Effects of Fiscal Stimulus in Structural Models

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Abstract

The paper subjects seven structural DSGE models, all used heavily by policymaking institutions, to discretionary fiscal stimulus shocks using seven different fiscal instruments, and compares the results to those of two prominent academic DSGE models. There is considerable agreement across models on both the absolute and relative sizes of different types of fiscal multipliers. The size of many multipliers is large, particularly for spending and targeted transfers. Fiscal policy is most effective if it has moderate persistence and if monetary policy is accommodative. Permanently higher spending or deficits imply significantly lower initial multipliers.

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The global economy has over recent years suffered from a number of large negative demand shocks, which were initially driven by sharp declines in house and stock prices and a tightening of financial conditions. The resulting collapse in output and the increase in unemployment also gave rise to a loss of confidence that intensified the downward pressures on the economy. Governments and central banks responded by introducing measures to deal with liquidity and solvency problems in financial institutions. Central banks reduced interest rates to unprecedented levels to support aggregate demand in the face of an increase in private sector risk premia. They also used nonconventional measures in the form of quantitative easing and qualitative or credit easing to reduce risk premia and to provide liquidity. Despite these actions, credit remained tight and aggregate demand in many countries continued to weaken. There were negative spillovers from the weakening economies to those that had appeared to be more robust, and increased concern that the global economy might be moving into a period of deep and prolonged recession (IMF (2009a)).

With limited scope for monetary policy to provide additional stimulus, many countries turned to fiscal policy.[1] For example, the United States implemented two major fiscal initiatives during the 2007-2009 recession. The Economic Stimulus Act of 2008, passed in February of 2008 against the backdrop of weakening economic growth, was mainly aimed at reviving consumer spending through one-time tax rebates. The American Reconstruction and Reinvestment Act (ARRA) was passed in February 2009 in the wake of a dramatic escalation of the crisis, and involved a combination of tax cuts, transfers to targeted groups (including a one-time $250 rebate to social security recipients), federal aid to states and localities, and increases in government spending on goods and services.

The implementation of large-scale fiscal spending programs in the United States and around the world sparked a vigorous policy debate. One key question was whether any type of fiscal expansion would be effective in lessening the depth and duration of the recession, taking into account the realistic assumption that monetary policy would remain accommodative for some time. A second issue involved the appropriate mix of fiscal policy actions in order to stimulate output – taxes, transfers, or spending. Finally, there was substantial debate about the longer-run consequences of fiscal stimulus. Many observers expressed concern that fiscal stimulus could have adverse long-run effects if higher taxes were eventually required to service the debt, or if additional stimulus heightened concerns about debt sustainability.

This paper takes a novel approach to addressing these questions. In particular, we analyze the effects of an array of different fiscal actions – government spending increases, tax cuts, and higher transfers – using seven structural policy models of national economies and the global economy that have been developed by economists at the Federal Reserve Board, the European Central Bank, the International Monetary Fund, the European Commission, the OECD and the Bank of Canada. These models have been tested extensively over the years and have been frequently applied to policy questions. Our simulations also directly compare the predictions of these policy models to two well-known

[1] The IMF called for global fiscal stimulus and discussed core principles for the fiscal response to the crisis. See Lipsky (2008), Spilimbergo et al. (2008), and Decressin and Laxton (2009). See also IMF (2009b) for a discussion of the state of public finances after the 2008 crisis.

estimated DSGE models – namely, the models of Christiano et al. (2005) and Smets and Wouters (2007). Our analysis therefore provides a useful check on the robustness of the predictions produced by state-of-the-art macroeconomic models that, while sharing a broadly New Keynesian orientation, nevertheless exhibit significant differences in model structure and calibration. Interestingly, we find that there is a considerable degree of agreement across the policy models.

We focus on the short-run effectiveness of fiscal stimulus, with an emphasis on comparing the effects of different types of fiscal instruments, and on analyzing how the effects of each type of fiscal action are affected by the degree of monetary accommodation. However, we also complement our analysis with some discussion of long-run issues.

Our analysis of monetary accommodation builds on a recent literature that has used DSGE models to analyze the effects of government spending shocks in a liquidity trap, including papers by Cogan et al. (2009), Freedman et al. (2010), Eggertsson (2011a), Woodford (2011), and Christiano et al. (2011). Many of these papers emphasize how temporary boosts in government spending can have large effects on output if monetary policy remains accommodative for a prolonged period. We corroborate these findings in our array of policy models. However, consistent with the analysis of Cogan et al. (2009), we find that the stimulative effects are reduced if the increase in government spending is perceived to be permanent.

A major contribution of our analysis is to use the policy models to also assess the impact of various tax and transfer policies under alternative assumptions about the stance of monetary policy. The alternative policies we consider – which include broad-based transfers to households, targeted transfers to specific types of households, and cuts in labor, corporate or sales taxes – have generally received much less attention in the recent literature. Even so, practical considerations suggest that they may afford a better way of delivering rapid fiscal stimulus than government spending. For example, the $152 billion Economic Stimulus Plan of 2008 was proposed by President Bush in mid-January, passed by Congress in early February, and checks were disbursed over a ten week period commencing in April. Similarly, much of the ARRA spending during the first 12 months after passage involved tax cuts and transfers to individuals (including in the form of aid to states used for similar purposes). By contrast, roughly half of the government purchases on infrastructure budgeted in the ARRA in 2009 were expected to be made after the end of calendar year 2010.

Our extensive analysis of tax and transfer policies is facilitated by some attractive features of the models. First, they have highly detailed fiscal policy blocks, which permits consideration of a wide set of fiscal instruments. Second, the policy models incorporate some empirically relevant channels that may significantly impact the transmission of fiscal shocks. For example, rather than assuming that all households are Ricardian "permanent income" consumers, they typically specify that a significant fraction of households is liquidity-constrained, or follows rule-of-thumb behavior.[2] Third, many of the

[2] Johnson et al. (2006) and Parker et al. (2011) find evidence of a substantial response of household spending, particularly for liquidity-constrained households, to the temporary tax rebates of 2001 and 2008, using micro data from the Consumer Expenditure Survey. On the macro side, Gali et al (2007) present evidence from structural VARs that government spending shocks tend to boost private consumption, and show how the inclusion of rule-of-thumb agents in their DSGE model helps it account for this behavior.

policy models attempt to capture the effects of automatic stabilizers on both the tax and spending side, including by allowing for tax feedback rules that in some cases involve distortionary taxes.

We find several important results. First, all of the discretionary stimulus measures we consider – on both the tax and spending side – raise output in the near-term, and the effects increase markedly with the degree of monetary accommodation for all fiscal instruments except the labor tax. Second, targeted transfers to liquidity constrained households and government spending stand out as particularly effective ways of boosting output, especially in a situation in which monetary policy is expected to remain accommodative for a prolonged period. For example, we find that a one percent of GDP increase in targeted transfers raises U.S. output by 1 to 1.5 percent in most of our policy models if monetary policy remains accommodative for two years, roughly twice as large as under normal conditions. Third, assuming persistent monetary accommodation of 2 years, the stimulative effects of fiscal policy actions tend to increase in the persistence of the stimulus up to horizons of roughly 3 years, reflecting that more persistent stimulus, even if lasting beyond the period of monetary accommodation, raises expected inflation. However, the short-run stimulative effects on GDP decrease if the fiscal stimulus becomes "too persistent." A permanent increase in government spending, for instance, leads to a long-run contraction in output, and substantially reduces the short-run output effects relative to a shorter-lived stimulus. Taken together, our results suggest a strong case for using targeted transfers to mitigate recessions, at least to the extent that it may be more difficult at the margin to inject and withdraw stimulus through adjusting government spending.

To give context to our model-based results, we provide a discussion of the empirical literature in Section I. Under normal business cycle conditions, the output effects of fiscal stimulus in the structural models we consider seem reasonably consistent with the mid-range of estimates provided by the empirical literature. However, because that empirical evidence was based on a sample period in which monetary policy acted more aggressively to demand pressures, by raising interest rates to keep inflation and inflation expectations near target, this empirical evidence is less relevant to gauge the effects of fiscal actions in the context of a prolonged crisis situation such as the one the world economy recently went through, which has been characterized by a persistent liquidity trap. By contrast, as we discuss at greater length in Section I, the structural models we consider are well-equipped to assess the impact of monetary accommodation through low interest rates. They are also able to account for a number of other important factors that affect the results of fiscal stimulus, including the length of time over which stimulus is provided, the type of fiscal instrument used, and the difference between automatic stabilizers and discretionary stimulus. We therefore feel that this work adds valuable information for policymakers concerning the effectiveness of fiscal stimulus measures.

The rest of the paper is organized as follows. Section I provides a literature review, including a discussion of the relative merits of using empirical evidence versus theoretical models to improve our understanding of the effects of fiscal stimulus. Section II introduces the seven structural models, their two academic peers, and the seven standardized specifications of temporary fiscal shocks. Section III compares the basic properties of the various models by subjecting each of them to an identical contractionary monetary policy shock. Section IV provides estimates of the output effects of temporary fiscal shocks using simulations of the models. Section V provides estimates of the output effects of permanent fiscal shocks. Section VI concludes.

I Fiscal Multipliers: A Review of the Literature

The debate concerning the effectiveness of fiscal stimulus is typically conducted in terms of the fiscal multiplier of different fiscal measures. We defer an exact definition of the term multiplier, for the purpose of the quantitative experiments in this paper, to the beginning of the next section. But in broad terms it stands for a ratio, computed either for a given period or cumulatively over longer periods, that has the deviation of real GDP from baseline GDP due to stimulus in the numerator, and the size of the stimulus measure (increase in expenditure or decrease in revenue) in the denominator.

Our knowledge of the multiplier effects of fiscal policy comes from two sources, reduced-form empirical analysis and structural models, which are discussed in the following two subsections. This is followed by a subsection on the asset pricing implications of the structural models.

A Empirical Studies

Reduced-form empirical work has produced estimates of fiscal multipliers that are dispersed over a very broad range, and this finding pertains both to government spending shocks and discretionary tax changes. In a seminal paper, Blanchard and Perotti (2002) pay close attention to the identification of fiscal stimulus in the United States and estimate that a fiscal stimulus of one percent of GDP would increase GDP by close to one percent. More generally, empirical studies using regression or vector autoregression analyses surveyed in Hall (2009) point to multipliers in the range from 0.5 to 1. Cross-country studies often find smaller fiscal multipliers and in some cases multipliers with a negative sign (Christiansen 2008). The most notable studies with negative multipliers are found in the literature on expansionary fiscal contractions initiated by Giavazzi and Pagano (1990) and surveyed in Hemming et al. (2002). However, more recent research by the IMF (2010) casts doubt on the idea of expansionary deficit reductions, and suggests that studies finding such effects tend to underplay the contractionary effects of fiscal austerity.

Although this evidence provides some support for the view that a well-executed global fiscal stimulus could provide an appreciable boost to aggregate demand in the world economy, there is some disagreement about the appropriate mix of government spending and tax cuts. Mountford and Uhlig (2009) find substantial multipliers for the United States that are comparable to those of Blanchard and Perotti (2002), but emphasize that the multipliers associated with tax cuts are much higher than those associated with changes in government spending, as private consumption does not react much to increases in government spending.[3] In the evidence provided by Blanchard and Perotti (2002) and Galí et al. (2007), private consumption rises significantly after a positive government spending shock,

[3] Barro and Redlik (2009) estimate U.S. fiscal multipliers on data that include the World War II period, and report multipliers below one for defense spending (due to crowding out of private investment), and somewhat above one for taxes. They argue that estimates of non-defense spending multipliers are not reliable due to lack of good instruments.

and these papers therefore obtain considerably larger spending multipliers. Typically tax multipliers estimated from a VAR approach peak at around one after two years (Blanchard and Perotti (2002), Perotti (2007)). But stronger values have been found in recent work. Mertens and Ravn (2010) concluded that an unanticipated tax cut equal to one percent of GDP gives rise to a multiplier that peaks at around two after around two to three years. Using a narrative approach and official documents to identify the size, timing and principal motivation of stimulus measures, Romer and Romer (2010) found a multiplier of nearly three after three years for the United States. Relaxing the assumption of orthogonality of tax shocks with any other macroeconomic shocks that is implicit in Romer and Romer's estimation, Favero and Giavazzi (2009) ended up with smaller tax multipliers, whose size is similar to the ones obtained using traditional fiscal VARs.

The existing empirical literature has not always accounted for the fact that many fiscal actions are known prior to their implementation. Leeper et al. (2009) show that econometric analyses that fail to take this into account can produce distorted results about the effects of fiscal actions. Blanchard and Perotti (2002) estimated a greater response of output once they account for anticipation effects. Mertens and Ravn (2010) found that when pre-announced tax cuts are implemented they stimulate the economy in a similar fashion to surprise tax cuts, but are associated with a drop in output and investment during the pre-implementation period. The authors noticed that implementation lags are likely to be longer than assumed in Blanchard and Perotti (2002), leading to sizable anticipation effects and a more gradual response of output to tax cuts than identified by the latter. Ramey (2009) showed that even if the entire path of government spending was perfectly anticipated, its effects on the paths of output, hours, investment and consumption would depend on the particular timing of the measures because of intertemporal substitution effects. She found that differences in timing can explain all the differences in fiscal multipliers obtained by VAR models and narrative approaches. According to Ramey (2009), government spending multipliers accounting for anticipation effects would range from 0.6 to 1.2.

To sum up, the empirical literature has contributed greatly to our understanding of how fiscal actions impact the economy, and we regard it as a useful benchmark for evaluating our model based results. Nevertheless, the empirical literature has some important limitations. First, empirical studies are not well suited to analyze a situation in which fiscal and monetary policy is anticipated to be conducted differently than in the past. This shortcoming is particularly relevant in the context of the recent financial crisis, where monetary policies pursued by many central banks differed markedly from historical norms.[4] Second, the identification schemes that have been used typically have not allowed for differentiation between the effects of the many alternative fiscal instruments available on both the tax and spending side in an integrated framework. Again, this limitation is particularly important during the recent crisis as a wide array of stimulus measures were employed.

[4] Auerbach and Gorodnichenko (2010) attempt to overcome this problem by estimating two-state regime-switching VARs (expansions and recessions), and find that empirical fiscal multipliers can be well above one in recessions. However, their approach is still limited in that it cannot distinguish between recessions with little or no monetary accommodation and deep recessions with significant monetary accommodation.

B Structural Models

Given these difficulties with the empirical evidence, structural models could be a potentially valuable additional source of information. Structural models are identified using more than variation in fiscal policy and can therefore bring more evidence to bear to deduce the likely effects of fiscal policy. This knowledge is reflected in the choice of the model structure itself, which would typically have been adapted to generate empirically valid correlations between key macroeconomic variables, and also in the calibration, which is typically based on a great variety of sources of empirical evidence. In this regard, it is perhaps not entirely surprising that the fiscal multipliers in the structural models considered here typically are in the mid-range of the fiscal multipliers reported in the empirical literature discussed above. Of course, structural models also have weaknesses, most importantly their incomplete consensus on the most appropriate structural features and calibration, which could have a material effect on the results. Our paper makes a valuable contribution on this dimension, by showing that there is considerable agreement across models on both the absolute and relative sizes of different types of fiscal multipliers. Another important contribution is that our analysis clarifies several key elements that should be important in enhancing the effectiveness of stimulative fiscal actions.

Several recent papers have used theoretical models to analyze the effects of fiscal stimulus. Hall (2009) finds that in an economy with an output multiplier of just under one in normal times, the multiplier can rise to 1.7 at a zero nominal interest rate. Christiano et al. (2011), using the theoretical framework of Altig et al. (2010), obtain an even stronger effect at the zero lower bound. They also underline that the larger the percentage of spending that comes online when the nominal interest rate is zero, the higher the multiplier. Eggertsson (2011a,b), using a two-state Markov-switching framework where monetary policy either responds to the fiscal action (normal times) or not (zero lower bound), finds that spending and sales tax multipliers are about five times higher at the zero lower bound than in normal times (2.5 instead of 0.5). Interestingly, Eggertsson also argues that temporary payroll tax increases and policies that increase the monopoly power of firms and unions, although contractionary in normal times, can in fact be expansionary at the zero lower bound due to benign effects on expected wage and price inflation.

Some studies have highlighted how practical issues associated with implementing and financing government spending programs can markedly reduce their potential to provide stimulus. Cogan et al (2009) analyze the effects of the government spending provisions in the U.S. ARRA stimulus package in the Smets and Wouters model (2007). They show how the hump-shaped spending profile – consistent with significant implementation lags – reduces the multiplier substantially, with the peak multiplier only in the range of 0.6-0.7. Drautzburg and Uhlig (2010) show that the long-run multiplier of the ARRA can become negative if distortionary labor taxes adjust quickly to balance the budget.

Even abstracting from the financing issue, the substantial disparity in spending multipliers across the studies mentioned above may seem surprising given that the estimates are derived from DSGE models that appear to have reasonably similar features. These pronounced differences reflect that, with the zero lower bound binding, the effects of shocks can be very sensitive to assumptions about the duration of the liquidity trap, the degree of flexibility of wages and prices, and the assumed permanence of the spending shock. Thus, the much larger multipliers in Christiano et al (2011) relative to Cogan et al (2009) reflect that the former examine a relatively longer liquidity trap duration (of 10 quarters rather than 4 to 8)[5], have a calibration which implies less stickiness in prices and wages (and thus a larger reduction of real interest rates through stimulus-induced inflation), and assume that the government spending profile is more front-loaded and transient. An important contribution of our analysis is to examine a wide group of models under common assumptions about these key features, including liquidity trap duration and the spending profile.

The analysis performed with our policy models, which highlights the difference between the effects of temporary and permanent stimulus, has an important antecedent in the work of Corsetti et al. (2009), who argue that the effects of fiscal stimulus on private consumption can differ dramatically depending on expectations about the long run path of spending. In particular, they show that the anticipation of post-stimulus spending reversals can help to crowd-in rather than crowd-out private consumption. Again, our design of fiscal stimulus in Section IV is as an explicitly temporary measure, and Section V contains the comparison with permanent stimulus that is consistent with the point made by Corsetti et al. (2009).

Finally, the foregoing theoretical contributions, with the exception of Eggertsson (2011a), focus almost exclusively on government spending as the single tool of fiscal policy, while our study allows for a number of other instruments.

C The Policy Models and Asset Prices

Recent research has shown that New Keynesian models, with nominal and real rigidities similar to the policy models we consider, can do a good job in tracking the behavior of short-term interest rates.[6] However, it is well-known that standard New Keynesian models without financial frictions have difficulties accounting for the joint behavior of standard macro variables and asset prices, including stock and house prices. This may be a concern, as sizeable asset price fluctuations have been an important characteristic of the recent crisis.

