The Fiscal Multiplier Morass: A Bayesian Perspective

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Abstract

A Bayesian prior predictive analysis is conducted on a suite of models to assess the probability that a model and corresponding prior distributions bias results toward a specific range of fiscal multipliers. We examine a wide range of DSGE models commonly used to estimate fiscal multipliers, including a real business cycle model, a New Keynesian model with nominal and real rigidities, and open economy models. We decompose changes in multipliers across models into wealth and substitution effects, allowing for a more uniform comparison across models. Through the prior predictive analysis, we show that many of the models and prior distributions impose a very tight range for the multiplier before the models are taken to data. We argue that constraining the multiplier to such a tight range prior to conditioning on data is tantamount to biasing results. A broader message of the paper calls for employing prior predictive analysis when estimating DSGE models.

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1 Introduction

Fiscal multipliers measure the ratio of a change in output (or consumption or investment) to an exogenous change in the fiscal deficit, such as a change in government spending or tax revenue. Depending on the time frame considered, multipliers quantify the impact of discretionary fiscal actions or the cumulative effects of discretionary policy over longer horizons. Following the 2008 and 2009 fiscal stimulus packages and financial rescue programs, much policy debate and academic research has centered on the size of fiscal multipliers.

A recent survey calculates government spending multipliers for seven different structural models and concludes that fiscal policy is robustly found to have sizeable[1] output multipliers across all models (see Coenen, Erceg, Freedman, Furceri, Kumhof, Lalonde, Laxton, Linde, Mourougane, Muir, Mursula, Resende, Roberts, Roeger, Snudden, Trabandt, and in't Veld (2010), hereafter referred to as IMF10/73). In addition, cumulative output multipliers remain positive, albeit small, in most of the models considered. These results suggest that fiscal stimulus has sizable positive effects. However, differing conclusions of other studies suggest a "multiplier morass" in the literature. Many papers that use similarly estimated or calibrated models and analogous data as IMF10/73 reach markedly different conclusions. Cogan, Cwik, Taylor, and Wieland (2010) and Cwik and Wieland (forthcoming) conclude that impact output multipliers are substantially smaller than one. Uhlig (2010) and Uhlig and Drautzburg (2011) conclude that multipliers are often negative over longer horizons.

Why do DSGE models estimated or calibrated with similar data yield very different conclusions about the size of the multiplier? Like many statistics reported in the macroeconomic literature, multipliers are conditional statistics, and different model specifications can deliver contrasting multipliers. An important quantitative question remains and is the focus of this paper: To what extent does a DSGE model *force* a particular multiplier range on the data? That is, before taking the model to data, will the model (and prior) specification bias the results in a particular way? We argue that a simple prior predictive analysis, well known in the Bayesian literature,[2] is needed to illuminate the extent to which the model *a priori* imposes an answer to the economic question at hand.

We examine fiscal multipliers in five nested models: (1) a simple real business cycle (RBC) model, (2) the RBC model with real frictions added, (3) the RBC model with nominal rigidities included (i.e. a basic New Keynesian model), (4) the New Keynesian model with hand-to-mouth agents, and (5) the New Keynesian model extended to an open economy framework. We use the nested models to show explicitly which features are most important for the fiscal multipliers. We find that real and nominal frictions, rule of thumb consumers, and open economy considerations are instrumental for determining fiscal multipliers. Nominal rigidities and rule of thumb consumers are key to achieving long run positive output multipliers. Although the model can produce output multipliers greater than one, it is difficult for any of the model specifications to produce substantially large multipliers. In addition, model restrictions often impose a priori a tight range of values for multipliers. The result highlights the importance of prior predictive analysis, as the tight multiplier range often imposed by models prior to conditioning on data is tantamount to biasing results.

Several recent papers emphasize important features of DSGE models that influence fiscal

[1] That is, impact output multipliers larger than one.

[2] Lancaster (2004) and Geweke (2005) provide textbook treatments.

multipliers. The extent of hand-to-mouth agents (also known as liquidity-constrained or rule-of-thumb agents) is crucial for the qualitative response of consumption following discretionary policy changes [see Gali, Lopez-Salido, and Valles (2007) and Forni, Monteforte, and Sessa (2009)]. Distortionary fiscal financing creates costly disincentive effects that can decrease multipliers [see Uhlig (2010) and Leeper, Plante, and Traum (2010)]. In addition, multipliers depend on monetary accommodations and fiscal-monetary interactions [see Bilbiie, Meier, and Muller (2008), Davig and Leeper (2009), Christiano, Eichenbaum, and Rebelo (2009), and Eggertsson (2009)].

As noted in IMF10/73, "there is no such thing as a simple fiscal multiplier" because multipliers depend on a number of factors. Including these various elements in a model incurs a cost: models quickly become large and intractable. Most DSGE models used for policy analysis take on an impenetrability of a "black box," making it difficult (without some additional work) to determine to what extent a model forces a particular multiplier. Bayesian methodology offers an ideal approach to address these issues. With prior predictive analysis, one can evaluate a model before taking it to data with little or no additional computational cost. Moreover, one can determine the entire range of multipliers allowed by the model specification. Following Geweke (2010), we argue that prior predictive analysis is important for *any* macroeconomic question in which DSGE models are employed, whether or not Bayesian estimation is used.

