The American Recovery and Reinvestment Act of 2009.
[9] The US government's 2009 fiscal year runs from October 1, 2008 to September 30, 2009.

Table 2
Impact of a permanent increase in government spending by 1 percent of GDP (federal funds rate set to zero throughout 2009).

	Percentage increase in real GDP				
	2009Q1	2009Q4	2010Q4	2011Q4	2012Q4
Romer/Bernstein	1.05	1.44	1.57	1.57	1.55
Smets/Wouters	0.96	0.67	0.48	0.41	0.40

Table 3
Increased deficit, federal government purchases, and transfers to state and local governments for purchases of goods and services in the February 2009 Stimulus Legislation (billions of dollars).

Fiscal year	Increase in federal purchases	Increase in transfers to states, localities	Increase in federal deficit[a]
2009	21	48	184
2010	47	107	400
2011	46	47	134
2012	36	8	36
2013	25	4	27
2014	27	0	22
2015	11	0	5
2016	−2	0	−8
2017	−3	0	−7
2018	−2	0	−6

Source: Authors' calculations derived from Congressional Budget Office.
[a] Excludes impact of interest payments on the public debt incurred to finance the stimulus package.

their purchases of goods and purchases. We also experimented with other interpolation schemes but the results were not substantially different and we focus here on the simple constant level assumption.

Fig. 2 presents the results of the simulation. The bar graph shows the increased government purchases as a share of GDP, and the line graph shows the impact of the increase in purchases on real GDP according to the Smets–Wouters model.

The quarters in Fig. 2 refer to the calendar year rather than the fiscal year. We show the results through 2013 even though we simulate the impacts over the full 10 years. The model solution techniques that we employ take into account the particular nonlinear time profile of government spending and ensure that households and firms form appropriate expectations.[10]

7. Estimated impacts

According to the Smets–Wouters model, the impacts of this package on GDP are very small. But particularly worrisome is that during the first year the estimated stimulus is minor and then even turns down in the third quarter. Why the very small effect in the first year?

The answer comes in part from the timing of the government expenditures and the forward-looking perspective of households. The small amount of government spending in the first year is followed by a larger increase in the second year. Households and firms anticipate the second year increase during the first year. They also anticipate that ultimately the expenditures will be financed by higher taxes. The negative impact of the delayed government spending and the negative wealth effect on private consumption of higher anticipated future taxes combine to reduce the positive impact of the stimulus. As a result, the first-year GDP impact is initially small and turns down.

In the Smets–Wouters model there is also a strong crowding-out of investment. Hence, both consumption and investment decline as a share of GDP in the first year according to the Smets–Wouters model. This negative effect is offset, as shown in Fig. 2, by the increase in government spending in the first year, but it causes the multiplier to be below one right from the start. Fig. 3 shows the impact on consumption and investment.

Note that as the government purchases come back down in 2013, the multiplier turns negative. The declines in consumption plus investment are greater than the increases in government spending. Though not shown in Fig. 2, the simulations show that the impact on GDP is negative for many years beyond 2013.

[10] The fiscal stimulus simulations with anticipated government spending plans and temporarily constant nominal interest rates require using nonlinear solution techniques. The methodology we use is described in Juillard (1996) and implemented in DYNARE. This solution approach builds on earlier work by Laffarge (1990) and Fair and Taylor (1983).

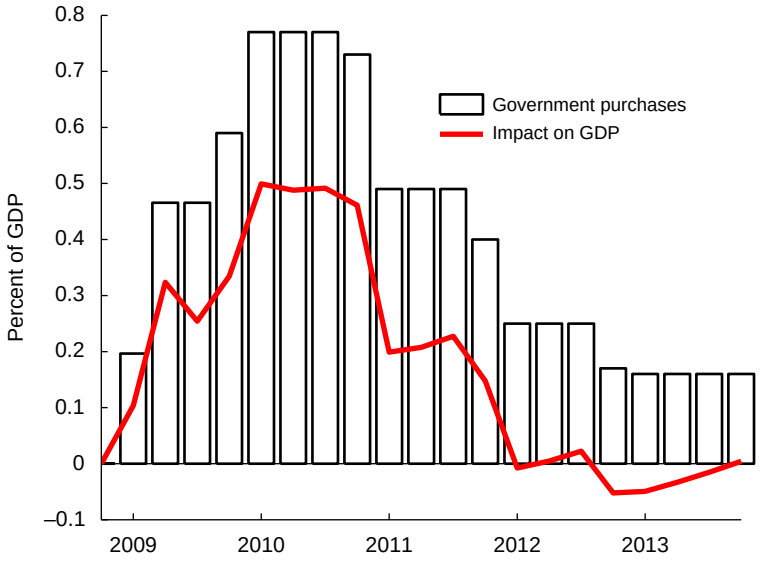

Fig. 2. Estimated output effects of government purchases in the February 2009 stimulus legislation. (Government purchases equal federal purchases plus 60 percent of transfers to state and local governments for purchases of goods and services.)

Because of the negative effects on consumption and investment, it is possible to get negative GDP multipliers in the first year with government purchases paths slightly different from those in Figs. 2 and 3. For example, a sharper increase in government spending in the second year compared to the first leads to more crowding out of consumption and investment in the first year and the multiplier can turn negative. In fact, our simulations of the first stimulus bill passed by the House of Representatives in 2009 had this property, but changes by the conference committee and revised estimates of the path of government purchases by the Congressional Budget Office removed the negative multiplier.