A recent literature has attempted to address this problem. Iacoviello and Neri (2010) add financial frictions in the household sector and show that their model is able to account reasonably well for the joint movements in standard macroeconomic variables and house prices in the United States. Christiano et al. (2010) augment a standard monetary DSGE model to include a banking sector and financial markets, and find that agency problems in financial contracts between banks and firms, along with liquidity constraints facing banks, enables their model to account well for the joint behavior of an extended set of macro variables, long-term interest rates and stock prices in the euro area and the United States. Both papers attribute a large share of asset price fluctuations to non-standard shocks, specifically housing preference shocks in Iacoviello and Neri (2010) and borrower riskiness shocks in

[5] See Erceg and Linde (2010a) for further details on the marginal fiscal multiplier as a function of the duration of the zero bound.

[6] Christiano, Eichenbaum and Evans (2005), Smets and Wouters (2003, 2007).

Christiano et al. (2010). These added financial frictions can provide an additional amplification mechanism in the policy experiments we consider.

To the extent that our models omit these kinds of financial frictions[7], our experiments might underestimate the impact of fiscal stimulus on asset prices. They might also face limitations due to linearization or the maintained assumption of rational expectations. But we nevertheless believe that the structural models remain very useful, based on the fact that they produce estimates of fiscal multipliers, and also of responses to monetary policy shocks, that are fairly close to the existing empirical evidence.

II Multipliers, Instruments, and Models

A Definition of Fiscal Multipliers

The term fiscal multiplier quantifies the effectiveness of fiscal stimulus by way of a ratio whose numerator equals the output effects of fiscal stimulus, and whose denominator equals the size of the stimulus itself, which can be either an exogenous increase in fiscal expenditures or an exogenous decrease in tax revenues. As we compare the effects on real GDP of many different fiscal instruments, we normalize the fiscal impulses so that the size of the discretionary shock in each case represents an increase in spending or a decline in revenues equal to 1 percent of baseline, pre-stimulus GDP, for two years. Government deficits respond endogenously to the fiscal actions because of automatic stabilizers, so that the post-stimulus change in the deficits is less than the discretionary fiscal stimulus.[8]

In our first definition the fiscal multiplier of a given fiscal stimulus measure equals the ratio of the resulting deviation of real GDP from baseline GDP in a given post-stimulus period to the size of the stimulus measure in the initial period, which in our experiments always equals one percent of baseline GDP. It will turn out that for strictly temporary fiscal stimulus measures this period-by-period definition of the multiplier is adequate, because the output effects are mostly limited to the period of the stimulus, with small effects thereafter. We will refer to this measure as the *instantaneous* multiplier.

But for comparison with the literature we also use a second definition which follows, e.g., Uhlig (2010), and which we will refer to as the *cumulative* multiplier. This equates the multiplier to a ratio whose numerator equals the present values of GDP deviations, and whose denominator equals the corresponding fiscal stimulus measures, at different horizons of between 1 and 20 quarters. The cumulative measure is useful insofar as it not only captures short-run stimulative effects, but also small and potentially persistent long-run contractionary effects that may arise if taxes must eventually be raised to service higher debt levels. We only analyze the case of zero discount rates, for two reasons. First, higher discount rates such as steady state growth or interest rates make very little difference to the results. Second, this approach keeps model results comparable given that different models

[7] Financial frictions are present in some of the models, see Tables 1 and 2 for further details.

[8] Because tax and expenditure systems vary across countries, some of the variation in the size of the multiplier across countries is due to divergences in the endogenous responses of automatic stabilizers.

assume different steady state growth and interest rates. As our measure of fiscal stimulus in the denominator we use only the initial discretionary changes in fiscal instruments and exclude fiscal rule-driven endogenous adjustments of deficits.

Although cumulative multipliers are especially useful for evaluating the permanent fiscal stimulus shocks reported in Section V, we will also use them to evaluate temporary stimulus shocks, but with an important caution attached. We would argue that an emphasis on the small but persistent long-run contractionary effects of short-run stimulus runs the risk of missing the point of stimulus altogether. The reason is that in a crisis such as the one the world started to experience in 2008, anything that can prevent a precipitous collapse in output is critical because it can prevent the economy from going into a downward spiral where collapses in different sectors start to feed on each other due to balance sheet and demand interdependencies between multiple sectors.[9] We know that our highly aggregative New Keynesian models are not going to capture such extreme and rare effects well, as they are designed to model dynamics over conventional business cycles. But we also know that policy advice should take account of such effects. Therefore, what matters most is that fiscal stimulus has positive multipliers over the first one or two years, at a time when there is little else to support output.

Our simulations assume that, under normal conditions, a domestic fiscal expansion induces monetary policy to tighten both at home and abroad according to each model's specified interest rate reaction function. We also analyze the effects of fiscal stimulus under one-year and two-year periods of monetary accommodation, in which case both domestic and foreign nominal short-term interest rates are assumed to remain unchanged. The latter is intended to capture a situation similar to that experienced during the recent global recession, when policymakers would have liked to reduce interest rates further but were constrained from doing so by the zero lower bound, so that monetary policy was able to accommodate large-scale fiscal stimulus by not raising interest rates. Consistent with the concern that a prolonged period of monetary accommodation would risk allowing inflation expectations to become unanchored, our simulations allow policy rates to eventually adjust according to a standard interest rate reaction function after the period of monetary accommodation ends.

B The Seven Fiscal Instruments

The simulations of the structural models examine changes in seven fiscal instruments. These are

- an increase in government consumption spending,
- an increase in government investment spending,
- an increase in general lump-sum transfers,
- a decrease in labor income tax rates,
- a decrease in corporate income tax rates,
- a decrease in consumption tax rates,
- an increase in lump-sum transfers targeted to financially constrained households.[10]

[9] This goes beyond the downward spirals at the zero lower bound on interest rates studied by Christiano et al. (2011).

[10] Table 1 lists the different specifications of financially constrained households in the models included in this study.

C The Seven Structural Policy Models (and Two Academic Peers)

Six institutions participated in this project using seven structural policy models — the Bank of Canada (BoC-GEM), the Board of Governors of the Federal Reserve System (with two models, FRB-US and SIGMA), the European Central Bank (NAWM), the European Commission (QUEST), the International Monetary Fund (GIMF), and the OECD (OECD Fiscal). Of the seven models, four are global (BoC-GEM, GIMF, QUEST and SIGMA), NAWM is a two-region model for the United States and Europe, FRB-US is a U.S. only model, and OECD Fiscal is a Europe-only model.[11] Six of the models are recent-vintage DSGE models. FRB-US is an older model — developed in the 1990s — that nonetheless shares many characteristics with more modern models.[12] An annual version of GIMF is used for the simulations presented here, and the results for QUEST, which is a quarterly model, are presented in annualized terms in the graphs. Quarterly versions are used for the simulations of the remaining models. For comparison with the academic literature we also report simulations from two key medium-scale estimated monetary DSGE models. The first is Christiano et al. (2005), henceforth referred to as CEE. The second is Cogan et al. (2009), henceforth referred to as CCTW, who use the Smets and Wouters (2007) model, but also estimate an extended version with financially-constrained households.

Table 1 summarizes the key structural model features of the seven models and compares them with CEE, whose features are shown in the first column.[13] The table includes references to papers that more thoroughly outline the models and their properties, and links to online versions of those papers are provided in the bibliography at the end of this paper. Table 2 lists the calibrated values of the most important structural parameters for each model.

The first important feature of all policy models, but not of CEE, is that they have a significant share of financially constrained households, ranging between 20% and 50% in terms of population shares, though somewhat less in terms of shares of aggregate consumption. In some models these are hand-to-mouth households, who take their labor income as given and determine consumption residually from a period-by-period budget constraint. In other models these are liquidity-constrained households, who face the same period–by-period budget constraint, but who solve an intratemporal decision problem between consumption and work effort. The main effect of financial constraints is on transmission channels that depend for their effectiveness on a high propensity of households to spend out of disposable income. They therefore give rise to a significant positive multiplier for tax

[11] All models which include a separate region for Europe focus on the euro area. In our discussion we will refer to that region as Europe, and in terms of acronyms, we will represent it by EU.

[12] Like the recent generation of DSGE models, most important economic decisions in the FRB-US model are based on optimization problems. In addition, in the simulations reported here, agents are assumed to have model-consistent expectations. A key difference between FRB-US and more recent DSGE models is that optimization problems in FRB-US are typically posed for one variable at a time, and the interrelationships among decisions implied by theory are not as tightly imposed as in more recent models.

[13] Although the CCTW model is not included in the table due to space constraints, the structure is quite similar to CEE. The key differences are that CCTW allow for financially constrained agents, but do not incorporate a working capital channel as in CEE.

and transfer based fiscal stimulus measures, and to higher second-round spending effects (through a disposable income channel) of spending based fiscal stimulus measures. In NAWM financially constrained households play a less important role than their share in the population would suggest. This mostly reflects the fact that the financial constraint is effectively looser, in that these households retain access to real money balances to smooth consumption over time. QUEST features, in addition to hand-to-mouth households, credit-constrained households that make an intertemporal consumption decision subject to a collateral constraint based on housing wealth. Like hand-to-mouth households, credit-constrained households have a higher propensity to spend out of disposable incomes than unconstrained households, and furthermore they have a higher interest rate sensitivity of spending. In FRB-US, the economy has a relatively muted response to temporary stimulus shocks despite a high share of financially constrained households, reflecting the high degree of real and nominal rigidities in that model. We use the extended version of the CCTW model for the temporary stimulus simulations. In that variant, CCTW reestimated the parameters of the Smets and Wouters (2007) model after including rule-of-thumb consumers, and estimated their share to be 25 percent. However, since CCTW run many of their simulations in the original Smets Wouters model, we run the permanent government spending shock (and the monetary shock) in the restricted variant to allow direct comparability.

On the production side, the models exhibit significant differences in the details of sectorial decomposition, but all models incorporate nominal rigidities in price and wage setting. Real rigidities affect consumption, investment and, if applicable, imports. There is considerable variation in the details of the models' fiscal structure. Most models, except CEE, CCTW, SIGMA and FRB-US, allow for productive government investment. CEE and CCTW do not allow for any distortionary taxes, while the other models have up to four distortionary taxes. All of the models except CEE have fiscal rules whereby either labor income taxes or lump-sum taxes react to deviations of debt and/or deficits from targets, with small coefficients that allow for temporary deviations from targets.[14] The use of labor taxes versus lump-sum taxes in these rules can explain important differences in both the short-run and the long-run behavior across models. This difference is particularly important for permanent government spending shocks, where the instrument used for financing higher spending plays an important role. For temporary stimulus shocks the size of the fiscal rule coefficients can also be an important factor in the variation of multipliers across models. Finally, all models incorporate an interest rate rule that responds to inflation, but there are differences in that some rules allow for interest rate smoothing while others do not, and some rules respond to contemporaneous inflation while others respond to forward-looking inflation. For CCTW, we use the version that replaces the estimated Smets and Wouters (2007) forward-looking monetary rule with a Taylor rule, as this is the main rule used in CCTW's simulations.

[14] Very large coefficients would make the rules similar to balanced budget rules, which in general have neither been practiced by the world's governments, nor would such a practice be desirable from a welfare perspective, especially in the presence of financially constrained households - see Bi and Kumhof (2011).

D Design of the Experiments

Ideally we would like to consider a fiscal experiment relative to a baseline that reflects the sharp drop in demand that was observed during the crisis. Unfortunately, it is impractical to establish an identical crisis situation baseline across all models, and we therefore rely on the steady state as the common baseline for our fiscal experiments. Specifically, we assume that the economy is initially, in period 0, in steady state, and that in period 1 it experiences an unanticipated shock that has a known future time profile. Before analyzing fiscal shocks, we first consider monetary shocks to study the models' basic properties.

For monetary policy shocks, we consider shocks to the interest rate reaction function such that the nominal interest rate remains 100 basis points above its steady state value for one year, with subsequent dynamics governed by the calibrated interest rate reaction function.

For temporary fiscal policy shocks, the time profile of shocks consists of increases in spending or declines in revenue equal to 1 percent of baseline, pre-stimulus GDP, for two years, with tax rates or spending thereafter returning to their pre-stimulus values. Because government deficits respond endogenously to the fiscal actions, the post-stimulus change in deficits is less than the discretionary fiscal stimulus. Following the withdrawal of fiscal stimulus after 2 years, fiscal rules ensure that the debt-to-GDP ratio is brought back to its baseline value.[15] However, the temporary increase in debt is not large given that the stimulus is very short-lived, and furthermore the fiscal rules are calibrated to reduce debt in a very gradual fashion that minimizes the short-run impact.

Our assumption that the fiscal stimulus is removed after two years seems to be a reasonable, albeit stylized, characterization of fiscal stimulus plans announced by many industrial countries in 2009/2010, as all envisaged an eventual phasing-out of higher spending or lower taxes.[16] With any such plan, there is a justifiable concern that some parts of the spending increases may become permanent, and require permanently higher taxes in the long run. In Section V.A, we attempt to account for this possibility by analyzing the effects of a permanent increase in government consumption equal to 1 percent of pre-stimulus GDP, financed by higher lump-sum or labor income taxes, depending on the fiscal rule embedded in each model. This forms another useful benchmark for comparison with the academic literature, including CCTW, that has long considered a permanent increase in spending as the canonical fiscal experiment.

There is little additional benefit, and in fact one major drawback, to analyzing mixed stimulus scenarios. For example, one could consider the case where the temporary increase in government spending stimulus is not credible, so that agents expect it, correctly, to remain in place beyond the announced two years. Stimulus would then exist for the first two years as in our temporary stimulus scenario, but thereafter instead of reducing spending the government would start to increase taxes.

[15] There is therefore assumed to be no problem with respect to the sustainability of the fiscal position and the credibility of the fiscal authorities.

[16] The bulk of fiscal spending authorized by the ARRA in the United States was spread out over three years rather than two years as in most other major industrial countries (with some infrastructure spending phased in over an even longer horizon).

The main drawback of such scenarios is that they would make it much harder to isolate and compare the quantitative effects of different fiscal instruments, which we see as one of the main contributions of this paper. Furthermore, the long-run effects of permanent increases in different taxes and transfers are discussed separately in Section V.B.

III A Benchmark: Response to Interest Rate Shocks

The dynamic response of monetary DSGE models to monetary policy shocks is well understood and can serve as a useful benchmark for a comparison of the policy models' properties, both among themselves and relative to CEE and CCTW. Before turning to an analysis of fiscal stimulus shocks, we therefore analyze the response of our model economies to a 100 basis points increase in policy rates for one year, with a subsequent reduction in policy rates that follows the respective interest rate rules.

In Figure 1, the baseline calibration of each model is maintained while the interest rate reaction function is standardized, with a (quarterly) interest rate smoothing coefficient of 0.7, output gap and output growth coefficients of zero, and an inflation coefficient of 2.5, where the latter is divided into a coefficient of 1.25 on contemporaneous inflation and a coefficient of 1.25 on one-year-ahead inflation.[17] The figure shows that in all cases the policy rate initially rises, and then falls below its original level within 2 to 3 years in order to allow inflation, which in all but one case initially falls, to return to its target over the medium term. The resulting increase in the real interest rate is strongest in models with comparatively smaller nominal rigidities, like GIMF and BoC-GEM, where it reaches over 150 basis points. Higher real interest rates reduce GDP by around 0.5 percent by the end of year 1 in all models except OECD Fiscal. The results for CCTW are in line with those of the policy models, while the main exception to this broad picture is CEE. In CEE inflation rises rather than falls over the first two years, so that real interest rates only rise by around 80 basis points initially. Nevertheless, the output contraction is stronger than in all other models. The reason is that this model incorporates a working capital channel, whereby firms finance their wage costs with loans from a financial intermediary at the going policy rate. Because the policy rate increases, marginal costs increase and drive up inflation, but at the same time this represents a negative supply shock that reduces output. This channel is a possible explanation for the well-known "price puzzle" in vector autoregressions for monetary policy shocks. In our standardized monetary policy experiment of Figure 1 this effect is amplified because interest rates respond to contemporaneous inflation, which is higher than expected inflation, while in the original CEE interest rates only respond to expected inflation.

In Figure 2 we report results for the same experiment as in Figure 1, but with the model-specific interest rate rule replacing the standardized rule while leaving the rest of the calibration unchanged. This of course better represents the behavior of each model, as the interest rate rule is calibrated jointly with other coefficients, especially the degree of nominal rigidities, to yield impulse responses that are consistent with the empirical evidence. The broad picture is qualitatively similar to Figure

[17] This coefficient combination was partly chosen based on the fact that it satisfies the requirement for dynamic stability in all seven policy models.

1, but there are noticeable quantitative differences that reflect the extent to which the standardized rule deviates from the model-specific rule.

Overall, these results show that the models participating in this study yield broadly similar and empirically plausible results for one of the most widely studied shocks in the literature. They differ from CEE principally because none of the models incorporates a working capital channel.

IV Fiscal Multipliers for Temporary Stimulus

A Introduction to Simulation Results

Figures 3 and 6-13 show the instantaneous output multipliers for a 2-year fiscal stimulus, with separate results for the United States and Europe, and for different fiscal instruments. Each figure compares the cases of no monetary accommodation (top panel), one year of monetary accommodation (middle panel) and two years of monetary accommodation (bottom panel). Figures 4 and 5 also show the effects on inflation and the real interest rate in the United States and Europe of a 2-year stimulus through government consumption spending. Not all models are used in all of these experiments, due to limitations imposed by the regional coverage of the models, and by the fiscal instruments they allow for. In addition to the figures, Table 3 summarizes the average instantaneous multipliers across models of different types of fiscal stimulus.

B Government Consumption

We begin by examining in some detail the simulation results for stimulus through a 2-year increase in government consumption. Figure 3 shows the instantaneous fiscal multipliers for the U.S. and Europe, Figure 6 shows the corresponding cumulative multipliers, and Figures 4 and 5 show the effects on U.S. and European inflation and real interest rates.

We start with a detailed look at government consumption because this is the type of stimulus that has received by far the most attention in the literature. But before proceeding we should return to a caveat already mentioned in the introduction to this paper. In practice government consumption is likely to be a problematic instrument for countercyclical fiscal policy, because it is hard to increase and decrease at will in significant amounts, and in a timely manner, in response to transitory economic shocks. Both implementation delays and policy inertia whereby temporary spending increases become permanent would typically reduce the multipliers achieved relative to our stylized experiments. On the other hand, the size of the spending increases in our experiments is of the actual order of magnitude of the stimulus packages implemented in 2009 and 2010[18], and given the highly persistent nature of the post-2008 downturn implementation delays were of less concern than at other times.