2 Model

Our model shares several salient details with the class of models used to evaluate the size of fiscal multipliers: (1) forward-looking, optimizing agents, (2) households who receive utility from consumption and leisure, (3) production sectors that utilize capital and labor inputs, (4) monopolistic competition in the goods and labor sectors, (5) empirically relevant nominal and real frictions, and (6) a fiscal and monetary authority. The monetary and fiscal authorities set their respective instruments using simple feedback rules.

Our main model, a standard open economy New Keynesian model similar to Adolfson, Laseen, Linde, and Villani (2007), nests four models that are commonly used in the literature when examining fiscal multipliers—a basic Real Business Cycle (RBC) model, an RBC model with real frictions, a standard New Keynesian (NK) model, a NK model with nonsavers. Only in the very simple models are analytical results for fiscal multipliers obtainable [Woodford (2011), Uhlig (2010)]. But these models tradeoff tractability for empirical plausibility. Sequential model building, coupled with prior predictive analysis, allows us to systematically isolate the important aspects of each model, even when the model is sufficiently rich to match important aspects of data. Thus, we are able to make precise statements about how certain frictions or policy parameters change the multiplier in empirically relevant models. We now describe the main model and discuss the restrictions that deliver the nested models below.

The world economy consists of two large countries, Home (H) and Foreign (F), with symmetric preferences. Public and private consumption and investment consist of domestically produced and imported goods. In the short run, the pass-through of the nominal exchange rate to export and import prices is incomplete due to local currency pricing. Financial markets are assumed to be complete.

2.1 Households Each economy is populated by a continuum of households on the interval $[0,1]$, of which a fraction μ are non-savers and a fraction $1-\mu$ are savers. The superscript S indicates a variable associated with savers and N with non-savers.

2.1.1 Savers An optimizing representative saver household j derives utility from consumption, $c_t^S(j)$, relative to a habit stock in terms of aggregate consumption from the previous period ($\theta_c C_{t-1}^S$ where $\theta_c \in [0,1)$), and derives disutility from hours worked, $l_t^S(j)$:

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{(c_t^S(j) - \theta_c C_{t-1}^S)^{1-\gamma}}{1-\gamma} - \frac{l_t^S(j)^{1+\xi}}{1+\xi} \right]. \tag{1}$$

where β is the discount rate, γ the household's risk aversion, and ξ is the inverse of the Frisch labor elasticity. The flow budget constraint for saver j is given by

$$\begin{aligned} P_t^C(1+\tau_t^c)c_t^S(j) + P_t^I i_t^S(j) + b_t^S(j) &= R_{t-1}b_{t-1}^S(j) + (1-\tau_t^l)\int_0^1 W_t(l) l_t^S(j,l)dl \\ &+ (1-\tau_t^k)R_t^k v_t(j)\bar{k}_{t-1}^S(j) - \psi(v_t)\bar{k}_{t-1}^S + P_t^C Z_t^S(j) + D_t(j) \end{aligned} \tag{2}$$

$W_t(l)$ is the nominal wage rate for labor input l, and $\int_0^1 w_t(l) l_t^S(j,l)dl$ is the total real labor income for household j.

The cost of capital utilization is $\psi(v_t)$ per unit of physical capital. In the steady state, we assume $v=1$ and $\psi(1)=0$. We define a parameter $\psi \in [0,1)$ such that $\frac{\psi''(1)}{\psi'(1)} \equiv \frac{\psi}{1-\psi}$. As $\psi \to 1$, the utilization cost becomes infinite, and the capital utilization rate becomes constant. The law of motion for capital is given by

$$\bar{k}_t^S(j) = (1-\delta)\bar{k}_{t-1}^S(j) + \left[1 - \Gamma_i\left(\frac{i_t^S(j)}{i_{t-1}^S(j)}\right)\right] i_t^S(j) \tag{3}$$

where $\Gamma_i(\cdot)\, i_t^S$ is an investment adjustment cost, as in Smets and Wouters (2003) and Christiano, Eichenbaum, and Evans (2005) and satisfies $\Gamma_i(1) = s'(1) = 0$, and $s''(1) \equiv s > 0$. Therefore, as $s \to 0$, investment costs decrease.

2.1.2 Wage Setting and Labor Aggregation To introduce wage rigidities, we assume households supply differentiated labor services to the intermediate goods producing firms. A perfectly competitive labor packer purchases the differentiated labor inputs and assembles them to produce a composite labor service L_t according to

$$L_t = \left[\int_0^1 l_t(l)^{\frac{1}{1+\eta^w}} dl\right]^{1+\eta^w}, \tag{4}$$

where η^w denotes the wage markup.

The demand function for a competitive labor packer can be derived from solving the profit maximization problem subject to (4), which yields

$$l_t(l) = L_t^d \left(\frac{W_t(l)}{W_t}\right)^{-\frac{1+\eta^w}{\eta^w}}, \tag{5}$$

where L_t^d is the demand for composite labor services, and W_t is the aggregate nominal wage.

Substantial variation in modeling wage-setting decisions exists in the literature.[3] We follow the conventional approach of assuming savers optimally set their wage while non-savers simply set their wage to be the average wage of the savers. Since non-savers face the same labor demand schedule as savers, they work the same number of hours as the average for savers.