The simulations reported in Figs. 2 and 3 are based on the assumption that the Fed starts following its feedback rule for policy starting in the first quarter of 2010. Of course, the increase in GDP would be greater if the zero interest rate policy is maintained till the end of 2010 as in the simulation of a more permanent increase in government spending reported in Table 1. In this case, GDP would rise by almost 0.8 percent in 2010 when most of the additional spending occurs. But even under this less realistic assumption regarding the Fed's policy response, the GDP effect of ARRA spending remains around 1/4 of the Romer–Bernstein estimates of 3.6 percent by the end of 2010.

8. Too Keynesian or not Keynesian enough?

A possible criticism of new-Keynesian models such as Christiano et al. (2005) and Smets and Wouters (2007) is that they are not Keynesian enough, because they assume that all households are forward-looking and optimize their spending decisions. Some have suggested that one should allow for the possibility that some households follow "rules of thumb" like the original Keynesian consumption function with a high and constant marginal propensity to consume. Others have proposed to assume that many households are constrained to consume all their current income.[11]

However, it is also possible to criticize new-Keynesian models because they are too Keynesian. In contrast with real business cycle models, the estimated new-Keynesian models assume "sticky prices" by introducing staggered price and wage setting. But as Chari et al. (2009) have emphasized the models go further in the Keynesian direction by assuming "the backward indexation of prices" in "a mechanical way" which amplifies Keynesian aggregate demand effects of policy.

It is well understood that the standard real business cycle model predicts increases in government spending to crowd out private consumption due to the negative wealth effect that arises from higher current or future taxes (see for example, Baxter and King, 1993). The particular time path of taxes is irrelevant if they are raised lump sum—the so-called Ricardian equivalence property. Thus, bringing the model of Smets and Wouters more in line with standard real business cycle analysis as proposed by Chari et al. (2009) would further strengthen the case against the "old" Keynesian multipliers used by Romer and Bernstein (2009).

The more interesting question is whether introducing "old" Keynesian rule-of-thumb consumers in new-Keynesian models would change our findings significantly. To address this question we extend the Smets–Wouters model to allow for two types of consumers. The rule-of-thumb consumers spend all their after-tax labour income whereas the others take into

[11] Models of consumption with an exogenous share of rule-of-thumb consumers were proposed by Campbell and Mankiw (1989). More recently, Coenen and Straub (2005) and Gali et al. (2007) have investigated the implications of this assumption for fiscal policy in New Keynesian models.

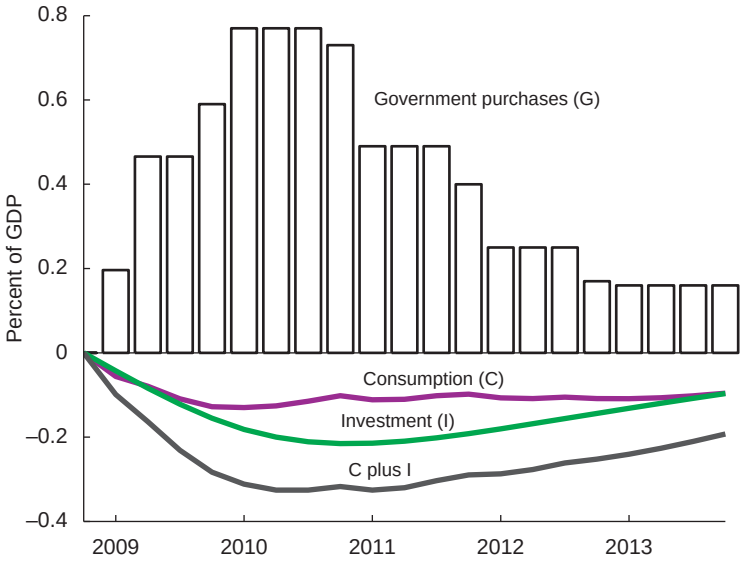

Fig. 3. Crowding out of consumption and investment in the February 2009 Stimulus Legislation (government purchases are as in Fig. 2).

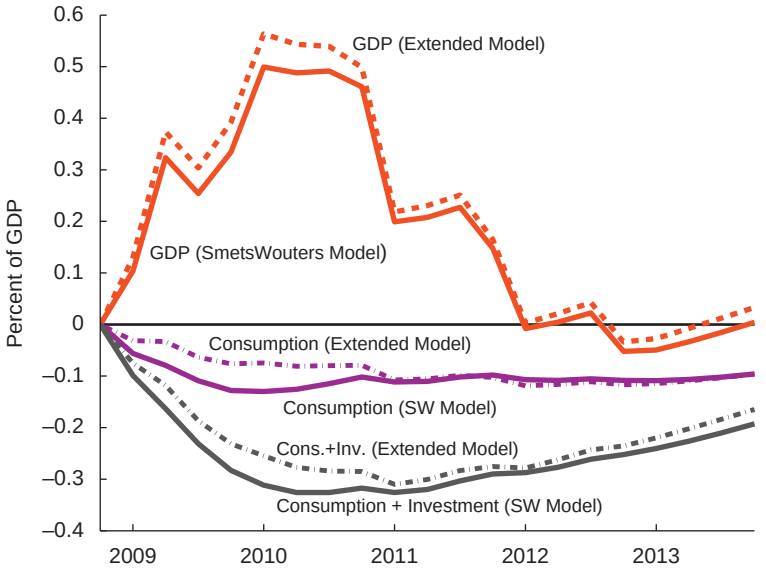

Fig. 4. Estimated impact of ARRA government purchases in new-Keynesian models with and without rule-of-thumb consumers.

account expected future earnings and taxes and make optimal consumption and savings decisions. In the presence of rule-of-thumb consumers, the Ricardian equivalence property fails to hold and the time path of lump-sum taxes influences aggregate outcomes. As in Gali et al. (2007) we assume that the particular path for taxes is determined by a fiscal policy rule which responds to the level of government spending and government debt. Taxes are raised from both types of consumers.