Quantitatively we find that, for the case of no monetary accommodation, the instantaneous multipliers for the first year are similar, ranging between 0.7 and 1.0 for the United States, with an even narrower range of 0.8 to 0.9 for Europe. The multipliers are typically a little below unity due to

[18] See Freedman et al. (2010).

modest crowding out of private domestic demand and net exports. In particular, the positive effect of higher government demand on output and inflation induces monetary policy to raise interest rates, which depresses private domestic demand. Moreover, net exports are reduced because higher real interest rates appreciate the real exchange rate. Interestingly, the largest impact multipliers occur in CEE and CCTW, at just above 1.0. But overall, the multipliers seem well within the mid-range of estimates from the empirical literature that were discussed in Section I.

As we move from no monetary accommodation to one year of monetary accommodation to two years of monetary accommodation, the multipliers become larger and the differences between the various models become more noticeable. In the latter case the smallest U.S. multiplier (for FRB-US) equals around 1.2, and the largest multiplier (for BoC-GEM) equals around 2.2. The corresponding multipliers for Europe show a similar pattern of increase as the degree of monetary accommodation lengthens, though the multipliers do not increase as rapidly as in the United States in three of the four models. With monetary accommodation the CCTW model is near the middle of the estimates of the policy models.

The reasons for the disparities between models relate in large part to differences in the effects of the fiscal stimulus on inflation and the real interest rate. There is ample evidence of marked differences of nominal rigidities across countries. For example, prices adjust more frequently in the United States than they do in Europe (Álvarez et al. (2006)). Table 2 shows that these differences are taken into account in the parameterization of the multi-regional models. In Figures 4 and 5 we see that these differences in nominal rigidities trigger different inflation dynamics. Specifically, a fiscal stimulus coupled with constant nominal interest rates can induce a stronger drop in real interest rates when there is, as in the United States, a stronger reaction of inflation. As shown in Figure 3, this results in higher instantaneous multipliers. This effect is strongest in BoC-GEM, which features the smallest nominal rigidities. Some variation of real interest rate movements also arises in the case of no monetary accommodation, mainly reflecting differences in the reaction functions embedded in the various models.

The cumulative multipliers in Figure 6 reflect the fact that, without monetary accommodation, instantaneous multipliers drop below zero after the stimulus period ends, both because of higher real interest rates in response to higher inflation, and also because of higher taxes to service the accumulated debt, with the latter effect more important at longer horizons. Cumulative multipliers at longer horizons are therefore lower than those at shorter horizons when there is no accommodation. However, with two years of monetary accommodation this pattern is reversed, because in this case, in most models, output remains above trend following the expiration of the stimulus, reflecting the persistent reduction of real interest rates due to monetary accommodation.

For expositional purposes we have omitted the CEE results from the graphs for the case of 2 years of monetary accommodation. Given that prices and wages are much less sticky in the CEE model, with estimated Calvo probabilities of not being able to re-optimize prices and wages of 0.6 and 0.64, inflation increases much more sharply than in the other models. As a consequence, the real interest rate drops by almost 3 percentage points in the medium term, and GDP rises by more than

6 percent. Including those impulse responses would therefore distort the graphical exposition of the other models' results. By contrast, the CCTW results do not exhibit this feature. The rapid increase in the multiplier with the degree of monetary accommodation in the CEE model is consistent with the results of Erceg and Linde (2010a).

C The ARRA Stimulus Package

CCTW estimate the impact of the ARRA stimulus package on government purchases of goods and services, and then use their model to simulate the effects of this spending component of the ARRA. In Figure 7 we perform the same analysis for all of the policy models, using CCTW's time profile of government spending variations. The policy models have implications that are generally quite similar both to each other, and to CCTW. The exceptions are the BoC-GEM model and especially CEE, which imply much larger output effects under two years of monetary accommodation. Given lower nominal rigidities in these models, the output effects of monetary accommodation increase steeply as the period of accommodation is increased. Overall, given that the ARRA was enacted during a period in which U.S. monetary policy was expected to remain accommodative for a prolonged period, our models suggest that the government spending provisions in the ARRA had larger effects than would have occurred had a similar spending package been enacted in normal times. Even so, the implied multipliers for most of the models are unity or lower even in the case of two years of monetary accommodation, which is considerably lower than the multipliers for the front-loaded stimulus reported in Figure 3. Thus, consistent with CCTW, our analysis suggests that the considerable phase-in provisions of the government spending component of the ARRA did reduce the multiplier noticeably relative to what would have occurred with more front-loaded stimulus.

Overall, these results should be interpreted with caution, not in terms of the size of the multipliers and therefore the ability of a sizeable spending package to have a sizeable effect on output, but in terms of the actual spending and therefore the likely final size of the output effects. As Cogan and Taylor (2010) have recently argued, CCTW overestimated the share of transfers to state and local governments that would result in increased state and local government purchases. As a result, the time profile of government spending variations used in CCTW and in this paper may be too large, which would translate to an overestimate of the overall GDP effects of ARRA.

D The Role of Monetary Accommodation

As we will show below, the tendency for multipliers to increase with the degree of monetary accommodation is found for all fiscal instruments except for labor income taxes. The mechanism is the same as for government consumption, in that all fiscal stimulus measures boost inflation by stimulating aggregate demand. With no monetary accommodation, the inflation pressures lead to an upward movement in real interest rates and thereby offset, in part, the effects of the fiscal stimulus on GDP. In contrast, with monetary accommodation and nominal interest rates held constant, the increases in inflation give rise to decreases in real interest rates. As a result, accommodative monetary policy complements the fiscal policy stimulus and intensifies its effects on real GDP. The indirect effects often differ considerably across models, reflecting that features such as the duration of price and wage contracts can markedly affect the linkage between aggregate demand and inflation. In the case of the United States, inflationary pressures and, consequently, real interest rate movements, are largest in GIMF and BoC-GEM, and smallest in FRB-US and NAWM. In the case of Europe, they are largest in GIMF and QUEST, and smallest in NAWM.

E The Persistence of Fiscal Stimulus

Our focus for most of the paper is on fiscal expansions that are, and are correctly perceived to be, temporary, and that therefore do not result in long-run crowding out of private spending. In such cases, as illustrated in Table 3, a two-year expansion will have significantly larger instantaneous multipliers than a one-year expansion, even in the first year. The reason is that a more persistent boost to demand creates higher inflation over a longer period, thereby causing a stronger reduction of real interest rates.

Table 4 quantifies this effect further by comparing, for four of the policy models, the first-year multipliers for government consumption-based stimulus that lasts between 1 and 5 years, in each case under two years of monetary accommodation. We observe that for three of the models the first-year multiplier peaks for 3 years of overall stimulus, while for one model (NAWM) it peaks for 2 years. This reflects the fact that for slightly more persistent stimulus, even if lasting beyond the period of monetary accommodation, inflation tends to rise by more, and therefore real interest rates can drop by more under monetary accommodation. But the short-run stimulative effects on GDP start to decrease if the fiscal stimulus becomes "too persistent", by causing larger and larger negative wealth effects. This decrease starts to occur if the period of stimulus stretches beyond three years, or beyond one year after monetary accommodation ends. The decrease is monotonic in the persistence of stimulus, and as we will see later, fiscal expansions that are expected to last indefinitely have much smaller first-year multipliers than even those for 5-year stimulus shown in Table 4. Stimulus is therefore most effective over intermediate horizons, where its direct demand and income-generating effects, combined with the interaction of nominal rigidities and monetary accommodation, are more powerful than its negative wealth effects.

F Government Spending versus Taxes and Transfers

Different types of fiscal measures operate on aggregate demand through different channels. Government investment and government consumption directly raise aggregate demand, while increases in transfers and reductions in taxes operate mainly through their effects on personal disposable incomes, as well as through their effects on incentives in the case of changes in distortionary taxes.

In comparing the implications of the different fiscal instruments across models, several results stand out. First, the instantaneous multipliers[19] for government investment and government consumption

[19] We will discuss all of the results in the remainder of Section 5 only in terms of their instantaneous multipliers.

spending are roughly similar in size, but somewhat larger for government investment, due to the latter's positive but small supply side effects (compare Figures 3 and 8). Second, the spending multipliers are, with one exception, considerably larger than for the other fiscal instruments considered. Multipliers are small for general transfers and consumption taxes, smaller for labor income taxes, and smaller still for corporate income taxes. Third, the key exception is targeted transfers, for which the multipliers approach those for government spending.

G Different Taxes and Transfers

The responses to tax and transfer-based stimulus measures depend critically on two factors, the behavior of financially constrained households and the relative distortions caused by different fiscal instruments.

Figure 9 shows the effects of a general increase in transfers to all households under the three alternative assumptions about monetary accommodation. We begin our discussion with general transfers because they cause no first-round distortions.[20] Financially constrained households have a much higher marginal propensity to consume out of current income than other "permanent income" households. Therefore, spending of financially constrained households responds strongly to transfer changes in all models. By contrast, permanent income households make their consumption decisions based on lifetime wealth, and accordingly, respond to the temporary nature of the transfer change largely by adjusting their saving behavior. In all but two of the models the permanent income households are infinitely-lived, so that – absent general equilibrium effects on interest rates and income brought about through the presence of financially constrained households – transfers would have no effect on their consumption, as future transfer cuts would exactly offset the current transfer increase. In GIMF a temporary increase in transfers has some effects on the permanent income households because they have finite lives and therefore interpret part of the transfers as an increase in lifetime wealth. BoC-GEM generates a similar non-Ricardian feature by positing a link between net foreign assets and government debt. But given realistic planning horizons of the finitely-lived permanent income households, the response of aggregate consumption spending mostly hinges on the behavior of the financially constrained households. The share of the latter in the population, and the precise nature in which they are constrained, are therefore critical determinants of the response of the economy to transfer shocks, and also to tax shocks.

Under the no accommodation case, the largest multipliers in Figure 9 occur in models with a high share of financially constrained households, including FRB-US, SIGMA and QUEST. Even so, the multipliers in all models except FRB-US are below 0.25 after one year, and are particularly low in NAWM, where households can use cash to smooth consumption. Multipliers do rise noticeably for two years of accommodation, with multipliers for the United States exceeding 0.4 in four out of six models.

[20] There can be second-round distortions if the taxes that are subsequently raised to balance the budget are distortionary.

Turning to distortionary tax cuts as the instrument of stimulus, these have additional effects on supply and therefore on inflation and real interest rates, but these effects differ significantly across instruments. The output effects of temporary cuts in labor income tax rates (Figure 10) are not very large, and in fact are smaller than for general transfers under monetary accommodation. These multipliers turn out to be nearly invariant to the duration of monetary accommodation, because although labor tax cuts stimulate the demand of financially-constrained agents, they also boost potential output through their effect on labor supply. This dampens the inflationary impact of the tax shock, giving monetary accommodation less traction to boost the multiplier. Our results contrast with Eggertsson (2011a) – where labor tax cuts actually cause output to contract under prolonged monetary accommodation – mainly because Eggertsson's model excludes financially-constrained agents, and hence minimizes the potential demand-side impact of tax cuts.

We have not computed the effects of cuts in employers' payroll taxes as an alternative to labor income tax cuts. This is mainly because the bulk of the 2009 stimulus packages consisted of the latter rather than the former. As an example, most of the federal tax cut provisions in the U.S. ARRA – which totaled over \$200 billion – were directed towards households, including a "making work pay" component that provided tax credits of up to \$800 per year to working households, and a component that provided relief from the alternative minimum tax. In most of the policy models, labor income tax cuts have a larger stimulative effect than equal-sized cuts in employers' payroll taxes. This is mainly because labor income tax cuts directly boost the income of financially constrained households, while payroll tax cuts do not. But in addition, payroll tax cuts, in the presence of sticky wages and prices, have a stronger disinflationary impact than labor income tax cuts, making them more contractionary if nominal interest rates cannot adjust. The reason is that payroll tax cuts immediately reduce firms' after-tax real wage and therefore marginal cost, while the increase in labor supply following labor income tax cuts only gradually reduces firms' marginal cost.

Temporary cuts in consumption taxes, which have a smaller effect on potential output, are somewhat more effective (Figure 11) than labor tax cuts under monetary accommodation. Temporary cuts in corporate income taxes (Figure 12) generally have the smallest multipliers, for two reasons. First, the duration of the stimulus period is too short, and therefore the effect of lower capital income taxes on the present value of future earnings is too small, to justify a sizeable increase in the capital stock that will last well beyond the stimulus period. Second, the presence of investment adjustment costs further slows down the optimal adjustment of the capital stock.

H Targeted Transfers versus General Transfers

Temporary increases in targeted transfers are presented in Figure 13. Multipliers are considerably higher than in the case of general transfers, and the increase in multipliers from using targeted instead of general transfers is greatest in those models that have the lowest percentage of financially constrained households, especially BoC-GEM and GIMF. The reason is that shifting the total value of the increase in transfers from the general public to the targeted groups leads to a larger increase in the disposable incomes of the targeted groups when they are a smaller proportion of the population.

The magnitude of the multipliers is roughly twice as large in most models when monetary policy is accommodative for two years relative to normal conditions. Under normal conditions, the consumption of liquidity constrained households rises sharply, but the increase in interest rates due to the monetary response to higher demand reduces the consumption of permanent income households. By contrast, under monetary accommodation real interest rates decline, which acts to boost the consumption of permanent income households, or at least to weaken crowding out effects.

The multipliers for targeted transfers in most models are in the range of 1 to 1.5 percent, only slightly smaller than for government spending. The targeted transfer multiplier would be even higher if it was not for some leakage of the increased disposable income into labor income taxes and especially consumption taxes. Furthermore, in models where financially constrained households solve a consumption-leisure choice problem, one of the effects of higher disposable incomes is a reduction in their labor supply, which reduces the output gain.

I United States versus Europe

Table 5 shows that, in general, temporary fiscal stimulative actions have substantially greater effects on output in the United States than in Europe. This could be due to a number of factors, and this section explores which of them is most important. First, Europe is more open than the United States, and therefore the leakage of stimulus into imports is larger. Second, the degree of nominal rigidities is larger in Europe than in the United States, and therefore the output-expanding effects of stimulus on inflation and real interest rates under monetary accommodation are lower in Europe than in the United States. Third, automatic stabilizers play a larger role in Europe than in the United States, and therefore the leakage from discretionary fiscal stimulus into higher taxes and lower transfers is greater in Europe.

We analyze the importance of these three factors by examining the effects of a two-year, one percent of baseline GDP, increase in government consumption spending under two years of monetary accommodation of this higher spending, using different calibrations of the IMF's model, GIMF. Table 5 shows the average (over years one and two) multipliers of the alternative calibrations.

Consider first the degree of openness of the economy, which is calibrated by specifying the steady state exports-to-GDP ratio. In the original calibration of Europe in GIMF, exports equal around 20 percent of GDP. Our alternative calibration sets exports as a share of GDP to just over half of the original calibration, which is close to the calibrated exports-to-GDP ratio for the U.S. economy. For the more open baseline calibration of Europe the multiplier equals 0.94, while for the less open economy it equals 1.11. In the less open economy, the increase in demand falls more heavily on the domestic sector, and it also leads to a larger inflation response and therefore a larger decline in real interest rates in the case of monetary accommodation. The conclusion that the more closed economy has significantly higher fiscal multipliers holds for all the temporary fiscal stimulus measures considered in this paper.

In our alternative calibration for nominal rigidities, U.S. rigidities have the same parameter values as in Europe, that is they are 50 percent higher than in the original calibration.[21] Under this assumption inflation responds less to aggregate demand, and the real interest rate therefore moves less under monetary accommodation. Thus, the multiplier is lower with higher nominal rigidities, dropping from the baseline 1.32 for the United States to 1.24.

In our alternative calibration for automatic stabilizers, we assume that the weight on the output gap in the U.S. fiscal policy rule is the same as in Europe, that is it equals 0.49 instead of 0.34, the original U.S. calibration.[22] This reduces the effect of the government discretionary fiscal action, because the resulting increase in GDP automatically reduces general transfers to households through the fiscal rule. That is, the overall increase in the fiscal deficit is smaller when automatic stabilizers are larger. The decline in the fiscal multiplier with larger automatic stabilizers, from 1.32 to 1.28, is however fairly small.

Overall, it appears that the smaller fiscal multipliers in Europe relative to the United States in GIMF are mostly a result of the higher relative openness of European economies and the resulting import leakages of stimulus, with higher nominal rigidities in Europe playing a somewhat smaller role, and larger automatic stabilizers in Europe being least important.

V Fiscal Multipliers for a Permanent Fiscal Expansion

In this section we demonstrate that, while the case for temporary fiscal stimulus, as outlined in the previous section, is strong, the case for a permanent fiscal expansion is much weaker. The first subsection discusses how, and why, a permanent increase in *spending* reduces the short-run output effects relative to a temporary increase in spending. The second subsection shows that the long-run output effects of a permanent increase in *deficits* are negative, and explores how those long-run effects depend on the fiscal instrument used.

A Permanent Increase in Spending and Short-Run Multipliers

In Figure 14 we implement the CCTW scenario of a permanent increase in government consumption spending, normalized to equal one percent of pre-stimulus GDP. This is assumed to be financed by higher labor income or lump-sum taxes, depending on which instrument is specified in the fiscal rule of the respective model. Because the time profile of the tax response is determined by fiscal rules that respond to deficits or debt with small coefficients, the initial response of taxes is similar for both temporary and permanent increases in government spending. What is different is of course the tax response over the medium and long term, where taxes now remain elevated to continue to finance higher spending. We compare our results to both CEE and CCTW, but for the latter we choose the

[21] In GIMF nominal rigidities are specified as quadratic adjustment costs on changes in the rate of inflation. The parameter values that are changed in this experiment are the coefficients multiplying these adjustment cost terms.

[22] These fiscal rule coefficients are based on Girouard and André (2005).

version without financially constrained households. Because this is a long-run scenario, we assume that there is no monetary accommodation.

A comparison with Figure 3 shows that the impact effects on output, except in some cases in the very first quarter, are considerably lower than for temporary stimulus. In the case of no monetary accommodation, instantaneous multipliers decline below 0.5 in all models after two years, except for NAWM. Moreover, even with two years of monetary accommodation, multipliers cluster around 0.7 after two years, about half as large as in the temporary stimulus simulations analyzed in Figure 3.

Cumulative multipliers, reported in Figure 15, of course follow the pattern set by instantaneous multipliers, by trending down with longer horizons. Monetary accommodation still increases multipliers, but by much less than for temporary stimulus. Interestingly, the policy models almost invariably exhibit lower multipliers than CCTW (and CEE). In other words, our models justify even stronger skepticism than CCTW towards fiscal stimulus if the latter were to be permanent. But at the same time, as we saw in our discussion of Figure 3, our models yield much larger multipliers for temporary stimulus, and, crucially, so does CCTW.