In each period, each member of a saver household receives a signal to reset its nominal wage with probability $(1-\omega_w)$. Those who cannot reoptimize partially index their wages to past inflation according to the rule

$$W_t(l) = W_{t-1}(l)\,\pi_{t-1}^{\chi^w}, \tag{6}$$

where $\chi^w \in [0,1]$ measures the degree of backward indexation. Savers that receive the signal choose the nominal wage rate $W_t(l)$ to maximize their utility. Finally, the nominal aggregate wage evolves according to

$$W_t = \left[(1-\omega_w)\widetilde{W}_t^{\frac{-1}{\eta^w}} + \omega_w\left(\pi^{1-\chi^w}\pi_{t-1}^{\chi^w}\right)^{\frac{-1}{\eta^w}} W_{t-1}^{\frac{-1}{\eta^w}}\right]^{-\eta^w}, \tag{7}$$

where $\widetilde{W}_t$ is the optimal nominal wage rate chosen by savers at time t.

2.1.3 Non-savers

Non-savers are assumed to have the same preferences as savers. We assume that non-savers are rule-of-thumb agents who must consume their entire disposable income each period. The budget constraint for the non-saver $j \in (\mu, 1]$ is

$$P_t^C c_t^N(j) = (1-\tau_t^L)W_t L_t^N(j) + P_t^C Z_t^N(j). \tag{8}$$

2.2 Firms and Price Setting

2.2.1 Intermediate Goods Firms

Each country consists of a continuum of monopolistically competitive intermediate goods firms (indexed by $i \in [0,1]$). These firms charge different prices at home and abroad, as in Betts and Devereux (1996). In the home market, the demand for firm i's output is given by

$$y_t^H(i) = Y_t^H\left(\frac{p_t^H(i)}{P_t^H}\right)^{-\frac{1+\eta_p}{\eta_p}} \tag{9}$$

where $\eta_p > 0$, $p_t^H(i)$ is the output price in the home market charged by firm i, Y_t^H is aggregate domestic demand, and P_t^H is the aggregate domestic price index. Likewise, in the foreign market, the demand for firm i's output is

$$m_t(i) = M_t^*\left(\frac{p_t^{H*}(i)}{P_t^{H*}}\right)^{-\frac{1+\eta_p}{\eta_p}} \tag{10}$$

[3] Variations in whether or not non-savers are allowed to optimally choose their wage and in how wages are chosen exist.

where $m_t(i)$ denotes the foreign quantity demanded of home good i, $p_t^{H*}(i)$ is the price that firm i charges in the foreign market, P_t^{H*} is the foreign import price index, and M_t^* denotes aggregate foreign imports.

Each individual firm i produces with a Cobb-Douglas technology

$$y_t(i) = A_t k_t(i)^\alpha l_t(i)^{1-\alpha} \tag{11}$$

where $\alpha \in [0, 1]$. Fixed costs of production are assumed to be zero, as in Del Negro, Schorfheide, Smets, and Wouters (2007). Firms face perfectly competitive factor markets for capital and labor. Cost minimization implies that the firms have identical nominal marginal costs per unit of output, given by

$$MC_t = (1-\alpha)^{\alpha-1}\alpha^{-\alpha}(R_t^k)^\alpha W_t^{1-\alpha} A_t^{-1} \tag{12}$$

Home and foreign prices evolve by a Calvo (1983) mechanism. An intermediate firm has a probability of $(1 - \omega_p)$ each period to reoptimize its price at home and a probability of $(1-\omega_{p,x})$ each period to reoptimize its price abroad. Those that cannot reoptimize partially index their prices to past inflation according to the rules

$$p_t^H(i) = \left(\pi_{t-1}^H\right)^{\chi_p}(\pi^H)^{1-\chi_p} P_{t-1}^H(i), \quad p_t^{H*}(i) = \left(\pi_{t-1}^{H*}\right)^{\chi_{p,x}}(\pi^{H*})^{1-\chi_{p,x}} P_{t-1}^{H*}(i) \tag{13}$$

where $\pi_{t-1}^H \equiv P_{t-1}^H/P_{t-2}^H$ and $\pi_{t-1}^{H*} \equiv P_{t-1}^{H*}/P_{t-2}^{H*}$.

Firms that are allowed to reoptimize their price in the domestic market in period t maximize

$$E_t \sum_{s=0}^{\infty}(\beta\omega_p)^s \frac{\lambda_{t+s}}{\lambda_t}\left[\left(\prod_{k=1}^{s}(\pi_{t+k-1}^H)^{\chi_p}(\pi^H)^{1-\chi_p}\right) p_t^H(i) y_{t+s}^H(i) - MC_{t+s} y_{t+s}^H(i)\right] \tag{14}$$

subject to (9). Firms that are allowed to reoptimize their price in the foreign market in period t maximize

$$E_t \sum_{s=0}^{\infty}(\beta\omega_{p,x})^s \frac{\lambda_{t+s}}{\lambda_t}\left[\left(\prod_{k=1}^{s}(\pi_{t+k-1}^{H*})^{\chi_{p,x}}(\pi^{H*})^{1-\chi_{p,x}}\right) p_t^{H*}(i)\tilde{S}_{t+s} m_{t+s}(i) - MC_{t+s} m_{t+s}(i)\right] \tag{15}$$

subject to (10). $\tilde{S}_t$ is the nominal exchange rate, expressed as the price of one domestic consumption basket in terms of foreign consumption.

2.2.2 Final Goods Firms

There are three distinct types of final-good firms which combine the domestically produced and imported intermediate goods to produce the three final non-tradable goods: a private consumption good, a private investment good, and a public consumption good.