We re-estimate all the parameters of the model including the share of rule-of-thumb consumers and the parameters of the fiscal policy rule. The additional model equations and the estimation results are discussed in detail in Appendix A. For the purpose of better comparability we use the same data set on US economic aggregates as in Smets and Wouters (2007). Using Bayesian methods requires specifying a prior belief on the parameters. We choose a prior mean of 0.5 for the share of rule-of-thumb consumers. This value is at the high end of those found in the literature. Our estimation shows that the US data is better fit by a smaller value. We obtain a posterior mean for the share of rule-of-thumb consumers of 27 percent. As to the fiscal policy rule the response of lump-sum taxes to government debt is estimated to be 0.06, while the fraction of increased government spending that is immediately financed by higher taxes has a posterior mean of about 0.13. This

reaction function implies a considerable build-up of government debt after an increase in government spending that is paid back slowly over time.

Fig. 4 reports the impact of government spending increases implied by the American Recovery and Reinvestment Act in our model with rule-of-thumb consumers compared to the impact in the Smets–Wouters model previously shown in Fig. 2. As one might have expected the GDP effect of ARRA spending is greater in the presence of rule-of-thumb consumers. However, the difference remains of modest magnitude. The maximum increase above baseline comes to 0.56 percent in the first quarter of 2010 relative to 0.5 percent in the Smets–Wouters model. Thus, a medium-size new-Keynesian model that allows for households that simply consume current income and fits US data quite well, still implies much smaller multiplier effects than the models considered in Romer and Bernstein (2009) for important practical policy analysis. The multiplier remains well below unity reaching a maximum of 0.73 in the first quarter of 2010.

As shown in the lower half of Fig. 4 increased government spending continues to crowd out private spending on consumption and investment goods in the estimated model with rule-of-thumb consumers. This finding stands in contrast to the study of Gali et al. (2007). There are several reasons for this difference. Our empirical estimate of the share of rule-of-thumb consumers is lower than their assumed value of 0.5.[12] Furthermore, our estimated model allows for wage rigidities. As a result, real wages increase more moderately after a rise in government spending and induce less of a boost to disposable income and consumption of rule-of-thumb consumers. Finally, the negative wealth effects induced by the ARRA spending plan are relatively large.

9. Reduced-form empirical evidence and the importance of anticipation effects

So far, we have investigated the magnitude of government spending multipliers and the effects of the ARRA legislation using estimated structural macroeconomic models of the US economy. However, there also exists a large literature that utilizes reduced-form methods in order to identify the likely effects of government spending shocks on the US economy. As emphasized by Ramey (2009) this literature remains divided on central questions such as whether the GDP effect is greater than unity and whether private spending rises or falls in response to government spending increases. She points out that studies using VAR techniques in which identification is achieved by assuming that government spending is pre-determined within the quarter typically find a larger effect of government spending on GDP and crowding-in of consumption (e.g. Blanchard and Perotti, 2002; Fatas and Mihov, 2001 or Gali et al., 2007) while studies using the Ramey–Shapiro "war dates" (e.g. Ramey and Shapiro, 1998; Burnside et al., 2004; Ramey, 2009) indicate a smaller GDP effect and crowding-out of consumption.

Indeed, a closer look at the above-mentioned studies as well as several more recent empirical analyses reveals a wide range of estimates of the GDP impact of government spending due to difficulties in identifying the presumed government spending shocks. Using VAR techniques, Blanchard and Perotti (2002) find a government spending multiplier close to one, Fatas and Mihov (2001) estimate it to be greater than one, while Gali et al. (2007) obtain a high-end estimate of 1.7 after 2 years that could be used as support of the Romer–Bernstein calculations.[13] These studies find that private consumption increases following a government spending shock. Using a different identification approach based on sign restrictions on VAR impulse responses, Mountford and Uhlig (2009) estimate a multiplier well below one for a deficit financed government spending shock. In their analysis, consumption does not move much in response to government spending.

Clearly, identification is a problem which is why other studies focus on military spending and attempt to collect additional information on the timing of particular changes. Ramey (2009) shows that increases in military spending and non-defense spending are anticipated several quarters before they occur. Consequently, it is important to capture the timing of the news about future increases in government spending correctly. Her multiplier estimates based on an extension of the Ramey-Shapiro (1998) "war dates" and new data series on defense news lie between 0.6 and 0.8 when World War II is excluded, and near unity with World War II included. Similar empirical findings are reported by Barro and Redlick (2009). They identify a defense spending multiplier of 0.6–0.7 including the World War II period. In addition, they obtain some evidence that the spending multiplier may reach unity in states with an unemployment rate as high as 12 percent. Their findings also indicate a significantly negative effect of defense-spending shocks on private investment and net exports.