To understand the differences between the short-run stimulative effects of temporary and permanent increases in spending, we note that our permanent experiment involves much higher taxes in the medium and longer run. This has two effects. First, the large increase in the present discounted value of taxes leads to a negative wealth effect that immediately starts to crowd out private demand. This is the main reason behind the smaller first-year multipliers for the permanent measure, and for the fact that the multipliers thereafter start to fall quickly back towards, and ultimately below, zero. Second, if taxes are distortionary, this exacerbates the crowding-out effects. The more distortionary the tax, the greater the effect on potential GDP. This can be seen in Figure 14 by around year 4 or 5, where models that use lump-sum taxes to satisfy their fiscal rules (CCTW, CEE, GIMF and NAWM) exhibit more favorable output effects than other models. The nature of taxes used to balance the budget is however not the only factor that determines the extent of crowding-out. This can be seen in the results for BoC-GEM, which also uses lump-sum taxes to satisfy its fiscal rule. A distinguishing feature of BoC-GEM is that its calibrated nominal rigidities are smaller[23], so that the effects of permanent fiscal stimulus on inflation and real interest rates lead to much stronger crowding-out effects in the absence of monetary accommodation. In the case of NAWM, the larger multiplier also relates to the fact that the output gap coefficient of the interest rate rule was set to zero for the permanent stimulus experiment.

B Permanently Higher Deficits and Long-Run Crowding Out

In the previous subsection we demonstrated that fiscal expansions that involve permanently higher taxes significantly reduce the short-run output effects of the expansions, and we argued that this effect is stronger the more distortionary is the tax used to balance the government budget in the long run. This subsection expands on the latter point by looking in more detail at the long-run output effects

[23] Compare Figure 4.

of raising different types of taxes. To simplify matters and concentrate on only one tax instrument at a time, we do away with the assumption of a permanent increase in government spending that is financed by taxes and without a long-run increase in debt. We replace it with a permanent increase in deficits that is brought about by a tilting in the time profile of taxes, with an initial cut followed by an eventual increase.

Specifically, we use the GIMF model to simulate the long-run or steady state effects of a permanent 0.5 percent increase in the U.S. interest-inclusive deficit-to-GDP ratio that increases long-run U.S. government debt by 10 percent of GDP. This long-run increase in debt has negative long-run output effects, for two main reasons. First, taxes have to rise in the long run to service the higher debt, and if those taxes are distortionary they reduce output. This is true for all models. Second, in GIMF, due to finitely-lived households, part of the increase in government debt is perceived as net worth, and therefore crowds out alternative investments, specifically physical capital and (net) foreign assets, as well as resulting in a permanent increase in the world real interest rate. Lower capital stocks and higher real interest rates eventually reduce output.[24] We use this long-run notion of crowding out throughout the remainder of this subsection. One of its advantages is that it has a very precise meaning in terms of the model used. Other, short-run notions of crowding out are more commonly used, but they tend to conflate persistent reductions of investment that are due to purely fiscal reasons, such as permanent increases in government debt, with transitory reductions in investment that are due to other reasons, such as monetary policy.

GIMF is calibrated so that a one percentage point increase in the U.S. government debt-to-GDP ratio leads to an approximately one basis point increase in the U.S. and world real interest rate. This is at the lower end of the range of estimates (1 to 6 basis points) reported by Laubach (2009), Engen and Hubbard (2004) and Gale and Orszag (2004). Of the other models in this paper, both QUEST and OECD Fiscal include an endogenous interest rate risk premium. In QUEST this risk premium applies to government debt interest payments, while in OECD Fiscal, as in GIMF, it applies to the economy-wide real interest rate. All other models used in this paper only generate long-run crowding-out effects due to higher long-run distortionary taxes.[25]

In the simulations deficits initially increase through a reduction in taxes or an increase in transfers. As debt and interest charges rise, the primary deficit has to fall to keep the overall deficit increase at 0.5 percent of GDP, and this is assumed to be implemented through an offsetting increase in the same taxes or a reduction in the same transfers.

Table 6 presents the effects on long-run real GDP in the United States, the rest of the world, and globally. As investment in the additional government debt crowds out saving in physical capital and (net) foreign assets, the world real interest rate rises by 9 to 11 basis points, and this contributes to a decline in global long-run real GDP of between 0.2 percent and 0.7 percent. The effects on real GDP in the United States are generally larger than in the rest of the world if the fiscal instrument

[24] See Kumhof and Laxton (2010).

[25] Of course, depending on the size of the distortions caused by higher taxes, long-run crowding out in the other models could well be larger than in GIMF.

is distortionary, because tax distortions increase in the United States but not elsewhere. The largest distortions arise in the case of corporate income taxes, due to their effect on capital accumulation, with a long-run GDP effect of -0.64 (-0.22 in the rest of the world). The GDP effect of higher labor income taxes is -0.35 (-0.24 in the rest of the world), and that of consumption taxes is -0.26 (-0.22 in the rest of the world). This corresponds closely to the rankings of alternative taxes by their distortionary effects in the public finance literature.

VI Conclusions

The simulations of the policy and academic models used in this study suggest that temporary fiscal stimulus can play an important role in mitigating the effects of the kind of prolonged downturn that the world experienced following the 2008 financial crisis. There is a robust finding across all models that fiscal policy can have sizeable output multipliers, particularly for spending and targeted transfers. Under normal conditions, in which monetary policy reacts to fiscal stimulus by raising interest rates, the multipliers derived from the policy models are broadly in line with those reported in the empirical literature. But they are significantly higher in circumstances in which monetary policy is supportive, by accommodating stimulative fiscal actions through holding interest rates constant for some period of time. More persistent stimulus, if the additional stimulus is measured in years rather than decades, is even more effective if monetary policy remains accommodative. But a permanent increase in fiscal deficits has significantly lower multipliers at the outset, and has negative output effects in the long run.

Many additional dimensions of fiscal stimulus remain to be explored in future work. This includes the effects of coordinated increases in fiscal deficits across multiple countries and regions of the world economy, which we could not systematically explore here because several participating models are not models of the world economy. In light of recent events it may also be interesting to compare the effects of using fiscal resources for government spending or tax cuts on the one hand, with the effects of using the same resources to support the financial system, for example through asset purchases. This is particularly relevant because the overall amount of resources that fiscal policy can draw on is not perceived to be limitless, even for the strongest industrialized economies. This growing concern with debt levels and sovereign risk in fact suggests that future work should also systematically look at the implications of government debt affecting both riskless interest rates and interest rate risk spreads.

References

[1] Altig, David, Larry Christiano, Martin Eichenbaum and Jesper Lindé. 2010. "Firm-Specific Capital, Nominal Rigidities and the Business Cycle." Board of Governors of the Federal Reserve System, International Finance Discussion Paper 990.

[2] Álvarez, Luis, Emmanuel Dhyne, Marco Hoeberichts, Claudia Kwapil, Hervé Le Bihan, Patrick Lünnemann, Fernando Martins, Roberto Sabbatini, Harald Stahl, Philip Vermeulen and Jouko Vilmunen. 2006. "Sticky Prices in the Euro Area: A Summary of New Micro-Evidence." Journal of the European Economic Association 4(2-3): 575-584.

[3] Auerbach, Alan and Yuriy Gorodnichenko. 2010. "Measuring the Output Responses to Fiscal Policy." http://www.econ.berkeley.edu/~auerbach/index.html.

[4] Barro, Robert and Charles Redlick. 2009. "Macroeconomic Effects from Government Purchases and Taxes." NBER Working Paper 15369.

[5] Bi, Huixin and Michael Kumhof. 2011. "Jointly Optimal Monetary and Fiscal Policy Rules under Borrowing Constraints." Journal of Macroeconomics (forthcoming).

[6] Blanchard, Olivier and Roberto Perotti. 2002. "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output." Quarterly Journal of Economics 117: 1329-68.

[7] Brayton, Flint, and Peter Tinsley. 1996. "A Guide to FRB/US: A Macroeconomic Model of the United States." Board of Governors of the Federal Reserve System, Finance and Economics Discussion Series 96-42. http://www.federalreserve.gov/pubs/feds/1996/199642/199642abs.html.

[8] Christiano, Larry, Martin Eichenbaum and Charles Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." Journal of Political Economy 113(1): 1-45.

[9] Christiano, Larry, Martin Eichenbaum and Sergio Rebelo. 2011. "When is the Government Spending Multiplier Large?" Journal of Political Economy 119(1): 78-121.

[10] Christiano, Larry, Roberto Motto and Massimo Rostagno. 2010. "Financial Factors in Economic Fluctuations." ECB Working Paper 1192.

[11] Christiansen, Lone. 2008. "Fiscal Multipliers–A Review of the Literature." Appendix II in International Monetary Fund Staff Position Note 08/01, Fiscal Policy for the Crisis.

[12] Coenen, Guenter, Peter McAdam, and Roland Straub. 2008. "Tax Reform and Labour-Market Performance in the Euro Area: A Simulation-Based Analysis Using the New Area-Wide Model." Journal of Economic Dynamics and Control 32: 2543-83. http://www.ecb.int/pub/pdf/scpwps/ecbwp747.pdf.

[13] Cogan, John, Tobias Cwik, John Taylor and Volker Wieland. 2009. "New Keynesian versus Old Keynesian Government Spending Multipliers." Journal of Economic Dynamics and Control 34(3): 281-95.

[14] Cogan, John and John Taylor. 2010. "What the Government Purchases Multiplier Actually Multiplies in the 2009 Stimulus Package." NBER Working Paper 16505.

[15] Corsetti, Giancarlo, André Meier and Gernot Müller. 2009. "Fiscal Stimulus with Spending Reversals." IMF Working Paper WP/09/106.

[16] Decressin, Joerg and Douglas Laxton. 2009. "Gauging Risks for Deflation." International Monetary Fund Staff Position Note 09/01.

[17] Drautzburg, Thorsten and Harald Uhlig. 2011. "Fiscal Stimulus and Distortionary Taxation." NBER Working Paper 17111.

[18] Eggertsson, Gautti. 2011a. "What Fiscal Policy is Effective at Zero Interest Rates?" NBER Macroeconomics Annual 25: 59-112.

[19] Eggertsson, Gautti. 2011b. "Was the New Deal Contractionary?" American Economic Review (forthcoming).

[20] Engen, Eric. and Glenn Hubbard. 2004. "Federal Government Debt and Interest Rates." NBER Macroeconomics Annual 19: 83-138.

[21] Erceg, Chris, Luca Guerrieri and Christopher Gust. 2005. "SIGMA: A New Open Economy Model for Policy Analysis." Board of Governors of the Federal Reserve System, International Finance Discussion Paper 835. http://www.federalreserve.gov/pubs/ifdp/2005/835/default.htm.

[22] Erceg Chris and Jesper Lindé. 2010a. "Is There a Fiscal Free Lunch in a Liquidity Trap?" Federal Reserve Board of Governors, International Finance Discussion Paper 1003.

[23] Erceg, Chris and Jesper Lindé. 2010b. "Asymmetric Shocks in a Currency Union With Fiscal and Monetary Handcuffs." Federal Reserve Board of Governors, International Finance Discussion Paper 1012.

[24] Favero, Carlo and Francesco Giavazzi. 2009. "How Large Are the Effects of Tax Changes?" CEPR Discussion Paper 7439.

[25] Freedman, Charles, Michael Kumhof, Douglas Laxton, Dirk Muir and Susanna Mursula. 2010. "Global Effects of Fiscal Stimulus During the Crisis." Journal of Monetary Economics 57: 506-526.

[26] Furceri, Davide and Annabelle Mourougane. 2010. "The Effects of Fiscal Policy on Output: A DSGE Analysis." OECD Working Paper 770. http://dx.doi.org.libproxy-imf.imf.org/10.1787/5kmfp4z3njg0-en.

[27] Gale, William and Peter Orszag. 2004. "Budget Deficits, National Saving, and Interest Rates." Brookings Papers on Economic Activity 2: 101-187.

[28] Galí, Jordi, David López-Salido and Javier Vallés. 2007. "Understanding the Effects of Government Spending on Consumption." Journal of the European Economic Association 5(1): 227-70.

[29] Giavazzi, Francesco and Marco Pagano. 1990. "Can Severe Fiscal Contractions be Expansionary: Tales of Two Small European Countries." NBER Macroeconomics Annual 5: 75-122.

[30] Girouard, Nathalie and Christophe André. 2005. "Measuring Cyclically-Adjusted Budget Balances for OECD Countries." OECD Economics Department Working Paper 434.

[31] Gust, Christopher, Sylvain Leduc and Nathan Sheets. 2009. "The Adjustment of Global External Balances: Does Partial Exchange-Rate Pass-Through to Trade Prices Matter?" Journal of International Economics 79(2): 173-85.

[32] Hall, Robert. 2009. "By How Much Does GDP Rise if the Government Buys More Output?" NBER Working Paper 15496.

[33] Hemming, Richard, Michael Kell and Selma Mahfouz. 2002. "The Effectiveness of Fiscal Policy in Stimulating Economic Activity - A Review of the Literature." IMF Working Paper WP/02/208.

[34] Iacoviello, Matteo and Stefano Neri. 2010. "Housing Market Spillovers: Evidence from an Estimated DSGE Model." American Economic Journal: Macroeconomics 2(2): 125–64.

[35] IMF. 2009a. "Global Economic Slump Challenges Policies." World Economic Outlook Update.

[36] IMF. 2009b. "The State of Public Finances: Outlook and Medium-Term Policies After the 2008 Crisis." Fiscal Affairs Department.

[37] IMF. 2010. "Will It Hurt? Macroeconomic Effects of Fiscal Consolidation." World Economic Outlook, October.

[38] Johnson, David, Jonathan Parker and Nicholas Souleles. 2006. "Household Expenditure and the Income Tax Rebates of 2001." American Economic Review 96(5): 1589-1610.

[39] Kumhof, Michael and Douglas Laxton. 2010. "Fiscal Deficits and Current Account Deficits." IMF Working Paper WP/09/237. http://www.imf.org/external/pubs/cat/longres.aspx?sk=23367.0.

[40] Kumhof, Michael, Douglas Laxton, Dirk Muir and Susanna Mursula. 2010. "The Global Integrated Monetary and Fiscal Model - Theoretical Structure." IMF Working Paper WP/10/34. http://www.imf.org/external/pubs/cat/longres.aspx?sk=23615.0.

[41] Lalonde, René and Dirk Muir. 2007. "The Bank of Canada's Version of the Global Economy Model (BoC-GEM)." Bank of Canada Technical Report No. 98. http://www.bankofcanada.ca/en/res/tr/2007/tr98-e.html.

[42] Laubach, Thomas. 2009. "New Evidence on the Interest Rate Effects of Budget Deficits and Debt." Journal of the European Economic Association 7(4): 858-885.

[43] Leeper, Eric, Todd Walker and Susan Yang. 2009. "Fiscal Foresight and Information Flows." NBER Working Paper 14630.

[44] Lipsky, John. 2008. "The Current Macroeconomic Outlook 2009: Issues of Systemic Stability." http://www.imf.org/external/np/speeches/2008/121008a.htm.

[45] Mertens, Karel and Morten Ravn. 2010. "Empirical Evidence on the Agregate Effects of Anticipated and Unanticipated US Tax Policy Shocks." National Bank of Belgium Working Paper 181.

[46] Mountford, Andrew and Harald Uhlig. 2009. "What Are the Effects of Fiscal Policy Shocks?" NBER Working Paper 14551.

[47] Parker, Jonathan, Nicholas Souleles, David Johnson and Robert McClelland. 2011. "Consumer Spending and the Economic Stimulus Payments of 2008." NBER Working Paper 16684.

[48] Perotti, Roberto. 2007. "In Search of the Transmission Mechanism of Fiscal Policy." NBER Working Paper 13143.

[49] Ramey, Valerie. 2009. "Identifying Government Spending Shocks: It's All in the Timing." NBER Working Paper 15464.

[50] Ratto, Marco, Werner Roeger, and Jan in 't Veld. 2009. "QUEST III: An Estimated Open-Economy DSGE Model of the Euro Area with Fiscal and Monetary Policy." Economic Modelling 26(1): 222-33.

[51] Roeger, Werner and Jan in 't Veld. 2009. "Fiscal Policy with Credit Constrained Households." European Economy Economic Papers 357. http://ec.europa.eu/economy_finance/publications/publication_summary13837_en.htm.

[52] Roeger, Werner and Jan in 't Veld. 2010. "Fiscal Stimulus and Exit Strategies in the EU: A Model-based Analysis." European Economy Economic Papers 426. http://ec.europa.eu/economy_finance/publications/economic_paper/2010/ecp426_en.htm.

[53] Romer, Christina and David Romer. 2010. "The Macroeconomic Effects of Tax Changes: Estimates based on a New Measure of Fiscal Shocks." American Economic Review 100(3): 763–801.

[54] Smets, Frank and Raf Wouters. 2003. "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area." Journal of the European Economic Association 1(5): 1123-1175.

[55] Smets, Frank and Raf Wouters. 2007. "Shocks and Frictions in U.S. Business Cycles: A Bayesian DSGE Approach." American Economic Review 97(3): 506-606.

[56] Spilimbergo, Antonio, Steven Symansky, Olivier Blanchard and Carlo Cottarelli. 2008. "Fiscal Policy For the Crisis." International Monetary Fund Staff Position Note 08/01.

[57] Taylor, John. 1999. "A Historical Analysis of Monetary Policy Rules." NBER Working Paper 6768.

[58] Uhlig, Harald. 2010. "Some Fiscal Calculus." American Economic Review Papers and Proceedings 100(2): 30-34.

[59] Woodford, Michael. 2011. "Simple Analytics of the Government Expenditure Multiplier." American Economic Journal: Macroeconomics 3(1): 1–35.