The final private consumption good Q_t^C to produced via the technology

$$Q_t^C = \left[(1-\nu_C)^{\frac{1}{\mu_C}}(C_t^H)^{\frac{\mu_C-1}{\mu_C}} + \nu_C^{\frac{1}{\mu_C}}(C_t^F)^{\frac{\mu_C-1}{\mu_C}}\right]^{\frac{\mu_C}{\mu_C-1}} \tag{16}$$

where $\mu_C > 0$ is the elasticity of substitution between home and foreign goods, $\nu_C \in [0,1]$ determines the relative preference a country has for domestic and foreign goods, and

$$C_t^H = \left[\int_0^1 C_t^H(i)^{\frac{1}{1+\eta_p}} di\right]^{1+\eta_p}, \quad C_t^F = \left[\int_0^1 C_t^F(i^*)^{\frac{1}{1+\eta_{p,x}}} di\right]^{1+\eta_{p,x}} \tag{17}$$

where $\eta_p > 0$ is the elasticity of substitution between differentiated goods. Similarly, the final private investment good Q_t^I and the public consumption good Q_t^G are produced via the technologies

$$Q_t^I = \left[(1-\nu_I)^{\frac{1}{\mu_I}} (I_t^H)^{\frac{\mu_I - 1}{\mu_I}} + \nu_I^{\frac{1}{\mu_I}} (I_t^F)^{\frac{\mu_I - 1}{\mu_I}}\right]^{\frac{\mu_I}{\mu_I - 1}} \tag{18}$$

$$Q_t^G = \left[(1-\nu_G)^{\frac{1}{\mu_G}} (G_t^H)^{\frac{\mu_G - 1}{\mu_G}} + \nu_G^{\frac{1}{\mu_G}} (G_t^F)^{\frac{\mu_G - 1}{\mu_G}}\right]^{\frac{\mu_G}{\mu_G - 1}} \tag{19}$$

where

$$I_t^H = \left[\int_0^1 I_t^H(i)^{\frac{1}{1+\eta_p}} di\right]^{1+\eta_p}, \quad I_t^F = \left[\int_0^1 I_t^F(i^*)^{\frac{1}{1+\eta_{p,x}}} di\right]^{1+\eta_{p,x}} \tag{20}$$

$$G_t^H = \left[\int_0^1 G_t^H(i)^{\frac{1}{1+\eta_p}} di\right]^{1+\eta_p}, \quad G_t^F = \left[\int_0^1 G_t^F(i^*)^{\frac{1}{1+\eta_{p,x}}} di\right]^{1+\eta_{p,x}} \tag{21}$$

2.3 Monetary Policy

The monetary authority follows a Taylor-type rule, in which the nominal interest rate R_t responds to its lagged value, the current inflation rate, and current output. We denote a variable in percentage deviations from the steady state by a hat. Specifically, the interest rate is set according to

$$\hat{R}_t = \rho_r \hat{R}_{t-1} + (1-\rho_r)\left[\phi_\pi \hat{\pi}_t^C + \phi_y \hat{Y}_t\right] + \epsilon_t^m, \quad \epsilon_t^m \sim N(0,1). \tag{22}$$

2.4 Fiscal Policy

Each period the government collects tax revenues and issues one-period nominal bonds to finance its interest payments and expenditures. The nominal flow budget constraint is

$$B_t + \tau_t^K R_t^K v_t K_{t-1} + \tau_t^L W_t L_t + P_t^C \tau_t^C C_t = R_{t-1} B_{t-1} + P_t^G G_t + P_t^C (Z_t^S + Z_t^N). \tag{23}$$

Fiscal instruments evolve according to the following rules:

$$\hat{\tau}_t^K = \rho_K \hat{\tau}_{t-1}^K + (1-\rho_K)\gamma_K \hat{s}_{t-1}^b + \epsilon_t^K, \tag{24}$$

$$\hat{\tau}_t^L = \rho_L \hat{\tau}_{t-1}^L + (1-\rho_L)\gamma_L \hat{s}_{t-1}^b + \epsilon_t^L, \tag{25}$$

$$\hat{\tau}_t^C = \rho_C \hat{\tau}_{t-1}^C + \epsilon_t^C, \tag{26}$$

$$\hat{G}_t = \rho_G \hat{G}_{t-1} - (1-\rho_G)\gamma_G \hat{s}_{t-1}^b + \epsilon_t^G, \tag{27}$$

$$\hat{Z}_t^S = \rho_{ZS} \hat{Z}_{t-1}^S - (1-\rho_{ZS})\gamma_{ZS} \hat{s}_{t-1}^b + \epsilon_t^{ZS}, \tag{28}$$

$$\hat{Z}_t^N = \rho_{ZN} \hat{Z}_{t-1}^N - (1-\rho_{ZN})\gamma_{ZN} \hat{s}_{t-1}^b + \epsilon_t^{ZN}, \tag{29}$$

where $s_{t-1}^b \equiv \frac{B_{t-1}}{Y_{t-1}}$, and $\epsilon_t^s \sim i.i.d.\ N(0,1)$ for $s = \{K, L, C, G, ZS, ZN\}$.