It remains to relate our analysis of the impact of the ARRA legislation with estimated structural macroeconomic models to the above-mentioned studies of government spending shocks. One advantage is that the timing and nature of the anticipation of fiscal spending packages due to the ARRA is known and need not be identified from macroeconomic time series. Of course, in estimating the structural models one also obtains empirical monetary and fiscal policy reaction functions. Thus, we can conduct a simulation in our models that is similar to the experiments considered by the

[12] Our estimate with US data is similar to euro area estimates of 25–35 percent obtained by Coenen and Straub (2005) and Ratto et al. (2009), respectively. The likely effects of euro area fiscal stimulus are investigated in several macroeconomic models by Cwik and Wieland (2009) and tend to confirm our findings for the United States.

[13] The higher estimates implied by VAR models such as Gali et al. (2007) are perhaps less surprising once one recognizes that regressions of output on lagged values of itself and other variables are similar to the type of Keynesian-style models with backward-looking expectations that are known to generate greater multiplier effects and appear to have been used by Romer–Bernstein in their calculations. Gali et al. (2007) also make use of the Congressional Budget Office estimate of potential output, which is essentially a model constructed in line with traditional Keynesian analysis, in defining some of the variables entering the VAR as gap variables.

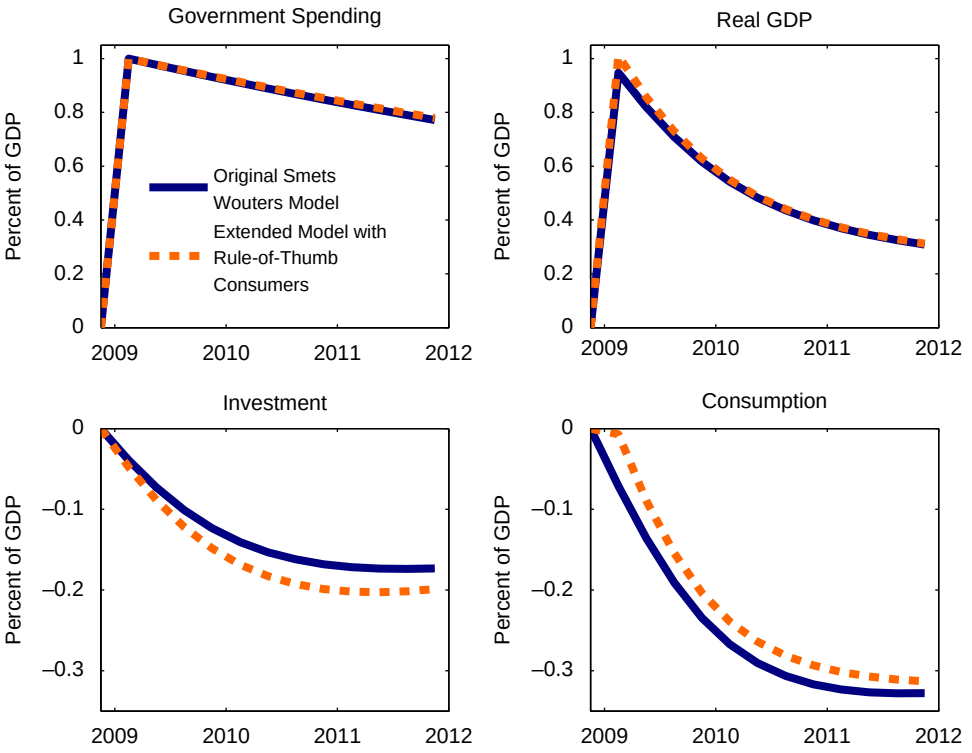

Fig. 5. Estimated impact of a gradually phased-out government spending shock in the original Smets–Wouters model (solid lines) and the extended model with rule-of-thumb consumers (dashed lines).

above-mentioned VAR studies, namely a one-time surprise increase in government spending that dies out slowly according to an anticipated autoregressive process. The outcomes of these simulations are shown in Fig. 5.

The initial effect of a typical government spending shock in the Smets–Wouters model and in our version of the model with rule-of-thumb consumers lies roughly in the middle of the wide range of estimates obtained in the reduced-form empirical studies reviewed above. The first-quarter impact on GDP in the model with rule-of-thumb consumers is slightly above unity. The average over the first year is 0.81, which is consistent with studies such as Ramey (2009) and Barro and Redlick (2009). The GDP effect however is smaller than in the simulations reported in Tables 1 and 2, because the spending increase is less than permanent and because the zero bound is not in force. With regard to private consumption, the model with rule-of-thumb consumers delivers a smaller decline of consumption. Interestingly, in simulations with one year of constant interest rates we obtain a small crowding-in effect.

The ARRA legislation, however, implies a different time profile of government spending than the autoregressive profile implied by standard impulse response functions, reaching its peak in the second year of the plan. In practice, such a delay and built-up period is unavoidable in executing fiscal stimulus packages because effective implementation of new projects takes time. Estimated structural macroeconomic models that account for a forward-looking and optimizing response of private sector decision makers to changes in government policies are the appropriate tool for quantifying the likely impact of such changes. Such models are better able to quantify the effect of the anticipation of future government spending and tax changes upon announcement of a stimulus package such as the ARRA. Thus, it is important to use them in the type of practical policy analysis conducted by Romer and Bernstein (2009).