Figure 1: Effects of Monetary Policy Shock with Standardized Monetary Rule

(Vertical axis in percent; horizontal axis in quarters)

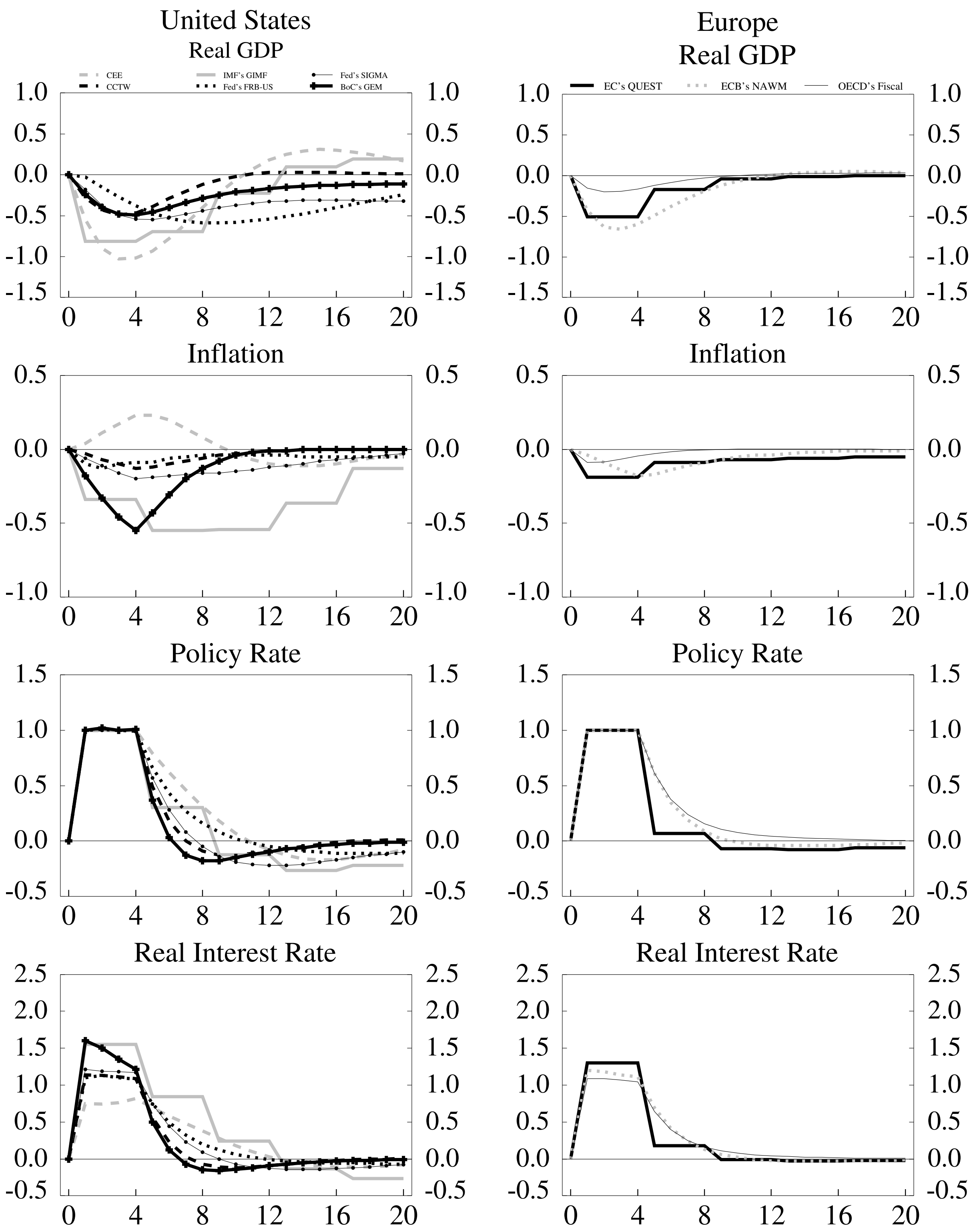

Figure 2: Effects of Monetary Policy Shock with Model-Specific Monetary Rule

(Vertical axis in percent; horizontal axis in quarters)

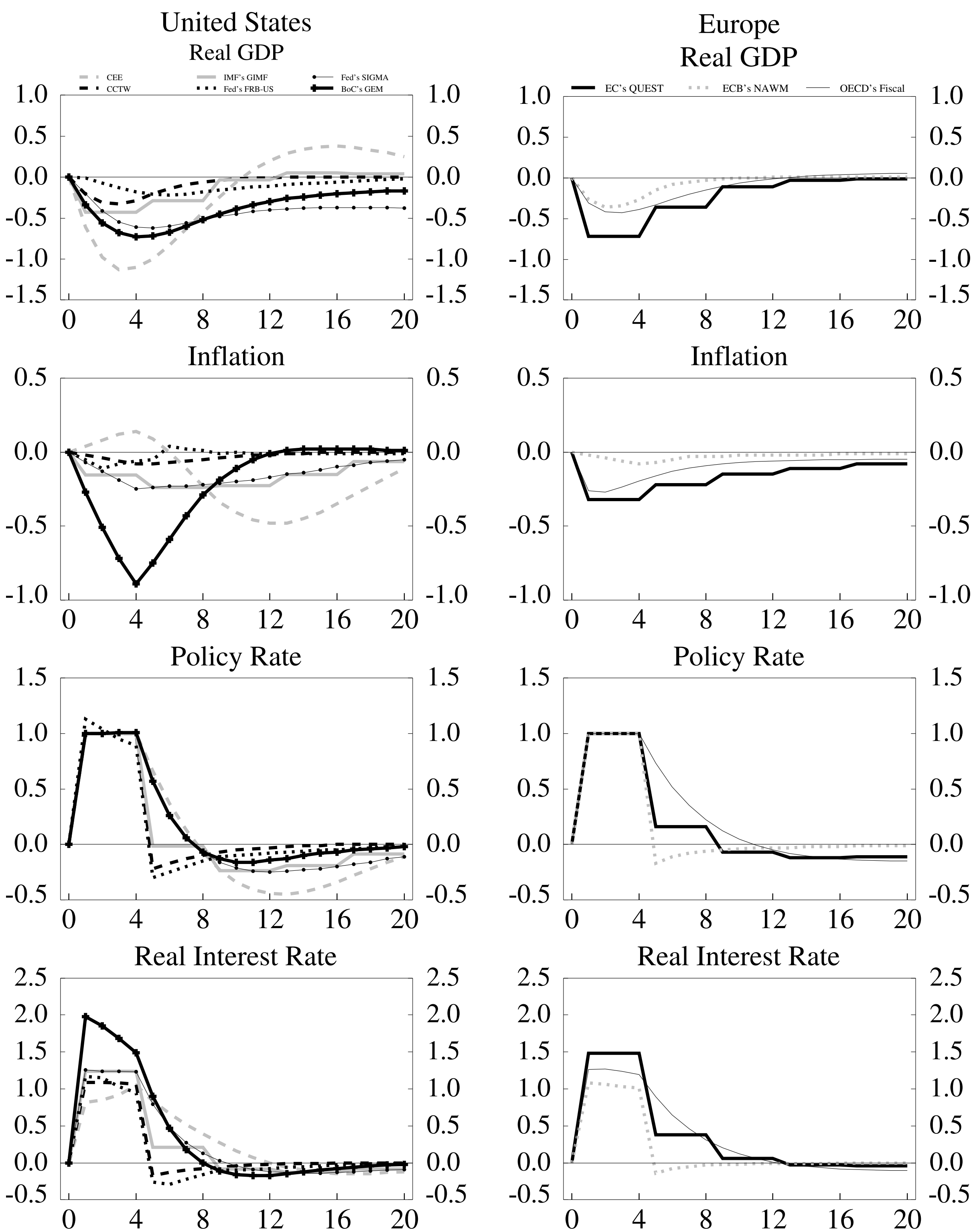

Figure 3: Instantaneous Fiscal Multipliers for 2-year Increase in Government Consumption

(Vertical axis in percent; horizontal axis in quarters)

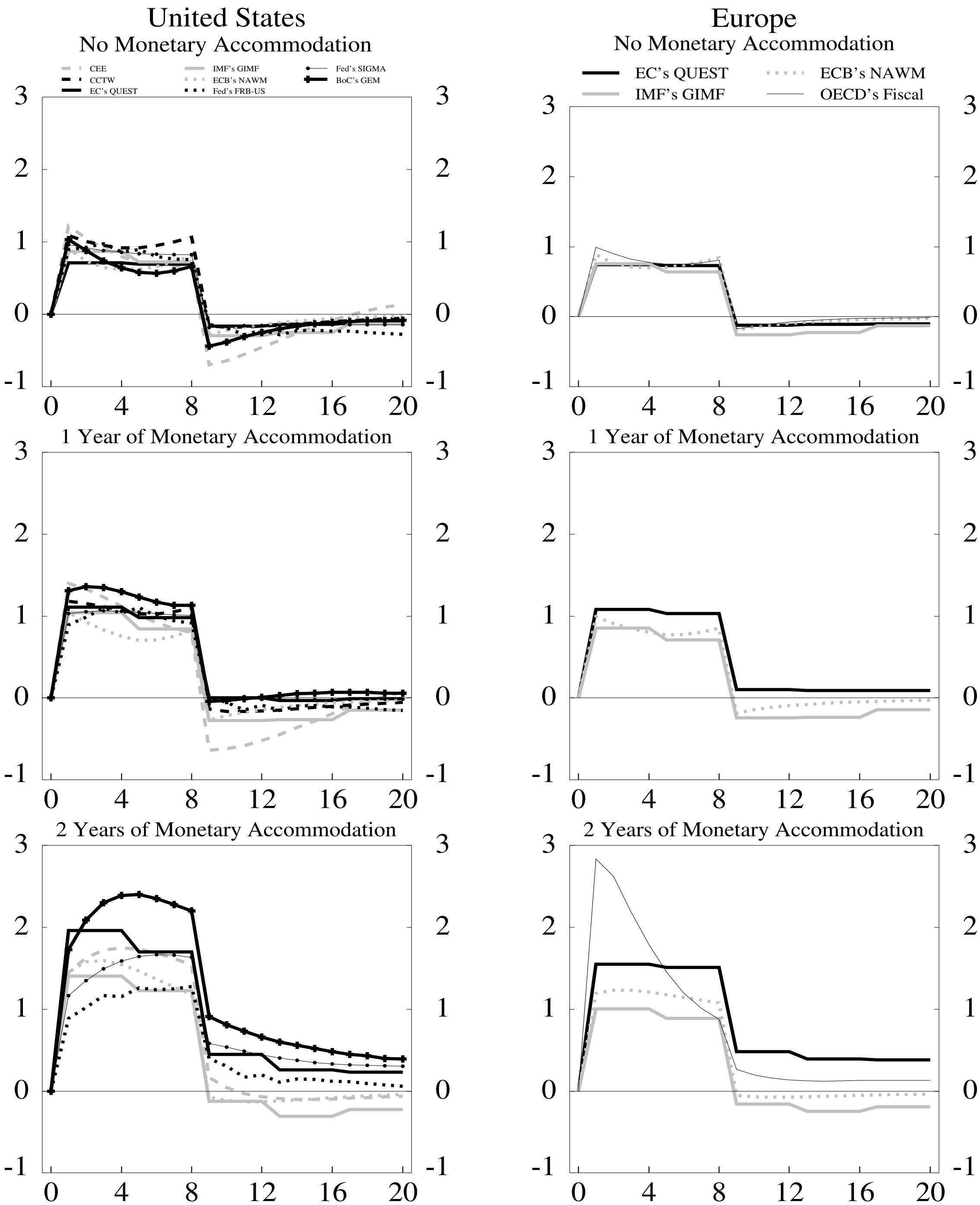

Figure 4: Inflation and Real Interest Rate for 2-year Increase in Government Consumption (U.S.)

(Vertical axis in percentage points; horizontal axis in quarters)

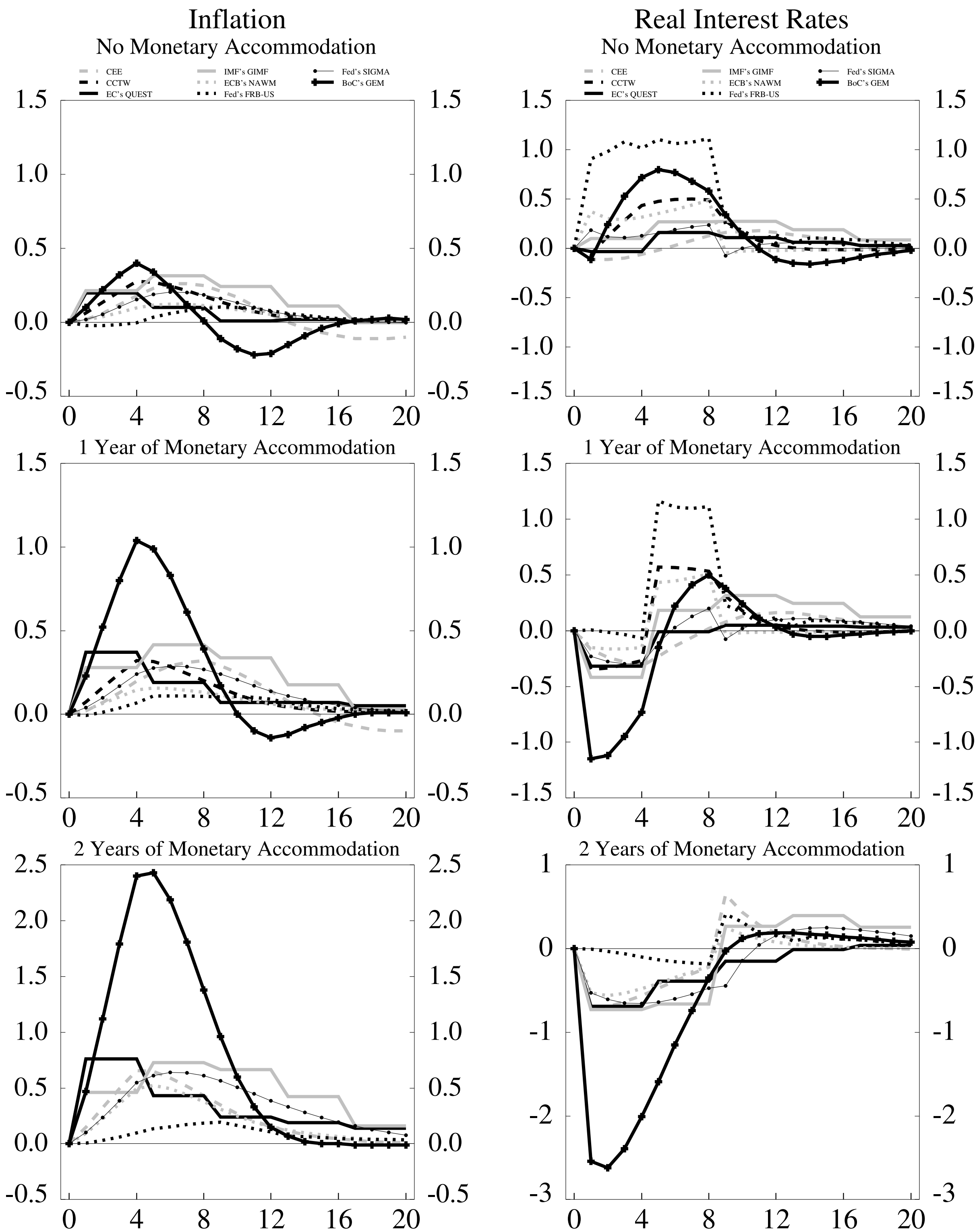

Figure 5: Inflation and Real Interest Rate for 2-year Increase in Government Consumption (Europe)

(Vertical axis in percentage points; horizontal axis in quarters)

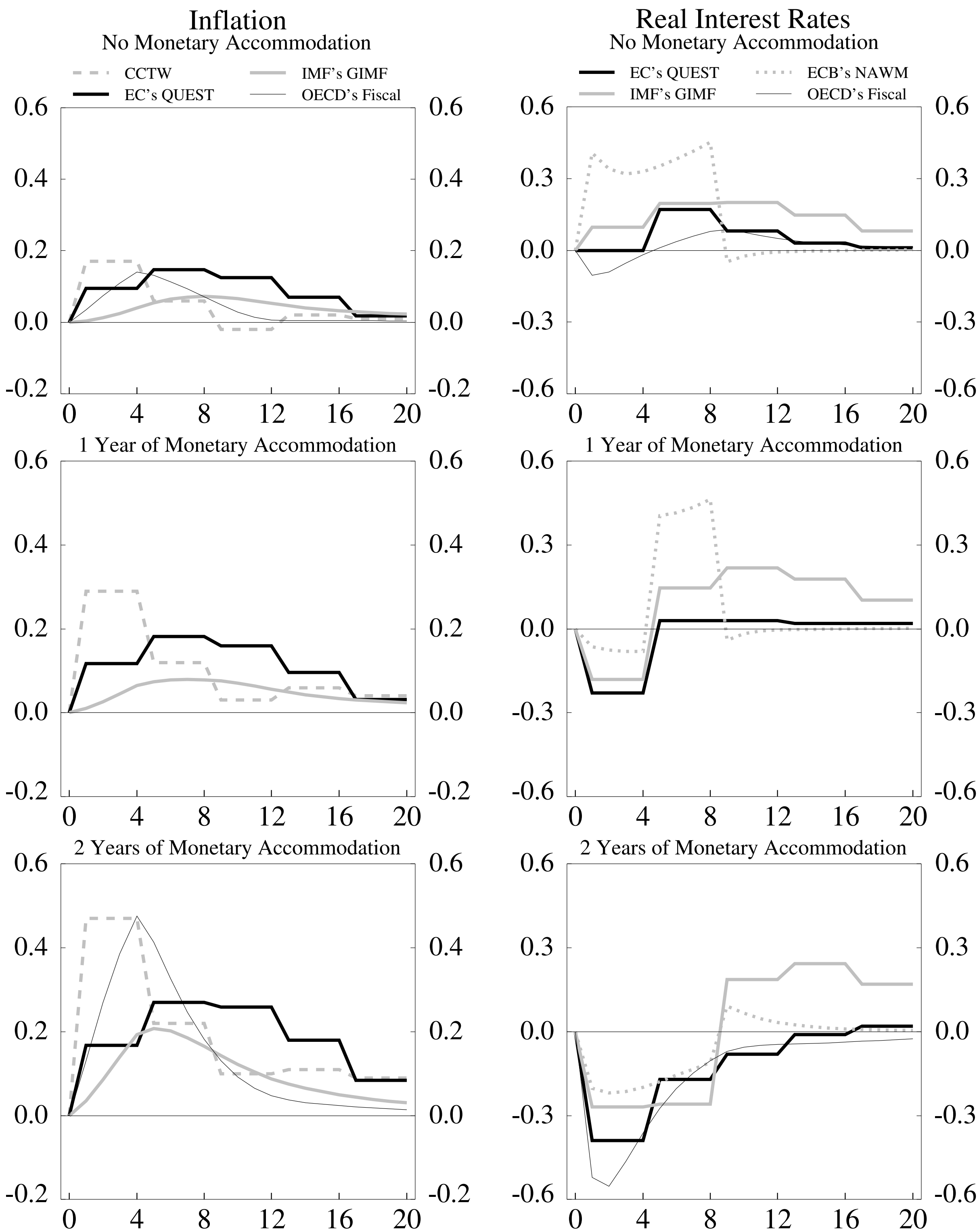

Figure 6: Cumulative Fiscal Multipliers for 2-year Increase in Government Consumption

(Vertical axis in percent; horizontal axis in quarters)