	Parameter Restrictions
Model 1: Basic RBC	$\psi = 1,\ \theta = s = \omega_w = \omega_p = \eta^w = \eta^p = \chi^w = \chi^p = 0$
	$\phi_\pi = \phi_y = \rho_r = \mu = \nu^C = \nu^I = \nu^G = 0$
Model 2: RBC Real Frictions	$\omega_w = \omega_p = \eta^w = \eta^p = \chi^w = \chi^p = \phi_\pi = \phi_y = \rho_r = 0$
	$\mu = \nu^C = \nu^I = \nu^G = 0$
Model 3: NK Sticky Price & Wage	$\mu = \nu^C = \nu^I = \nu^G = 0$
Model 4: NK Nonsavers	$\nu^C = \nu^I = \nu^G = 0$
Model 5: NK Open Economy	$\nu^G = 0$

Table 1: **Parameter restrictions on the main model that deliver nested models.**

2.5 Resource Constraint and Net Foreign Assets Aggregate home consumption is defined as the sum of the two types of households consumption:

$$C_t = \mu C_t^S + (1-\mu)C_t^N \tag{30}$$

Market clearing in the final-good markets implies

$$Q_t^C = C_t, \quad Q_t^I = I_t + \psi(v_t)\bar{K}_{t-1}, \quad Q_t^G = G_t \tag{31}$$

The home country's aggregate resource constraint is given by

$$Y_t = C_t^H + I_t^H + G_t^H + C_t^{H*} + I_t^{H*} + G_t^{H*} \tag{32}$$

The real exchange rate s_t is defined by the relationship

$$S_t = \frac{s_t P_t^{C*}}{P_t^C} \tag{33}$$

where S_t is the nominal exchange rate, expressed as the price of one foreign consumption basket in terms of domestic consumption. We define the domestic terms of trade, TOT_t, as the ratio between the import price and domestically produced price levels in domestic currency terms:

$$TOT_t = \frac{P_t^F}{S_t P_t^{H*}} \tag{34}$$

2.6 Nested Models The open-economy model is sufficiently rich to nest a wide range of models that are commonly used to examine the size of the fiscal multiplier. Five nested model specifications are considered. Table 1 lists the specific parameter restrictions implied by each model specification. Model 1 eliminates the all the real and nominal frictions and is a standard RBC closed-economy model. Model 2 allows for real frictions (investment adjustment costs, habit formation, and capacity utilization) but eliminates the nominal frictions and the open economy aspects. Model 3 is a standard NK model with sticky prices and wages, which introduces a role for policy. Model 4 adds non-savers to the standard NK model. And model 5 allows for an open-economy structure.

3 Prior Predictive Analysis

We use prior predictive analysis to determine a priori what restrictions are imposed on the data by the DSGE models under investigation. Using the notation and language of Geweke (2010), a complete model contains four elements:

i. a probability density of observables conditional on unobservables $p(y_T|\theta_{A_j}, A_j)$ where $j = 1, ..., n$ denotes the number of models under consideration, y_T denotes the random ex ante observable, and θ_{A_j} are the unobservables. Evaluating this density at the ex post realized observables (i.e., data) yields the likelihood function $L(\theta_{A_j}; y_T^o) = p(y_T^o|\theta_{A_j}, A_j)$. For our purposes here, this density is given by the log-linearized version of the model described in section 2 and the nested models listed in table 1. The θ_{A_j} denotes the parameters of the various DSGE models.

ii. a prior density function $p(\theta_{A,j}|A_j)$, which specifies a range over which the unobserved parameter values are likely to take. Calibration, which is well known in the macroeconomics literature, is an example of a degenerate or dogmatic prior density.

iii. a vector of interest, ω, and its corresponding distribution $p(\omega_T|y_T, \theta_{A,j}, A_j)$. Our vector of interest is the fiscal multiplier, which we define formally below. As the conditional distribution makes explicit, the fiscal multiplier will depend upon the choice of model (A_j), observables (y_T), and unobservable parameters $(\theta_{A,j})$.

iv. a Bayes action or decision, $\hat{d}_T = \text{argmax}_{d_T} E[U(\omega_T, d_T|y_T^o, A_j)]$, which determines the optimal action and can be cast into the expected utility framework of von Neumann and Morgenstern.

The relationship between the four model elements is straightforward. The first two elements yield the posterior distribution $p(\theta_{A,j}|y_t^o, A_j) = p(\theta_{A,j}|A_j)p(y_T^o|\theta_{A_j}, A_j)/p(y_T^o)$, which is then used to obtain the posterior of the vector of interest according to $p(\omega_T|y_T^o, A_j) = \int_{\Theta_{A,j}} p(\omega_T|y_T^o, \theta_{A,j}, A_j)\ p(\theta_{A,j}|y_T^o, A_j) d\theta_{A,j}$. This distribution is then be used to calculate the conditional expectation associated with the Bayes action, $\hat{d}_T$.

An example of such a decision could be whether or not to implement expansionary fiscal policy. Indeed, the debate surrounding the American Recovery and Reinvestment Act was couched in the form of fiscal multipliers. Romer and Bernstein (2009) argued in favor of a large stimulus due to sizeable multipliers. Conditioning on similar data, Cogan, Cwik, Taylor, and Wieland (2010) took the opposite view, citing a much smaller multiplier. This paper takes a step back in that we fix the vector of interest to focus exclusively on multipliers, and will not formulate/evaluate a decision rule. We focus on the importance of steps [i] and [ii] of the model building process, and advocate using a prior predictive analysis to illuminate how these initial steps may influence the vector of interest, and hence the Bayes action.