10. Fiscal stimulus in the 2008/09 recession and the zero bound on nominal interest rates

Many commentators on the monetary and fiscal responses to the 2008/09 recession have argued that the special circumstance of near zero nominal interest rates provides a strong argument in favour of fiscal stimulus. The argument goes as follows: the Federal Reserve might want to lower nominal interest rates further but is prevented from doing so by the zero-interest-rate floor that arises because savers can use cash as a zero-interest bearing asset. As a consequence, the Fed may not want to increase interest rates as output rises as it usually does and instead accommodates the fiscal stimulus for some time. Christiano et al. (2009) suggest that fiscal multipliers can be much larger than usual in such circumstances. They make use of an estimated new-Keynesian DSGE model due to Altig et al. (2004).

In our simulations using the Smets–Wouters model in Sections 3–5 we have already taken into account this argument by assuming a constant funds rate for up to 2 years and then a return to a stabilizing rule. This assumption induces a

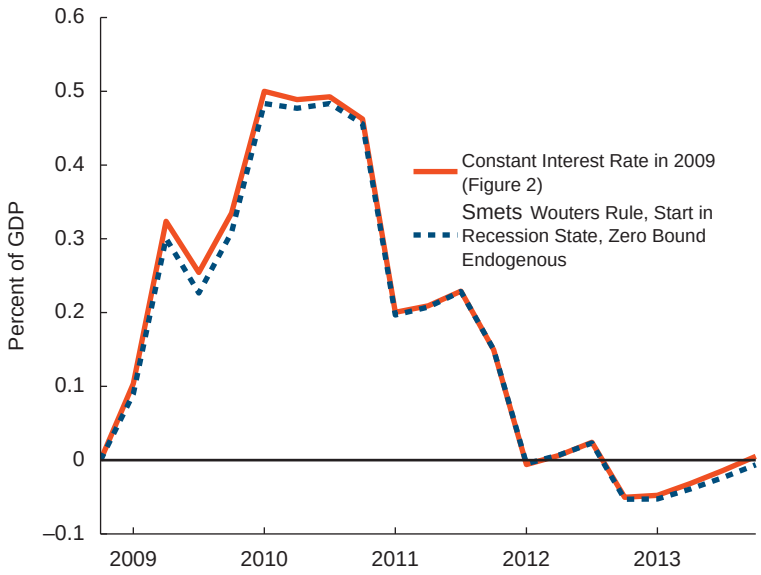

Fig. 6. Estimated GDP impact of ARRA government purchases on projections of the Smets–Wouters model based on actual US data throughout 09Q:1.

nonlinearity, which has important anticipation effects. Nevertheless, this period of monetary accommodation only causes a modest increase in the government spending multiplier. An even longer period of monetary accommodation would be needed to obtain a more significant increase in multiplier effects as in Christiano et al. (2009).

Nevertheless, a reasonable question to ask is whether our findings could be influenced by the fact that we simulate the fiscal stimulus as a deviation from the model's steady state. Clearly, the US economy was still in a deep recession in the first quarter of 2009 when the fiscal packages were enacted. In a linear model, it would make no difference if the stimulus is simulated in deviation from steady state or in a scenario far below this level. In the linear case one can simply apply the simulation to any baseline of interest to the policy maker. In a nonlinear model, however, this need not be true any more. For this reason, we conduct further sensitivity analysis to check whether our findings still hold if the fiscal stimulus is applied in a deep recession during which the federal funds rate may be endogenously constrained at the zero bound for some time.

We simulate the Smets–Wouters model with the actual US data through the first quarter of 2009. Then, we compute projections of the recovery implied by this model with and without the additional government spending. This projection is calculated in a version of the model that incorporates the non-negativity restriction on the federal funds rate.[14] Whether or not the federal funds rate endogenously visits the zero bound depends on the monetary policy rule that determines the systematic response of the Federal Reserve to economic developments.

If we use the Taylor rule then the zero-interest floor does not become a binding constraint for monetary policy. The simulated recovery is sufficiently quick so that Taylor's rule would prescribe an increase in the funds rate. If we use instead the interest rate rule originally estimated by Smets and Wouters along with the other equations in their model, then the funds rate endogenously visits the zero bound in the second and third quarter of 2009.

Fig. 6 reports the difference in GDP projections with and without the ARRA government purchases (dashed line). The underlying simulations are carried out with monetary policy following the Smets–Wouters rule and start in the first quarter of 2009 from an output gap of $-6\frac{1}{2}$ percent annualized. Thus, the difference between the two simulations shown in Fig. 6 is comparable to the results shown previously in Fig. 2 but computed at a state far away from the steady-state level of output. We find that the GDP impact of the additional government purchases remains very close in magnitude to the scenario in Fig. 2 that is indicated by the solid line in Fig. 6 and was simulated as a deviation from steady state with a constant funds rate for four quarters.