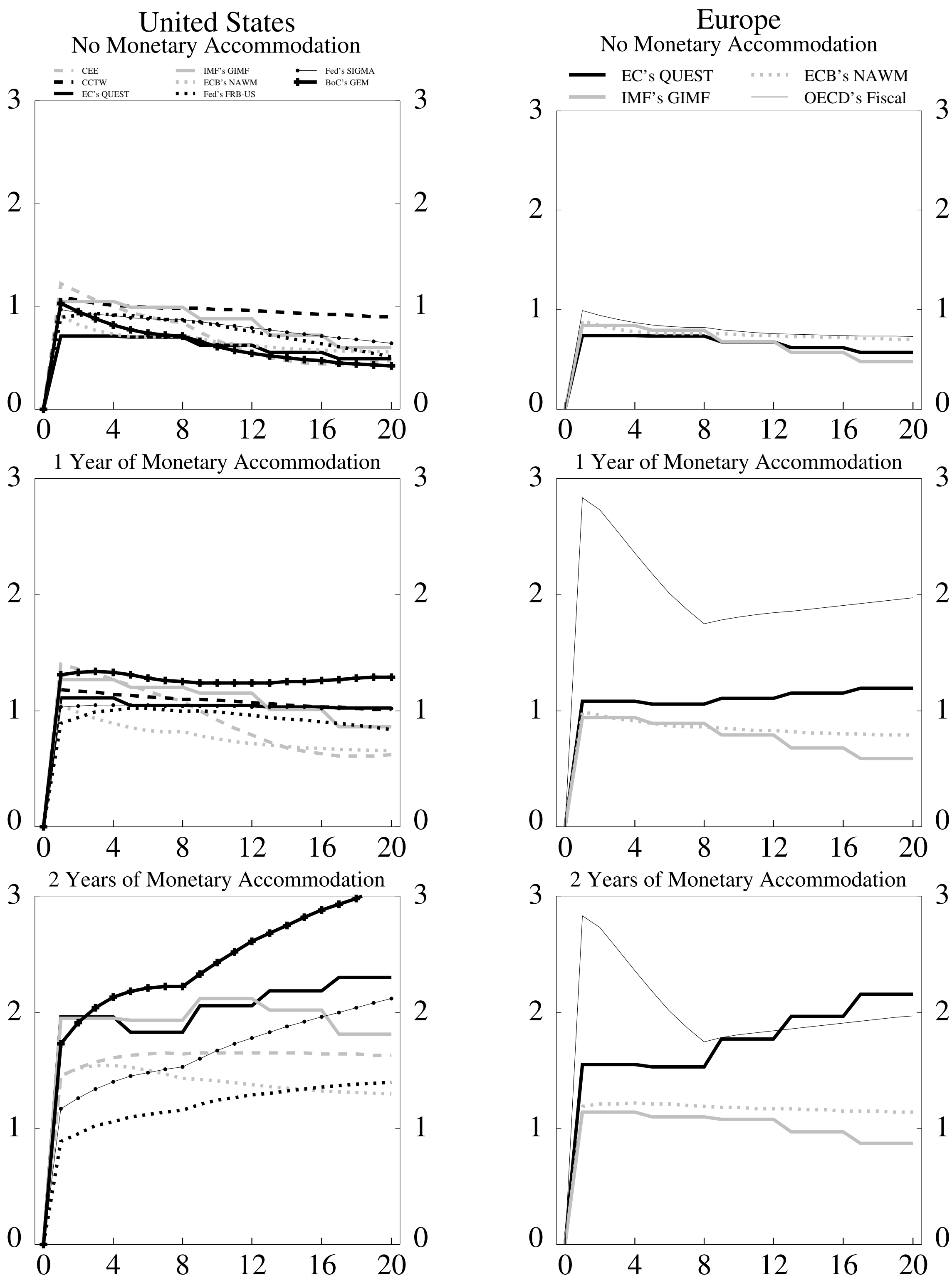

Figure 7: Instantaneous Fiscal Multipliers for the ARRA Stimulus Package

(Vertical axis in percent; horizontal axis in quarters)

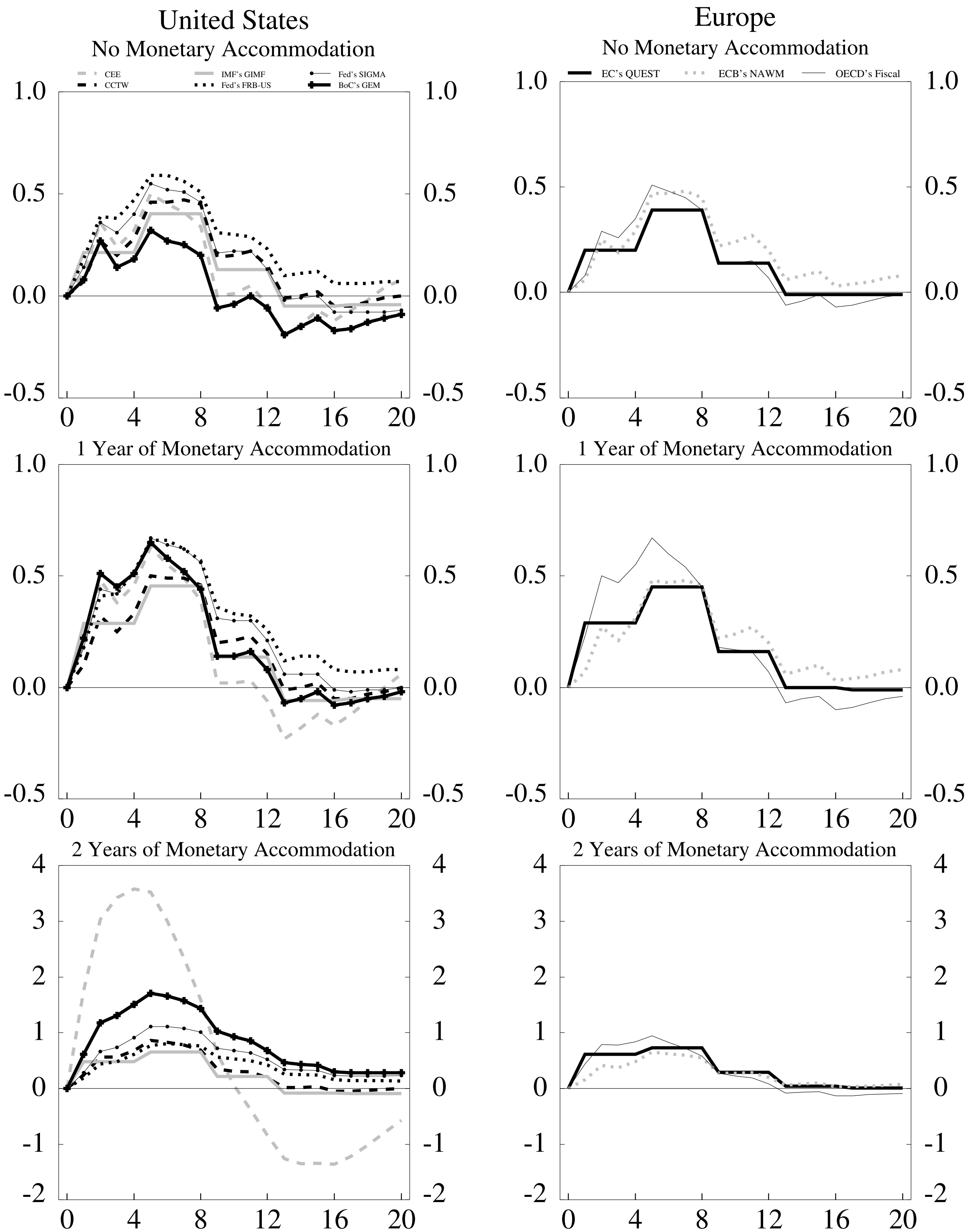

Figure 8: Instantaneous Fiscal Multipliers for 2-year Increase in Government Investment

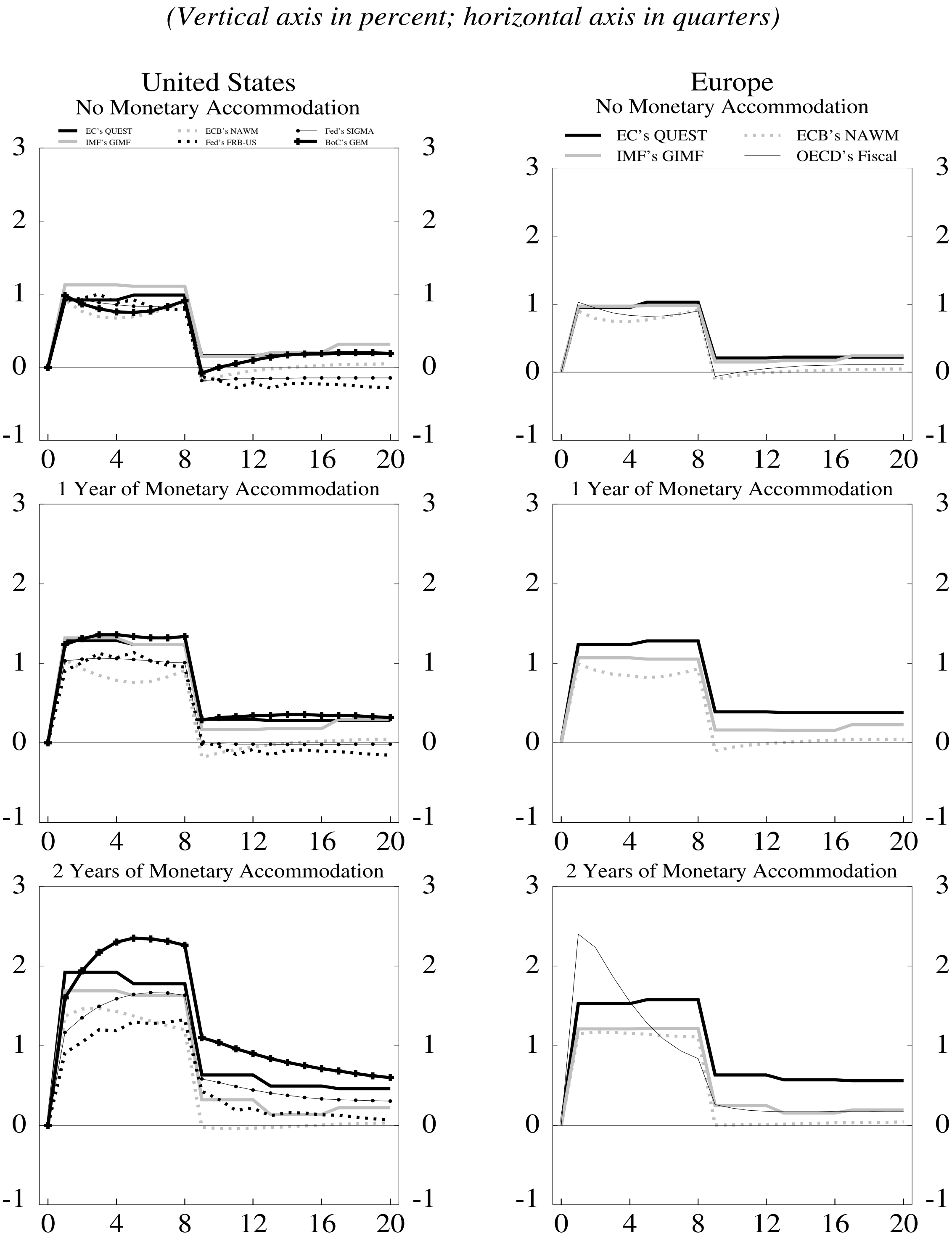

Figure 9: Instantaneous Fiscal Multipliers for 2-year Increase in General Transfers

(Vertical axis in percent; horizontal axis in quarters)

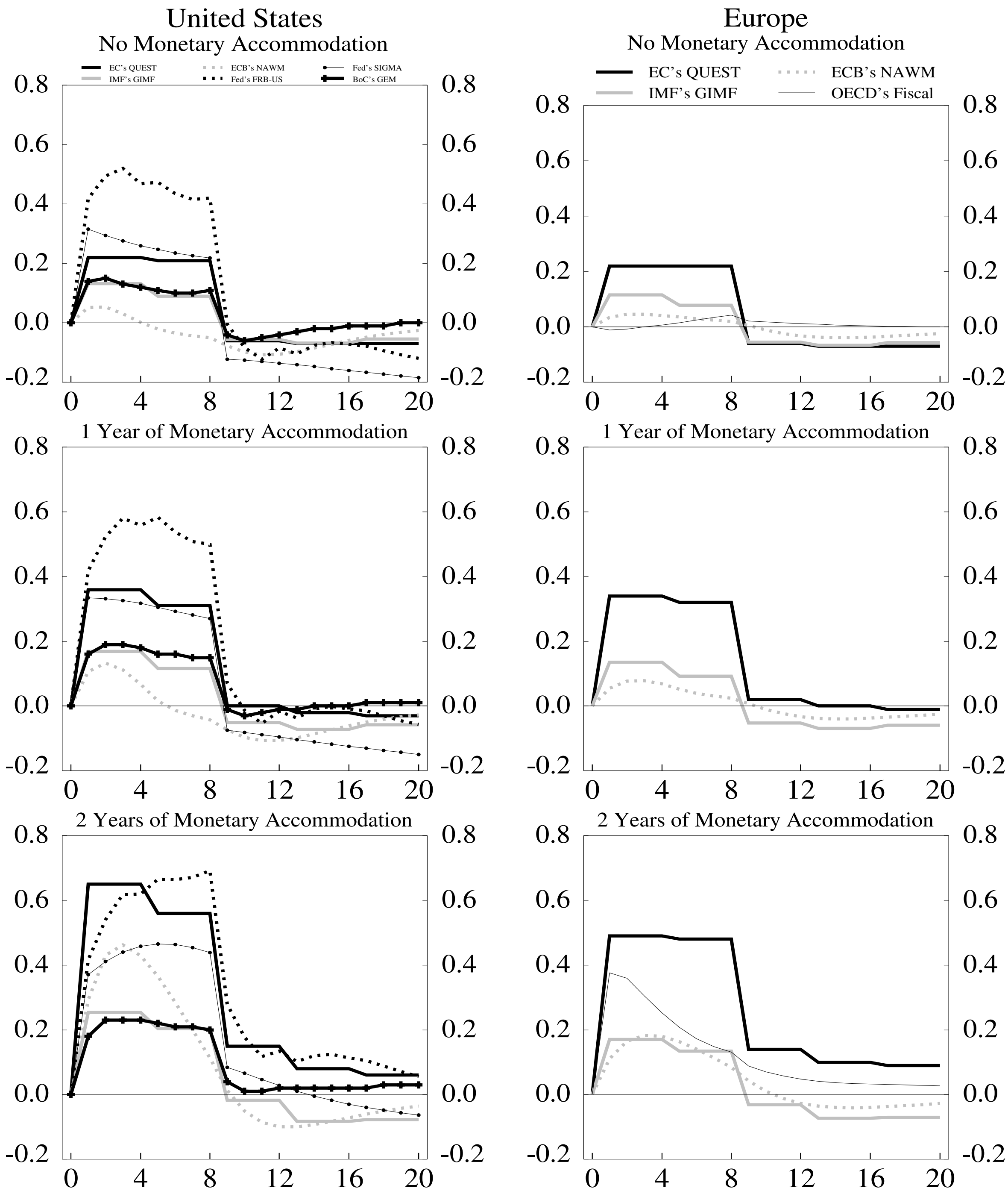

Figure 10: Instantaneous Fiscal Multipliers for 2-year Cut in Labor Income Tax

(Vertical axis in percent; horizontal axis in quarters)

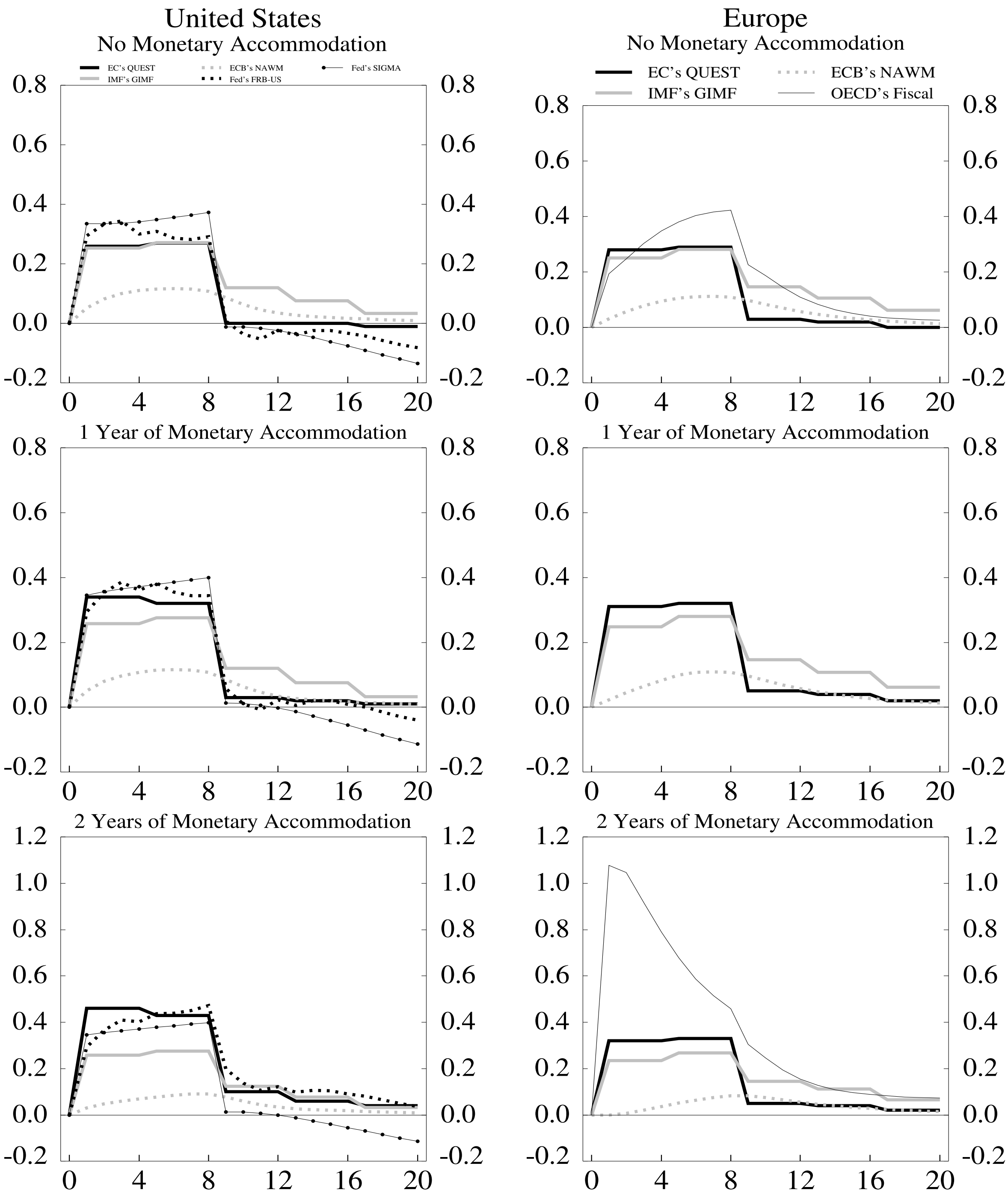

Figure 11: Instantaneous Fiscal Multipliers for 2-year Cut in Consumption Tax

(Vertical axis in percent; horizontal axis in quarters)