Elements [i] and [ii] of a complete model imply an ex ante predictive distribution for the observables

$$p(y_T|A_j) = \int_{\Theta_{A_j}} p(\theta_{A,j}|A_j)p(y_T|\theta_{A,j}A_j)d\theta_{A,j} \tag{35}$$

This distribution gives the a priori distribution of observables before data is collected. Computationally, it is straightforward to simulate from (35). The algorithm draws from $\theta_{A_j}^{(m)} \sim p(\theta_{A,j}|A_j)$, and $y_T^{(m)} \sim p(y_T|\theta_{A_j}^{(m)}, A_j)$. Drawing sequentially from these distributions delivers (35) and any function of y_T including the vector of interest, $\omega^{(m)}$. That is, we can use the model specification and a prior distribution to obtain the range of values of the fiscal multiplier implied by the DSGE models. This allows us to evaluate the model *before* taking it to data, as prior predictive analysis gives the entire range of possible multipliers allowed by the model and prior. This is a useful exercise to perform before estimating a model, since the prior predictive becomes the posterior distribution if data are totally uninformative. Following Geweke (2010), we argue that prior predictive analysis (PPA) is important for *any* macroeconomic question in which DSGE models are employed, whether or not Bayesian estimation is used. This is because prior predictive analysis allows us to check for model adequacy, in the sense that the model can adequately account for various phenomena of interest (in our case the size of multipliers).

We fix a few parameters in all model specifications whose values are standard in the literature. The discount factor, β, is set to 0.99, which implies an annual steady-state real interest rate of 4 percent. The capital income share of total output, α, is set to 0.36, implying a labor income share of 0.64. The quarterly depreciation rate for private capital, δ, is set to 0.025 so that the annual depreciation rate is 10 percent. The steady-state inflation rate, π, is assumed to be 1.

In addition, we calibrate steady-state fiscal variables to the values in Traum and Yang (2010), which are mean values from U.S. data over the period 1983Q1-2008Q1.[4] The federal government consumption to output share is 0.074, the federal debt to annualized output share is 0.386, the average marginal federal labor tax rate is 0.209, the capital tax rate is 0.196, and finally, the consumption tax rate is 0.015.

The priors used for our analysis are listed in table 2. Figure 1 plots the prior distributions for each parameter. The priors were chosen to cover the range of parameter values considered in the calibrated exercises of IMF10/73 and Cwik and Wieland (forthcoming). In addition, our priors are similar to those employed for Bayesian estimation of similar models [examples include Coenen and Straub (2005), Forni, Monteforte, and Sessa (2009), Lopez-Salido and Rabanal (2006), Leeper, Plante, and Traum (2010), and Traum and Yang (2010)]. We take 5,000 draws from our priors and calculate draws for multipliers from the prior distributions.

4 Fiscal Policy Multipliers

Following Mountford and Uhlig (2009), we calculate present-value multipliers, which embody the full dynamics associated with exogenous fiscal actions and properly discount future macroeconomic effects. The present value of additional output over a k-period horizon that

[4] In addition, we also adopted priors for these steady-state values and repeated the prior predictive analysis while allowing the fiscal steady-state values to vary. Results, available upon request, show that short-run fiscal multipliers are largely insensitive to variations in steady-state fiscal parameters. However, long-run multipliers are more sensitive to the steady state values.

Parameter	Prior			
	func.	mean	std.	90% int.
Preference and HHs				
γ, risk aversion	N^+	2	0.6	[1, 3]
ξ, inverse Frisch labor elast.	N^+	2	0.6	[1, 3]
θ_c, habit formation	B	0.5	0.2	[0.17, 0.83]
μ, fraction of non-savers	B	0.3	0.1	[0.14, 0.48]
Frictions				
ψ, capital utilization	B	0.6	0.15	[0.35, 0.85]
s, investment adj. cost	N	6	1.5	[3.5, 8.5]
ω_p, domestic price stickiness	B	0.5	0.1	[0.34, 0.66]
ω_{px}, foreign price stickiness	B	0.5	0.1	[0.34, 0.66]
ω_w, wage stickiness	B	0.5	0.1	[0.34, 0.66]
η_p, price mark-up	N^+	0.15	0.02	[0.12, 0.18]
η_w, wage mark-up	N^+	0.15	0.02	[0.12, 0.18]
χ^p, domestic price partial indexation	B	0.5	0.15	[0.25, 0.75]
χ^{px}, foreign price partial indexation	B	0.5	0.15	[0.25, 0.75]
χ^w, wage partial indexation	B	0.5	0.15	[0.25, 0.75]
Openness				
ν^C, consumption import share	N^+	0.25	0.07	[0.13, 0.37]
ν^I, investment import share	N^+	0.25	0.07	[0.13, 0.37]
μ^C, cons. substitution btw brands	N^+	1.5	0.25	[1.1, 1.9]
μ^I, invest. substitution btw brands	N^+	1.5	0.25	[1.1, 1.9]
Monetary policy				
ϕ_π, interest rate resp. to inflation	N	1.5	0.25	[1.1, 1.8]
ϕ_y, interest rate resp. to output	N^+	0.15	0.05	[0.07, 0.23]
ρ_r, lagged interest rate resp.	B	0.5	0.2	[0.17, 0.83]
Fiscal policy				
γ_G, govt consumption resp to debt	N^+	0.2	0.05	[0.12, 0.28]
γ_K, capital tax resp to debt	N^+	0.2	0.05	[0.12, 0.28]
γ_L, labor tax resp to debt	N^+	0.2	0.05	[0.12, 0.28]
γ_{ZS}, saver tranfr resp to debt	N^+	0.2	0.05	[0.12, 0.28]
γ_{ZN}, nonsaver tranfr resp to debt	N^+	0.2	0.05	[0.12, 0.28]
ρ_G, lagged govt cons resp.	B	0.5	0.2	[0.17, 0.83]
ρ_K, lagged capital tax resp.	B	0.5	0.2	[0.17, 0.83]
ρ_L, lagged labor tax resp.	B	0.5	0.2	[0.17, 0.83]
ρ_C, lagged cons tax resp.	B	0.5	0.2	[0.17, 0.83]
ρ_{ZS}, lagged saver tranfr resp.	B	0.5	0.2	[0.17, 0.83]
ρ_{ZN}, lagged nonsaver tranfr resp.	B	0.5	0.2	[0.17, 0.83]