11. Impacts of an entire US stimulus package

Although the simulations in this paper have focussed on government spending multipliers in the case of changes in government *purchases* of goods and services, it is possible to say something about the impact of the broader US fiscal stimulus package, which also includes tax rebates and one-time transfer payments to individuals. For this purpose we

[14] The functional form chosen for the non-negativity constraint is the same as in earlier analysis of the implications of the zero-interest rate floor by Orphanides and Wieland (2000), Coenen et al. (2004) and Coenen and Wieland (2003).

focus on the impact in the fourth quarter of 2010 where the size of the increased government purchases (including 60 percent of transfers to states and localities for this purpose) is .73 percent of GDP and the impact on GDP is .46 percent, implying a multiplier in that quarter of .63 (= .46/.73). We choose this quarter for two reasons. First, as shown in Fig. 2, it is close to the quarter of maximum GDP impact, so by choosing this quarter we will in no way be understating the results. In fact, the impact declines sharply after this quarter. Second, this is the quarter for which Romer and Bernstein (2009) report their widely cited calculation that the fiscal stimulus package of February 2009 will increase GDP by 3.6 percent and employment by 3.5 million. Hence, the last quarter of 2010 is useful for comparison purposes.

As Table 3 shows, the deficit (excluding interest payments) increases by more than the increase in government purchases in fiscal year 2009 through 2011. The lion's share of the difference between the deficit and purchases, 80 percent, consists of temporary tax rebates and entitlement benefits for unemployment insurance, Medicaid benefits, health insurance subsidies, and cash welfare payments. The fourth quarter of 2010 (calendar year) is the first quarter of fiscal year 2011. In fiscal year 2011, the deficit minus purchases is $41 billion ($= 134 - 93 = 41$). However, this is a large decrease from fiscal year 2010 where the difference is $246 billion ($400 - 154 = 246$). So for the purpose of estimating the impact of the broader package in 2010Q4 (calendar) we take the average of fiscal year 2010 and 2011, or the average of 41 and 246, which is $144 billion or about 1 percent of GDP.

How much of this "non-government-purchases" increase in the deficit should we add to government purchases to compute the impact on GDP? To the extent that the tax rebates and transfers to individuals are temporary, permanent income theory, even in the presence of liquidity effects, says that the impact on consumption and thereby aggregate demand will be small. Although there is a great deal of uncertainty, a review of the literature over the years suggests that the marginal propensity to consume for such tax and transfer payments is at most 0.3, though it will depend on timing, expectations, and other factors. Recent aggregate evidence suggests that it may be much smaller. For example, an examination of the Economic Stimulus Act of 2008 indicates that the impact of the tax rebates on consumption was insignificantly different from zero.[15] Transfers to individuals, such as entitlement payments for unemployment compensation, and health and welfare benefits, could be expected to have an effect on consumption similar to temporary tax rebates. Although such payments may temporarily boost household income, they also create employer incentives for layoffs and for household members to delay their return to work. In sum, in our view, a coefficient of .3 for the impact of these tax and transfers payments on consumption is likely an upper bound and certainly a generous assumption about the size of the impact.

In any case, by assuming that the impact on consumption of the extra 1 percent discretionary increase in the deficit is .3 percent of GDP and using the above-mentioned multiplier of .63 the impact will be to increase GDP by an additional .19 percent. If we add this to the .46 percent GDP increase from purchases, the total impact will be to increase GDP by .65 percent in the fourth quarter of 2010 compared to what it would otherwise be.

Romer and Bernstein (2009) calculated that the impact of the 2009 stimulus package would be to raise GDP by 3.6 percent by the fourth quarter of 2010, which is 6 times greater than our calculation based on the new-Keynesian model simulations of the impact of purchases and a generous assessment of the impact of tax rebates and temporary transfers.

Romer and Bernstein (2009) also give an estimate of the increase in employment from the fiscal package. They assume an additional 1 million jobs for each 1 percent increase in real GDP. Thus they estimate an increase of 3.5 million jobs as a result of the fiscal policy package enacted in February 2009. Using the same method our estimate is closer to 1/2 million additional jobs. To put that smaller number into perspective it is less than the 598 thousand payroll jobs lost in the single month of January 2009 while the fiscal policy packages were being debated.

Romer and Bernstein also report job estimates in a number of private sector industries which would have to be radically scaled down if the numbers we have calculated are correct. In addition, our finding of crowding-out of private consumption and investment due to the increase in government purchases raises doubts about the estimate that 90 percent of the jobs will be created in the private sector. Indeed, with the impact of government purchases on GDP (.46) nearly three times greater than the impact of tax rebates and transfers on GDP (.19), a net decline in private sector jobs is likely.

12. Conclusions and outlook

In this paper, we used a modern empirical approach to estimate government spending multipliers, and we contrasted these multipliers with those that have recently been used in practice to analyze fiscal policy in the United States. We focused on an empirically estimated macroeconomic model—the Smets–Wouters model—recently published in the *American Economic Review*. As attested by leading macroeconomic researchers, such as Michael Woodford in his recent survey, this model well represents new-Keynesian macroeconomic thinking of the kind that many macroeconomists now teach their graduate students and use in their research.

We find that the government spending multipliers from permanent increases in federal government purchases are much less in new-Keynesian models than in old-Keynesian models. The differences are even larger when one estimates the

[15] The estimated regression coefficients reported in Taylor (2009) are not statistically different from zero.

impacts of the actual path of government purchases in fiscal packages, such as the one enacted in February 2009 in the United States or similar ones discussed in other countries. The multipliers are less than one as consumption and investment are crowded out. The impact in the first year is very small. And as the government purchases decline in the later years of the simulation, the multipliers turn negative.