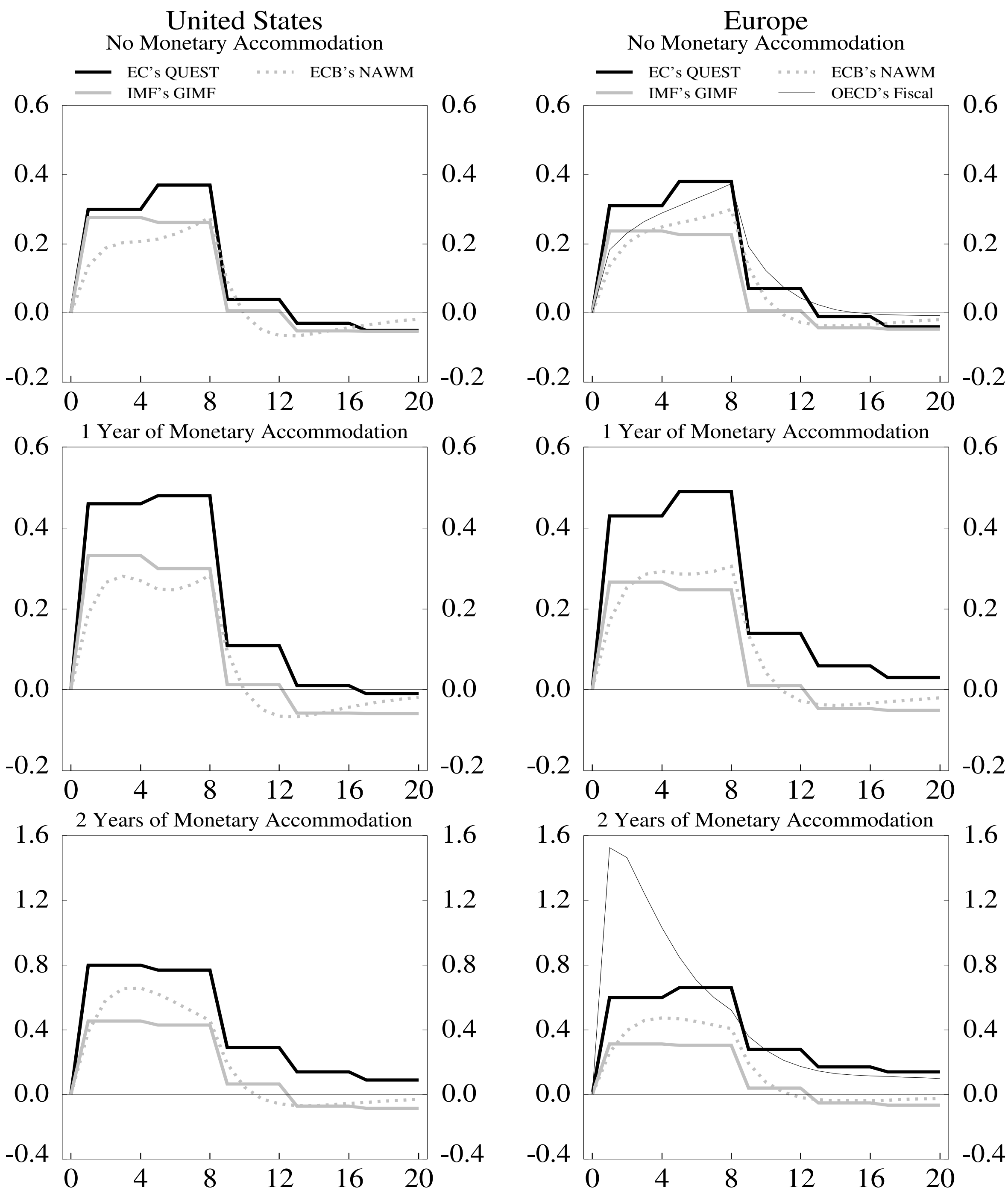

Figure 12: Instantaneous Fiscal Multipliers for 2-year Cut in Corporate Income Tax

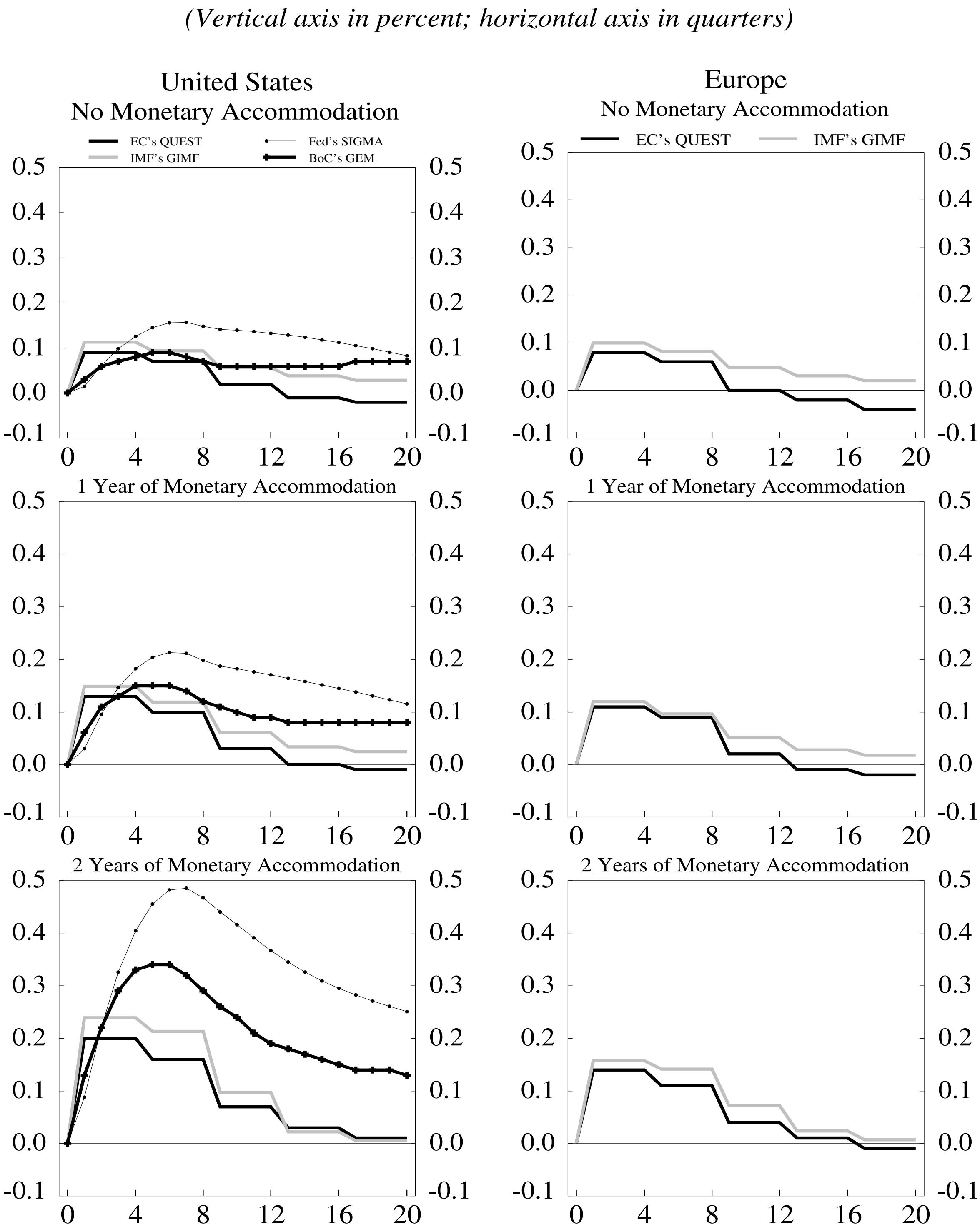

Figure 13: Instantaneous Fiscal Multipliers for 2-year Increase in Targeted Transfers

(Vertical axis in percent; horizontal axis in quarters)

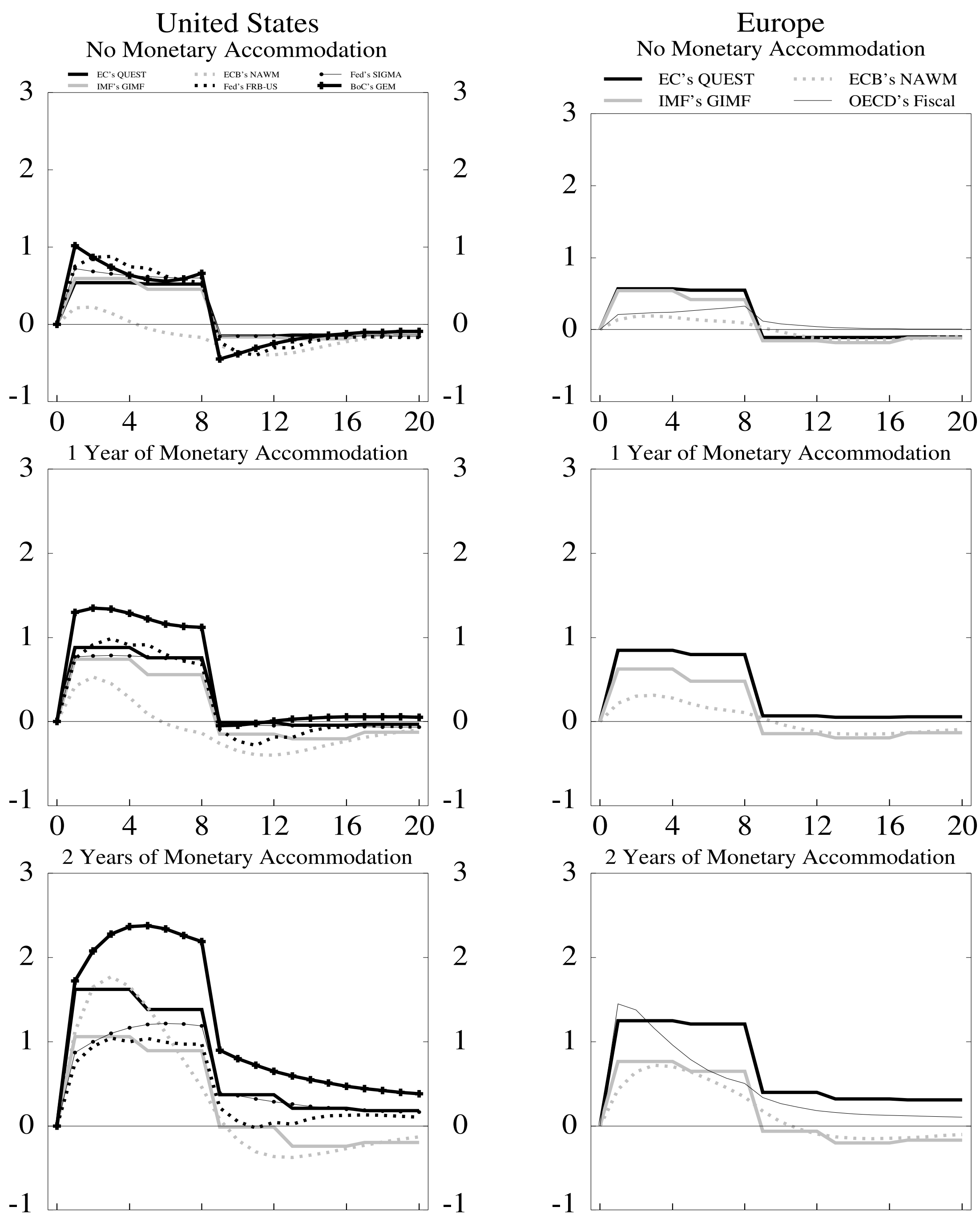

Figure 14: Instantaneous Fiscal Multipliers for Permanent Increase in Government Consumption

(Vertical axis in percent; horizontal axis in quarters)

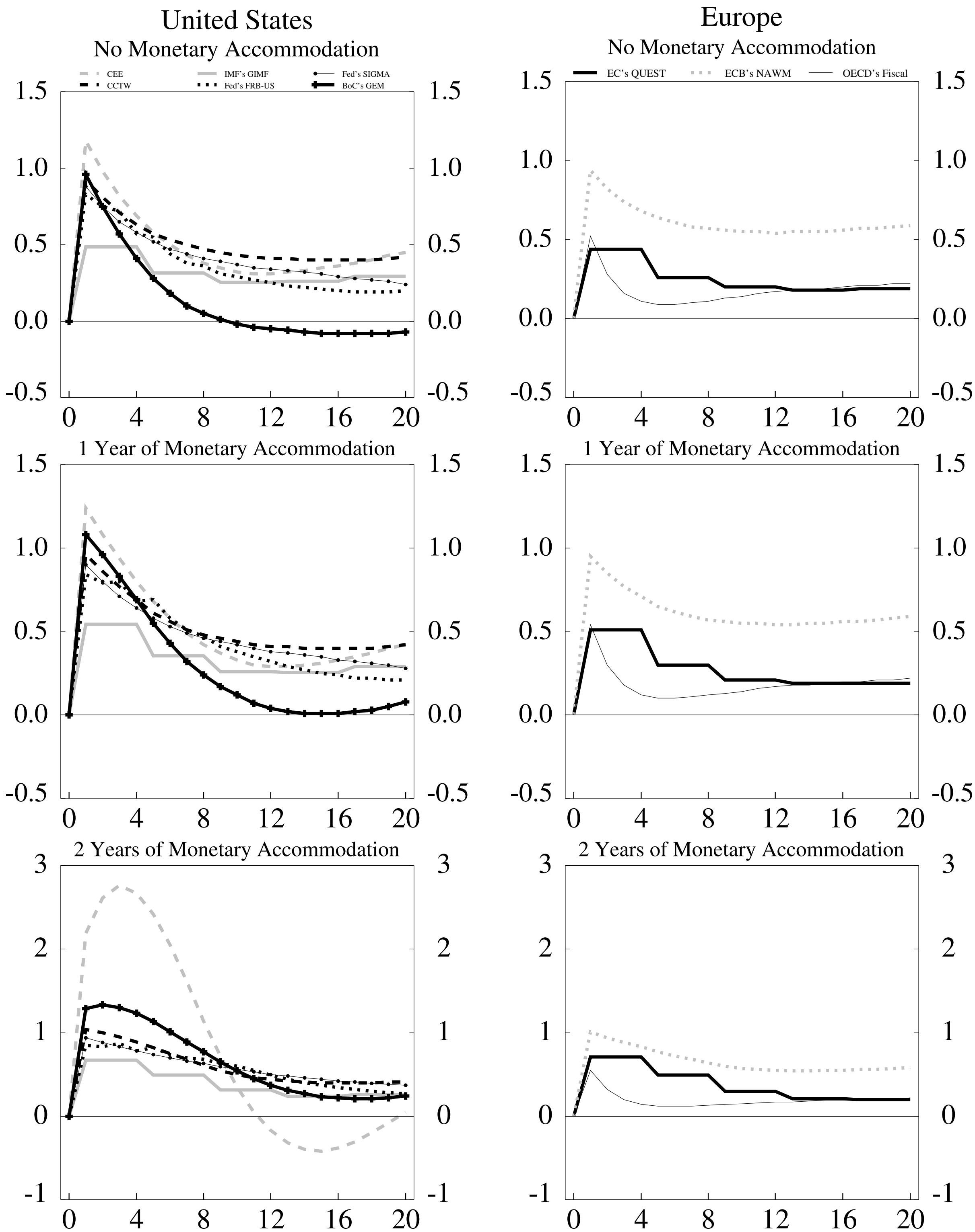

Figure 15: Cumulative Fiscal Multipliers for Permanent Increase in Government Consumption

(Vertical axis in percent; horizontal axis in quarters)

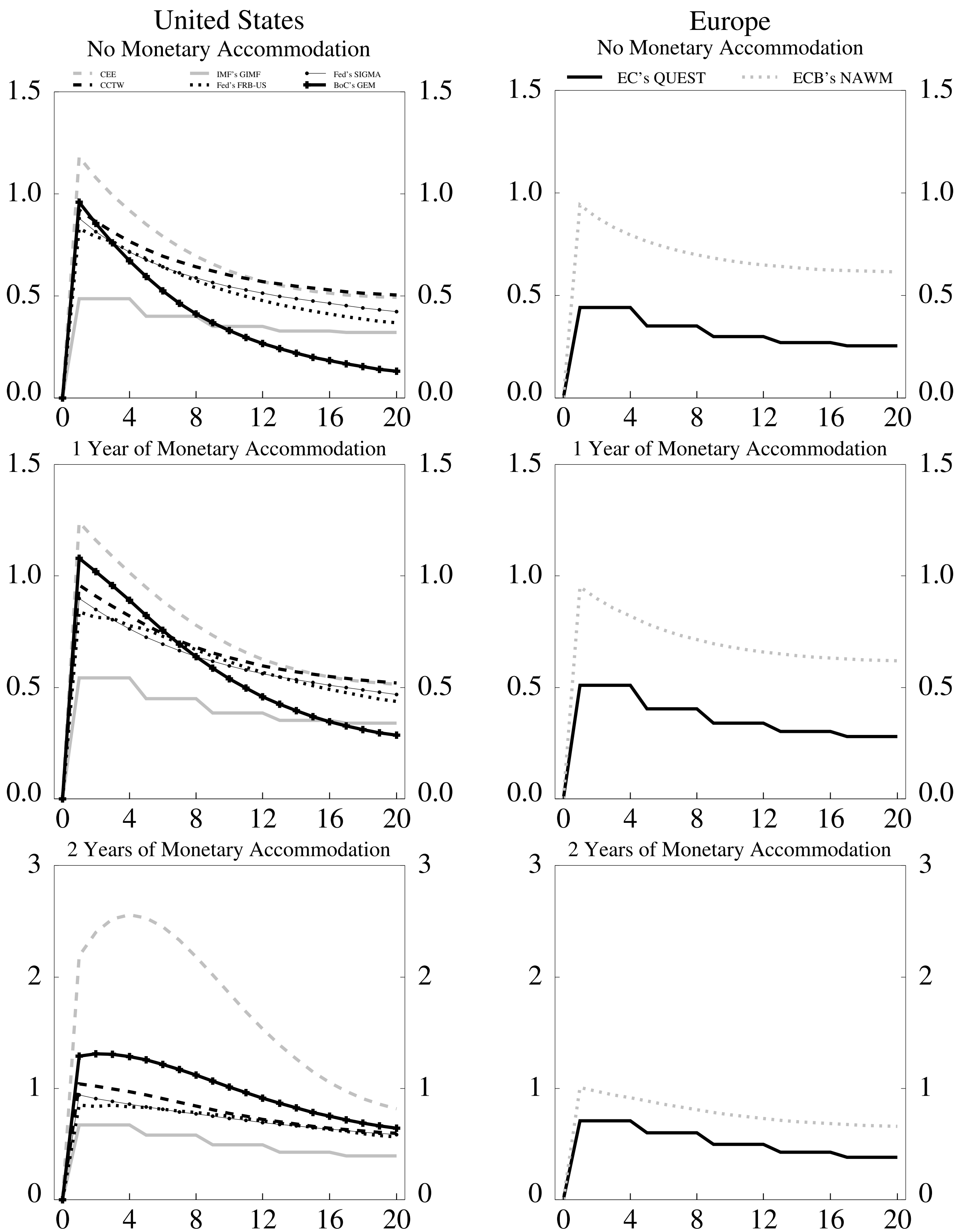

Table 1: Key Model Features[1]

Regional Decomposition

	CEE	BoC-GEM	FRB-US	GIMF	OECD Fiscal	NAWM	QUEST	SIGMA
# of Regions	1	6	1	5	1	2	4	2
Regions	U.S.	U.S., commodity exporters, Canada, Japan, emerging Asia, remaining countries	U.S.	U.S., Japan, euro area, emerging Asia, remaining countries	Euro area	Euro area, U.S.	U.S., euro area, rest of EU, remaining countries	U.S., remaining countries

Household Types[2]

	CEE	BoC-GEM	FRB-US	GIMF	OECD Fiscal	NAWM	QUEST	SIGMA
Household Types	Infinite horizon	1. Infinite horizon 2. "Liquidity-Constrained"	1. Infinite horizon 2. "Hand-to-mouth"	1. Overlapping generations 2. "Hand-to-mouth"	1. Infinite horizon 2. "Hand-to-mouth"	1. Infinite horizon 2. "Liquidity-Constrained" (but with access to real balances)	1. Infinite horizon 2. Collateral-constrained 3. "Hand-to-mouth"	1. Infinite horizon 2. "Hand-to-mouth"
Population Share of Liquidity-Constrained or Hand-to-Mouth Households	0%	15%-25% dep. on region; 50% in em. Asia (2-4% of steady-state private consumption; 15% in em. Asia)	No population shares (29% of steady-state private consumption)	25% in advanced economies, 50% elsewhere (21% of steady-state private consumption, 43% in em. Asia, rem. countries)	25% (18% of steady-state private consumption)	25% (20% of steady-state private consumption)	20% collateral-constrained, 20% "hand-to-mouth" (17% and 17% of steady-state private consumption)	47% (22% of steady-state private consumption)

[1] All of the policy models are calibrated, except for FRB-US, which is estimated equation-by-equation. CEE is estimated using impulse-response matching.
[2] "Liquidity-constrained" households make an intratemporal consumption-leisure decision. "Hand-to-mouth" households take labor income as given and determine consumption as a residual from their budget constraint.