Table 2: **Prior distributions.**

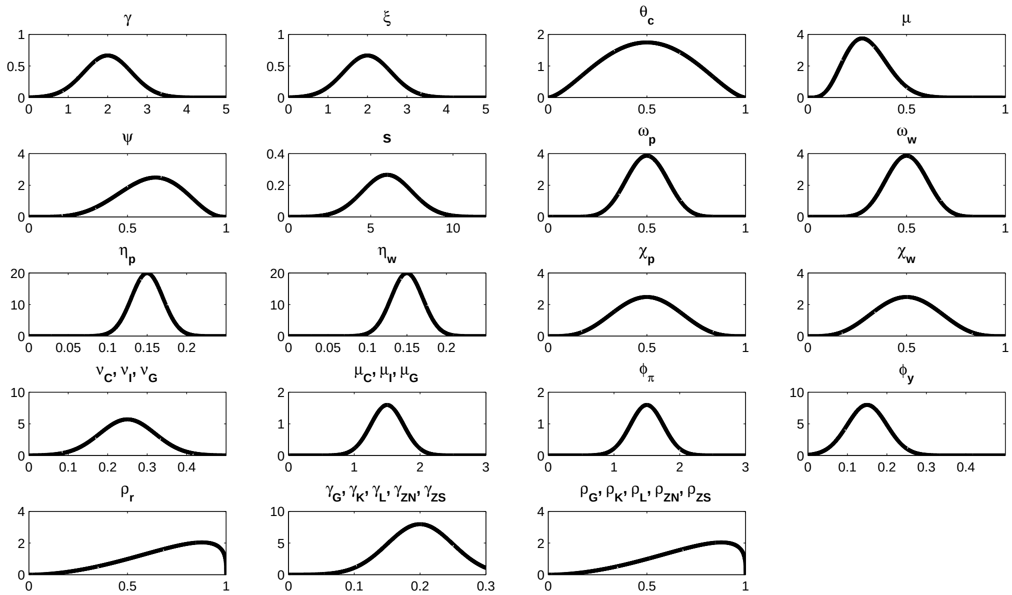

Figure 1: Prior distributions for parameters.

is generated by a change in the present value of government spending is calculated as

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

Note that the present-value multiplier at $k = 0$ is equal to the initial impact multiplier. To compare multipliers across models, we focus on a form of prior predictive p-values. P-values give the probability of observing the multiplier $\omega(\theta)$ greater than a particular value in repeated sampling from the model and prior. Table 3 compares multiplier p-values at various horizons across the five model specifications.[5] Specifically, the top panel of table 3 reports the probability of present-value multipliers for output being larger than one at various horizons. The middle and lower panels report the probabilities that multipliers for consumption and investment, respectively, are positive at various horizons. We focus on these particular probabilities as they address the key issues of the multiplier debate.

Although the p-values allow easy comparisons across models, they give a poor summary of the entire prior distribution. Therefore, figure 2 displays the median and 90-percent intervals for present-value government spending multipliers for output and consumption at various horizons for models 2, 3, and 4. The consumption multipliers are also decomposed into dynamic Hicksian wealth and substitution effects, following the approach in King (1991) and Baxter (1995).

We start by examining the basic real business cycle model with flexible prices and complete asset markets (model 1 in table 3). This model is similar to Baxter and King (1993)

[5]We approximate the infinite horizon by calculating the present value multipliers over 200 quarters.

Prob $\left(PV\frac{\Delta Y}{\Delta G} > 1\right)$

	Impact	4 quart.	10 quart.	25 quart.	∞
Model 1: Basic RBC	0.00	0.00	0.00	0.00	0.00
Model 2: RBC Real Frictions	0.01	0.00	0.00	0.00	<0.01
Model 3: NK Sticky Price & Wage	0.35	0.01	<0.01	0.00	0.00
Model 4: NK Nonsavers	0.88	0.32	0.07	0.02	0.01
Model 5: NK Open Economy	0.81	0.27	0.05	0.01	0.01
Open Economy PMAF	1.00	1.00	0.97	0.93	0.91

Prob $\left(PV\frac{\Delta C}{\Delta G} > 0\right)$

	Impact	4 quart.	10 quart.	25 quart.	∞
Model 1: Basic RBC	0.00	0.00	0.00	0.00	0.00
Model 2: RBC Real Frictions	0.00	0.00	0.00	0.00	<0.01
Model 3: NK Sticky Price & Wage	<0.01	0.00	0.00	0.00	0.00
Model 4: NK Nonsavers	0.84	0.46	0.18	0.02	0.01
Model 5: NK Open Economy	0.82	0.48	0.23	0.02	<0.01
Open Economy PMAF	1.00	1.00	1.00	0.99	0.93