To further investigate the robustness of our findings we extend the model of Smets and Wouters to allow for a share of "old" Keynesian rule-of-thumb households that consume all their disposable income, estimate the extended model and re-evaluate the likely impact of the ARRA government purchases. Then, the multiplier effect is slightly more pronounced but without changing our quantitative findings significantly. We also relate our analysis with estimated structural models to contributions using reduced-form VAR models and regression analysis in order to identify government spending shocks and their effects. A review of this literature suggests a wide range of multiplier effects from 0.6 to 1.7 depending on the particular approach to identification. The typical time profile of government spending studied in this literature differs from the ARRA spending plan. Following an initial surprise increase government spending gradually returns to steady state. We simulate this time profile in our estimated new-Keynesian models and find that the short-run effect of such shocks in our models lie roughly in the middle of the estimates by this literature. This experiment underscores the need for analysis with estimated structural models that account for the reaction of forward-looking optimizing households and firms in assessing the likely impact of changes in government policies.

The estimates reported in this paper of the impact of fiscal stimulus packages are in stark contrast to those reported in the paper by Christina Romer and Jared Bernstein. They report impacts on GDP for a broad fiscal package that are six times larger than those implied by government spending multipliers in a typical new-Keynesian model and our calculations based on generous assumptions of the impacts of tax rebates and transfers on GDP. They also report job estimates that are six times larger than these alternative models, and the impacts on private sector jobs are likely to be at variance with the alternative models by an even larger amount. At the least, our findings raise serious doubts about the robustness of the models and the approach currently used for practical fiscal policy evaluation.

We also investigate whether our findings obtained by simulating the increase in additional spending as a deviation from the steady state of the economy would also result from a simulation starting in deep recession far away from the steady state. While the choice of baseline for the policy experiment is irrelevant in linear models, the zero-interest rate floor on nominal interest rates introduces an important nonlinearity that may affect our assessment. We simulate the Smets–Wouters model with the actual US data through the first quarter of 2009 and compute projections of the recovery with and without the additional government spending. These projections imply that the funds rate would visit the zero-interest-rate floor for two to three quarters. The GDP impact of the additional government purchases remains fairly close to the scenario simulated as a deviation from steady state with a constant funds rate for four quarters.

We have shown that the anticipation of the time profile of government spending and the monetary policy response have an important influence on the likely impact of fiscal stimulus in the US economy. It is useful to explore such anticipation effects further. While our analysis is predicated on the view that US monetary policy will eventually act to stabilize inflation, an interesting study by Davig and Leeper (2009) considers the anticipation of a shift to a monetary regime that would de-stabilize the economy if maintained. Such a belief, they argue, would induce greater short-run multiplier effects. By contrast, Corsetti et al. (2009) suggest that the anticipation of a more conservative fiscal stance that aims to contain the rise in government debt by promising future spending cuts would support greater short-run effects. However, such a belief is inconsistent with the ARRA spending plan and would have required announcing very substantial spending cuts starting as soon as the end of 2010 as discussed in Wieland (2010).

The longer-run effects of the American Recovery and Reinvestment Act will also be influenced by two other factors that we have not accounted for in our model simulations. First, increases in future taxes will be of a distortionary nature rather than lump-sum and therefore tend to depress output in the long-run below the steady-state level assumed in our simulations. Uhlig (2009) indicates that this long-run cost of short-run fiscal stimulus could be substantial. On the optimistic side, there is a possibility that some of the additional government spending has an investment—rather than consumption-character and would induce a positive long-run effect on output countering the negative effect of distortionary taxation. Due to implementation lags, however, expansionary government investment can lead to a short-run contraction of output as indicated in Leeper et al. (2009).

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Appendix A. The new-Keynesian DSGE model with rule-of-thumb consumers

This appendix discusses how we have extended the Smets and Wouters model to include rule-of-thumb consumers and reports the estimates we have obtained. We only review the model equations that result from the extension. For the remainder of the model equations the reader is referred to the appendix of Smets and Wouters (2007).

A.1. Households

There is a continuum of households indexed by $h \in [0,1]$. A share $1-\omega$ of these households makes optimizing, forward-looking decisions. They are indexed by $j \in [0,1-\omega]$. These households have access to financial markets. They buy and sell government bonds and accumulate physical capital that they rent to firms. They receive wage income and dividend payments from the firms and pay taxes $T_{j,t}$ in a lump-sum fashion to the government. Their decisions made so as to maximize a utility function that is non-separable in consumption $C_{j,t}$ and labour supply $L_{j,t}$. Their maximization problem corresponds to the problem solved by all households in the Smets and Wouters model.

The remaining share ω of households—the "rule-of-thumb'ers"—is indexed by $i \in [1-\omega, 1]$. They simply consume their disposable income which is given by the wage income $W_t^h L_t$ minus lump-sum taxes $T_{i,t}$:

$$C_{i,t} = \frac{W_t^h L_t}{P_t} - \frac{T_{i,t}}{P_t} \tag{A.1}$$

Labour unions set the same nominal wage rate for both types of households. Hence, labour supply is equalized across the two groups. Aggregating over all households implies that overall consumption is a weighted average of the consumption function of rational and rule-of-thumb consumers:

$$C_t = \int_0^1 C_{h,t}\, dh = (1-\omega)C_{j,t} + \omega C_{i,t}. \tag{A.2}$$

A.2. Government policy

The government purchases the final good G_t, issues bonds B_t and raises lump-sum taxes to finance government spending. Aggregate taxes correspond to $T_t = (1-\omega)T_{j,t} + \omega T_{i,t}$. The government budget constraint is then given by