Preferences[3]

	CEE	BoC-GEM	FRB-US	GIMF	OECD Fiscal	NAWM	QUEST	SIGMA
Preferences	Separable. Log consumption, quadratic labor disutility, CRRA money	Greenwood, Hercowitz and Huffman, AER, 1988	Separable. Permanent income/wealth specification	King, Plosser and Rebelo, JME, 1988a,b, adapted to OLG framework	King, Plosser and Rebelo, JME 1988a,b	Separable. CRRA consumption, constant Frisch elasticity in labor disutility	Separable. CRRA consumption, constant Frisch elasticity in labor disutility, log housing services	Separable. CRRA consumption, CRRA leisure, CRRA money
Habit Formation	Consumption	Leisure and consumption	Adjustment costs for nondurables (implications similar to habit formation)	Consumption	Consumption	Consumption	Consumption	Consumption
Role of Money	Money separably in utility function	None	None	None	None	Transaction services technology	None	Money separably in utility function

[3] All of the models feature exogenous discount factors.

Production and Market Structure[4]

	CEE	BoC-GEM	FRB-US	GIMF	OECD Fiscal	NAWM	QUEST	SIGMA
Sectors (TG=Tradables; NTG=Nontradables; INT=Intermediates; FIN=Final Goods)	1	5 INT: TG, NTG, oil, fuel, commodity. 3 FIN NTG: C,I,G (all using INT imports).	Hybrid: One production function, many relative prices.	2 INT: TG, NTG (all using INT imports). 3 FIN TG: C, I, G (all using FIN imports).	1	1 INT: TG. 3 FIN NTG: C, I, G (C and I using INT imports).	3 sectors: TG, NTG, construction. Input-output intermediates trade between sectors.	1 INT: TG. 3 FIN NTG: C,I,G (all using INT imports).
Production Functions	Intermediates: Cobb-Douglas. Final goods: CES.	Intermediates: CES. Final goods: CES.	Cobb-Douglas.	Intermediates: CES. Final goods: CES.	Intermediates: Cobb-Douglas. Final goods: CES.	Intermediates: Cobb-Douglas. Final goods: CES.	CES nesting Cobb-Douglas on value added and CES on intermediate inputs.	Intermediates: Cobb-Douglas. Final goods: CES.
Factor Adjustment Costs in Optimal Input Choice	None	Capital, labor, and fixed factors in oil and commodities	Labor	None	None	None	Labor	None
Market Structure	Intermediates: Monopolistic competition. Final goods: Perfect competition.	Intermediates: Monopolistic competition. Final goods: Perfect competition.	Monopolistic competition (implicit)	Intermediates: Monopolistic competition. Final goods: Monopolistic competition.	Intermediates: Monopolistic competition. Final goods: Monopolistic competition.	Intermediates: Monopolistic competition. Final goods: Perfect competition.	Tradables: Monopolistic competition. Non-tradables: Monopolistic competition.	Intermediates: Monopolistic competition. Final goods: Perfect competition.

[4] All models except BoC-GEM and SIGMA feature variable capacity utilization.

Nominal, Real and Financial Frictions[5]								
	CEE	**BoC-GEM**	**FRB-US**	**GIMF**	**OECD Fiscal**	**NAWM**	**QUEST**	**SIGMA**
Price Rigidity	Calvo with full indexation to past price inflation	Adjustment costs on price inflation (relative to a combination of past and target inflation)	Adjustment costs on both price level and price inflation	Adjustment costs on price inflation	Adjustment costs on price inflation	Calvo with indexation to a combination of past and steady state price inflation	Adjustment costs on price inflation	Calvo with indexation to a combination of past and steady state price inflation
Wage Rigidity	Calvo with full indexation to past price inflation	Adjustment costs on wage inflation (relative to a combination of past and target wage inflation)	Adjustment costs on both wage level and wage inflation	Adjustment costs on wage inflation	Adjustment costs on wage inflation	Calvo with indexation to a combination of past or steady state price inflation	Adjustment costs on wage inflation	Calvo with indexation to a combination of past or steady state wage inflation
Expenditure Adjustment Costs	Investment	Investment, import share	Consumption, investment, housing investment	Consumption, investment, import share	Consumption, investment, import share	Consumption, investment, import share	Investment, housing investment	Investment, import share
Time-to-Build / Time-to-Plan	One quarter	No	One to two quarters	One quarter	One quarter	One quarter	No	One quarter
Financial Accelerator[6]	Fin. inter-mediaries provide working cap. to firms	No	Yes: Spreads endogenous to business cycle	Yes	Yes	No	Yes (collateral constraints for household borrowers)	Yes

[5] In addition to the adjustment costs listed here, QUEST features adjustment costs on house prices and land prices.
[6] None of the models has a formal banking sector. All financial frictions are related solely to a financial accelerator mechanism on corporate or household balance sheets.

Fiscal Structure

	CEE	BoC-GEM	FRB-US[7]	GIMF	OECD Fiscal	NAWM	QUEST	SIGMA
Consumption Taxes	No	No	Yes	Yes	Yes	Yes	Yes	No
Labor Income Taxes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capital Income Taxes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Property Taxes	No	No	No	No	No	No	Yes	No
Transfers (LIQ=liq. constrained; HTM=hand-to-mouth; CC=credit constrained)	Lump-sum	Lump-sum and targeted (to LIQ households)	Lump-sum	Lump-sum and targeted (to HTM households)	Lump-sum and targeted (to HTM households)	Lump-sum and targeted (to LIQ households)	Lump-sum and targeted (to CC & HTM households)	Lump-sum and targeted (to HTM households)
Productive Government Investment[8]	No	Yes (increases TFP in all sectors)	No	Yes (increases TFP in final goods)	Yes (increases TFP in final goods)	Yes (increases TFP in intermediates)	Yes (increases TFP in tradables and nontradables)	No
Special Fiscal Instruments	None	None	Social security taxes, investment tax credits	None	None	Social security contributions	Unemployment benefits, investment subsidies	None
Fiscal Rule for Stationary Debt	No	Lump-sum taxes react to debt	Personal income tax rates react to debt and/or deficit	Lump sum taxes react to deficit	Lump sum taxes react to deficit	Lump-sum taxes react to debt	Tax rate on labor income reacts to debt and/or deficit	Tax rate on labor income reacts to debt and deficit
Risk Premium on Domestic Interest Rates	No	Exogenous, applies to government debt	Endogenous to state of business cycle	Endogenous changes in the interest rate due to changes in gov't debt	Endogenous changes in the interest rate due to changes in gov't debt	No	Endogenous sovereign risk premium	No

[7] FRB-US also includes public workers as a separate part of the labor force, a feature unique to this model.
[8] All models feature wasteful government spending. The models indicated in this row feature productive government investment in addition to wasteful government spending.

Other General Features

	CEE	BoC-GEM	FRB-US	GIMF	OECD Fiscal	NAWM	QUEST	SIGMA
Monetary Policy Rule	Taylor rule	Forward-looking interest rate rule with smoothing	Taylor rule (1999 version)	Forward-looking interest rate rule with smoothing	Forward-looking interest rate rule with smoothing	Taylor (1993) rule	Taylor rule with smoothing	Contemp. interest rate rule with smoothing
Stationarity of Net Foreign Assets	Not needed (closed economy)	Financial intermediation costs in UIP condition sensitive to net foreign assets	Term premium in UIP condition sensitive to net foreign assets	Automatic due to OLG structure	Not needed (closed economy)	Financial intermediation costs in UIP condition sensitive to net foreign assets	Financial intermediation costs in UIP condition sensitive to net foreign assets	Financial intermediation costs in UIP condition sensitive to net foreign assets

References

	CEE	BoC-GEM	FRB-US	GIMF	OECD Fiscal	NAWM	QUEST	SIGMA
	Christiano, Eichenbaum and Evans (2005)	Lalonde and Muir (2007)	Brayton and Tinsley (1996)	Kumhof, Laxton, Muir and Mursula (2010), Kumhof and Laxton (2010)	Furceri and Mourougane (2010)	Coenen, McAdam and Straub (2008)	Ratto, Roeger, and in't Veld (2009), Roeger and in't Veld (2009, 2010)	Erceg, Guerrieri and Gust (2005), Gust, Leduc and Sheets (2009), Erceg and Lindé (2010a,b)

Table 2: Some Key Model Parameters[1]

Monetary Policy Rule Coefficients								
	CEE	**BoC-GEM**	**FRB-US**	**GIMF (annual freq.)**	**OECD Fiscal**	**NAWM**	**QUEST**	**SIGMA**
Lagged Int. Rate	0.8	0.95	0	0.3	0.9	0	0.82	0.7
Long-Run Weight on CPI Inflation	1.5	1.9	1.5	2.0 in US, RC; 2.5 EU; 1.9 JA	1.5	1.5	2	2
Contemporaneous or Lead on CPI Inflation	1-qtr-ahead (qu.-on-qu. inflation)	1-year-ahead (yr-on-yr inflation)	Cont.	Weighted avg. of cont. and 1-year-ahead	Cont. (yr-on-yr inflation)	Cont. (yr-on-yr inflation)	Cont. (yr-on-yr inflation)	Cont. (qu-on-qu inflation)
Weight on Output Gap	0.1	0	1.0	0	0.5	0.5	0.05	0
Weight on GDP Growth	0	0.25 in US; 0 elsewhere	0	0	0	0	0	0.25
Weight on Nom. Exchange Rate	-	100000 in AS, 0 elsewhere	0	100000 in AS, 0 elsewhere	-	0	0	0

Fiscal Rule Coefficients								
	CEE	**BoC-GEM**	**FRB-US**	**GIMF (annual)**	**OECD Fiscal**	**NAWM**	**QUEST**	**SIGMA**
Targeting or Instrument Rule	-	Instrument rule. Lump-sum taxes respond to debt-to-GDP ratio.	Instrument rule. Labor income taxes respond, with smoothing, to deficit- and/or debt-to-GDP ratio	Targeting rule. Deficit-to-GDP ratio responds to output gap. Lump-sum taxes adjust.	Instrument rule. Lump-sum taxes respond to deficit.	Instrument rule. Lump-sum taxes respond to debt-to-GDP ratio.	Instrument rule. Labor income taxes respond to deficit- and/or debt-to-GDP ratio.	Instrument rule. Labor income taxes respond, with smoothing, to deficit- and/or debt-to-GDP ratio.

[1] For a more complete presentation of the model parameters, readers are referred to the Online Appendix, found on the AEJ-Macro website.

Households and Household Preferences								
	CEE	**BoC-GEM**	**FRB-US**	**GIMF (annual)**	**OECD Fiscal**	**NAWM**	**QUEST**	**SIGMA**
Households' Planning Horizon	Infinite	Infinite	Infinite	20 years	Infinite	Infinite	Infinite	Infinite
Intertemporal Elasticity of Sub. in Consumption	1	0.71	0.3 (implicit)	0.25	0.24	0.5	0.25	0.5
Share of Hand-to-Mouth / Liquidity-Constrained	0	0.5 AS; 0.15 US; 0.20 CA, JA; 0.25 elsewhere	0.40 (nondurable consumption only)	0.5 AS, RC; 0.25 elsewhere	0.25	0.25	0.2	0.47
Share of Credit-Constrained	0	0	0	0	0	0	0.2	0

Price/Wage Adjustment Costs								
	CEE	**BoC-GEM**	**FRB-US**	**GIMF (annual)**	**OECD Fiscal**	**NAWM**	**QUEST**	**SIGMA**
Calvo or Adjustment Costs	Calvo	Adjustment Costs	Adjustment Costs	Adjustment Costs	Calvo	Calvo	Adjustment Costs	Calvo
Sticky Prices, Sticky Inflation (indexation or infl. adj. costs), or Hybrid	Sticky inflation	Sticky inflation (price indexation=0.5; wage indexation=0.5)	Sticky inflation	Sticky inflation	Sticky inflation	Hybrid (price indexation=0.5; wage indexation=0.75)	Sticky inflation	Hybrid (price indexation=0.75; wage indexation=0.75)

Risk Premia								
	CEE	**BoC-GEM**	**FRB-US**	**GIMF**	**OECD Fiscal**	**NAWM**	**QUEST**	**SIGMA**
UIP Risk Premium	-	Yes (small)	Yes (small)	No	No	Yes (small)	Yes (small)	Yes (small)
Government Debt Risk Premium	No	No	No	No	No	No	Yes (3 bp per 1 pp gov. debt)	No

Table 3
Average First-Year Instantaneous Multipliers From Different Types of Fiscal Stimulus[1]

		US	EU
Gov. Consumption:	2 Years, 2-Year Accommodation	1.55	1.52
	1 Year, 2-Year Accommodation	1.20	0.90
Gov. Investment		1.59	1.48
Targeted Transfers		1.30	1.12
Consumption Taxes		0.61	0.66
General Transfers		0.42	0.29
Corporate Income Taxes		0.24	0.15
Labor Income Taxes		0.23	0.53

Table 4
First-Year Multipliers for Different Persistence of Fiscal Stimulus[2]
(increase in government consumption by 1% of baseline GDP,
with 2 years of global monetary accommodation)

	1 Year	2 Years	3 Years	4 Years	5 Years
GIMF	1.18	1.41	1.45	1.33	1.16
SIGMA	1.08	1.40	1.45	1.38	1.25
NAWM	1.15	1.22	0.98	0.81	0.71
BoC-GEM	1.31	2.12	2.58	1.91	1.35

Table 5
Sensitivity Analysis for US versus EU Multipliers in GIMF[3]
(2-year increase in government consumption by 1% of baseline GDP,
with 2 years of global monetary accommodation)

	US	EU
Original Calibration	1.32	0.94
50% Lower Trade Openness in EU	...	1.11
50% Higher Nominal Rigidities in US	1.24	...
44% Higher Automatic Stabilizers in US	1.28	...

[1] All multipliers are averages, across the models, of the first-year effects on real GDP of fiscal stimulus lasting for two years, with two years of monetary accommodation globally, except where otherwise specified.

[2] All multipliers are for the United States, with the exception of the ECB's NAWM, where the multipliers are for the euro area.

[3] All reported multipliers are the average response of real GDP over the first two years.

Table 6: Steady State Effects of a Permanent 10 Percentage Point Increase in the U.S. Government Debt to GDP Ratio in GIMF[4]

	US	RoW	Global
Financed by a Cut in General Transfers			
Real GDP	-0.18	-0.22	-0.21
Real Exchange Rate	0.18	-0.18	...
Real Interest Rate	0.10	0.10	0.10
Current Account to GDP	-0.34	0.10	...
Investment	-0.44	-0.48	-0.47
Goverment Deficit to GDP	0.48	0.00	0.11
Private Saving to GDP	0.10	0.04	0.06
General Transfers to GDP	-0.14	-0.07	-0.08
Financed by an Increase in Consumption Taxes			
Real GDP	-0.26	-0.22	-0.23
Real Exchange Rate	0.15	-0.15	...
Real Interest Rate	0.10	0.10	0.10
Current Account to GDP	-0.34	0.10	...
Investment	-0.51	-0.49	-0.49
Goverment Deficit to GDP	0.48	0.00	0.11
Private Saving to GDP	0.09	0.04	0.06
Consumption Tax Rate	0.28	0.00	0.06
Financed by an Increase in Corporate Income Taxes			
Real GDP	-0.64	-0.22	-0.31
Real Exchange Rate	-0.03	0.03	...
Real Interest Rate	0.09	0.09	0.09
Current Account to GDP	-0.32	0.09	...
Investment	-1.76	-0.47	-0.75
Goverment Deficit to GDP	0.48	0.00	0.11
Private Saving to GDP	-0.03	0.04	0.03
Corporate Income Tax Rate	1.27	0.00	0.28
Financed by an Increase in Labor Income Taxes			
Real GDP	-0.35	-0.24	-0.26
Real Exchange Rate	0.13	-0.13	...
Real Interest Rate	0.11	0.11	0.11
Current Account to GDP	-0.37	0.11	...
Investment	-0.62	-0.53	-0.55
Goverment Deficit to GDP	0.48	0.00	0.11
Private Saving to GDP	0.06	0.05	0.05
Labor Income Tax Rate	0.35	0.00	0.08

[4] Real GDP, the real exchange rate, and investment are in percent deviations from the baseline. All other variables are in percentage point deviations from the baseline.