$$P_t G_t + B_{t-1} = T_t + \frac{B_t}{R_t} \tag{A.3}$$

A.3. Log-linearized model

Detrending the model variables with a deterministic trend γ and log-linearizing Eqs. (A.1) to (A.3) results in three linear relationships that need to be added to the Smets and Wouters model:

$$\hat{c}_{i,t} = \frac{w_*^h L_*}{c_*}(\hat{w}_t + \hat{L}_t) - \frac{y_*}{c_*}\hat{t}_t \tag{A.4}$$

$$\hat{c}_t = (1-\omega)\hat{c}_{j,t} + \omega \hat{c}_{i,t} \tag{A.5}$$

$$\hat{b}_t = R_*\left(\frac{\hat{b}_{t-1}}{\pi_*} + \hat{g}_t - \hat{t}_t\right) \tag{A.6}$$

Steady-state consumption is set equal for rational and rule-of-thumb consumers to simplify the log-linearization: $C_i = C_j = C$. The level of debt in steady state is assumed to be zero. Furthermore, we assume that both types of households pay lump-sum taxes in equal proportions. Lump-sum taxes, government debt and government spending are defined as a percentage of steady-state output.

Smets and Wouters (2007) effectively disregard taxes and government debt dynamics because their model exhibits the Ricardian equivalence property. Because all households act in a rational, forward-looking manner, and because taxes are raised in lump-sum fashion, the particular time path of debt and taxes is irrelevant. In our model with rule-of-thumb households, however, the speed at which government debt is paid off with higher taxes matters for the model dynamics. Therefore, we close the model by defining a log-linear fiscal policy rule as suggested in Gali et al. (2007):

$$\hat{t}_t = \phi_b \hat{b}_t + \phi_g \hat{g}_t \tag{A.7}$$

The parameters of the fiscal policy rule, ϕ_b and ϕ_g, determine the elasticities of lump-sum taxes with respect to government debt and government spending.

Table A1
Estimates of key model parameters.

		Smets and Wouters (2007)	Our estimates of the new-Keynesian DSGE model with rule-of-thumb consumers			
		Post. mean	Prior mean	Post. mode	s.d.	Post. mean
ω	Share of non-Ricardian households	–	0.5	0.286	0.062	0.2651
σ_c	Inverse of intertemporal elasticity of substitution	1.380	1.500	1.332	0.134	1.286
h	Degree of habit formation	0.713	0.700	0.660	0.055	0.673
ξ_p	Sticky prices (Calvo parameter)	0.652	0.500	0.639	0.058	0.645
ι_p	Price indexation	0.243	0.500	0.194	0.083	0.221
σ_l	Inverse of labour supply elasticity	1.838	2.000	1.963	0.566	1.869
ξ_w	Sticky wages (Calvo parameter)	0.706	0.500	0.769	0.053	0.730
ι_w	Wage indexation	0.585	0.500	0.646	0.124	0.617
ϕ_b	Elasticity of lump-sum taxes with respect to debt	–	0.1	0.043	0.012	0.0531
ϕ_g	Elasticity of lump-sum taxes w.r.t. government spending	–	0.1	0.124	0.048	0.1242

A.4. Estimation

Just like Smets and Wouters (2007) we use Bayesian inference methods to estimate our new-Keynesian model with rule-of-thumb consumers.[16] For better comparability we also use the Smets–Wouters data set on US macroeconomic aggregates covering the period 1966:1-2004:4 and consider identical prior distributions as starting points in the parameter estimation. With regard to the prior distribution of household types and the parameters of the fiscal policy rule we consider values similar to Coenen and Straub (2005). Specifically, we assume that ω has a Beta distribution with mean 0.5 and standard deviation 0.1. This prior is at the high end of what is found in the literature. The parameter prescribing the response of lump-sum taxes to debt, ϕ_b, is assumed to follow an Inverted Gamma distribution with mean 0.1 and degrees of freedom equal to 2. The coefficient on government spending in the fiscal policy rule is set to a Normal distribution with mean 0.1 and standard deviation 0.05.

Our estimation results indicate that the new parameters are well identified. The posterior mode of the share of rule-of-thumb consumers is estimated to be $\sim$28.6 percent with a standard deviation of 6.2 percent. The posterior mean is 26.5 percent. Thus, the data clearly drive the estimate of the parameter downwards from the prior of 50 percent. The parameters of the fiscal policy rule are significant and of reasonable magnitude. The posterior mode of the elasticity of lump-sum taxes to debt is estimated to be 0.043. An increase in government debt of 1 percent of GDP leads to an increase in lump-sum taxes of $\sim$0.05 percent. The posterior mode for the elasticity of lump-sum taxes to government spending is estimated to be 0.12. Hence 1/8 of an increase in government spending is financed by lump-sum taxes directly. The other part is initially financed with debt and eventually implies higher taxes later on. The estimates of the other parameters change relative to Smets and Wouters (2007) but the differences remain moderate. Selected estimates are reported in Table A.1.

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[16] Matlab routines for solution and estimation procedures are implemented in DYNARE. It is important to note that the estimation can be carried out on the linearized model, while the fiscal stimulus simulations with anticipated government spending plans and temporarily constant nominal interest rates require using nonlinear solution techniques.

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