Prob $\left(PV\frac{\Delta I}{\Delta G} > 0\right)$

	Impact	4 quart.	10 quart.	25 quart.	∞
Model 1: Basic RBC	<0.01	<0.01	<0.01	<0.01	0.00
Model 2: RBC Real Frictions	<0.01	<0.01	<0.01	<0.01	<0.01
Model 3: NK Sticky Price & Wage	<0.01	<0.01	<0.01	<0.01	0.00
Model 4: NK Nonsavers	<0.01	<0.01	<0.01	<0.01	0.01
Model 5: NK Open Economy	<0.01	<0.01	<0.01	<0.01	0.01
Open Economy PMAF	0.73	0.53	0.45	0.44	0.47

Table 3: Government spending multiplier probabilities implied by prior predictive analysis with informative priors.

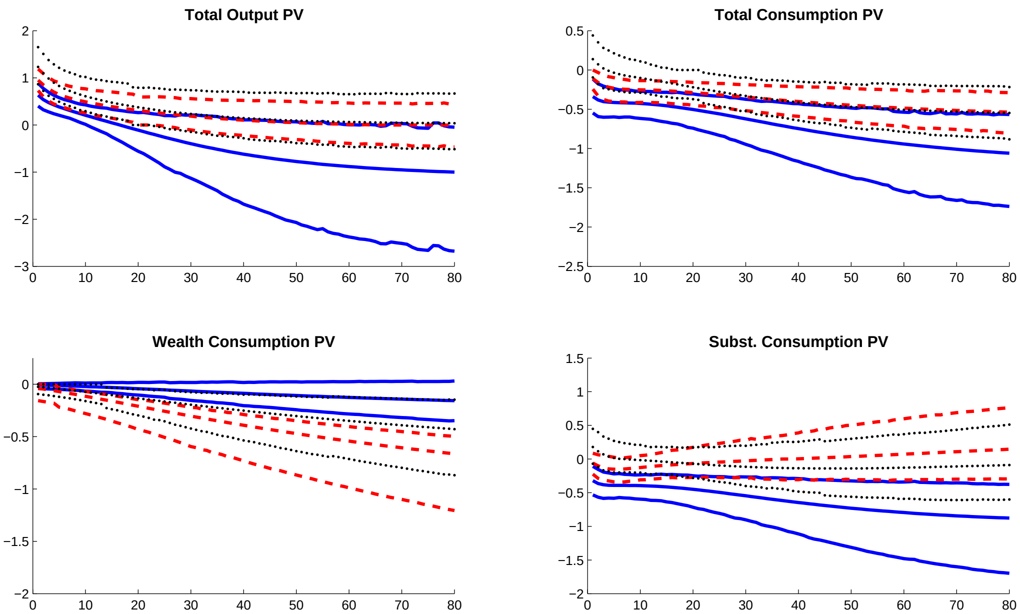

Figure 2: Present-value government spending multipliers for output and consumption at various horizons. Consumption multipliers are decomposed into components due to wealth and substitution effects. Blue solid line: Model 2, RBC model with real frictions. Red dashed line: Model 3, New Keynesian model with sticky prices and wages. Black dotted line: Model 4, New Keynesian model with non-savers.

and Monacelli and Perotti (2008), with the addition of distortionary fiscal financing, as in Leeper, Plante, and Traum (2010). It is impossible for this model to generate output multipliers greater than one or positive consumption multipliers at any horizon. An unexpected increase in government expenditures creates a negative wealth effect, as taxes are expected to increase in the future to off-set the implied budget deficit. As a result, agents decrease consumption and work more. These wealth effects are exasperated by negative substitution effects. Real wages decrease as agents are willing to work more, and the rental cost of capital increases as the marginal product of capital rises. These effects encourage households to work more and firms to demand less capital. As a result, consumption and investment are likely to decrease. The resulting declines in private demand offset most of the increased public demand, causing output to increase by less than the increase in government consumption.

There is a small probability (< 0.01) that investment will increase at most horizons. This is the only result consistent across all model specifications. The small probability stems from a subset of very high draws for ρ_G, the serial correlation of government spending. As ρ_G approaches one, an exogenous change in government spending is viewed as approximately permanent. The permanent increase in demand encourages households to invest more, causing investment to increase. This effect occurs in all model specifications.

Model 2 introduces real frictions (habit formation, investment adjustment costs, and capacity utilization), which substantially affect the short and long run fiscal multipliers. Intuitively, following a temporary government spending increase, agents are less willing to decrease consumption with habit formation, as changes in consumption are costly, and consumption must return to its steady-state value in the long-run. This decreases the negative consumption multipliers. Similarly, investment adjustment costs and capacity utilization costs deter households from sizeable swings in investment, noticeably decreasing the negative investment multipliers.[6] Although the multipliers change quantitatively relative to model 1, the policy implications from the two models are virtually the same, as the probabilities measured in table 3 are unaltered.

Introducing sticky prices and sticky wages, model 3, further increases the multipliers at all horizons, as demonstrated by Woodford (2011). A higher degree of price stickiness implies that more firms respond to a government spending increase by increasing production rather than their price. This causes markups to respond more strongly. In the long run, the 90-percent interval for present value output multipliers includes positive values (the red dashed lines of panel 1 of figure 2). The preceding RBC models were unable to produce these long run positive values, implying a New Keynesian-style model is necessary to produce long run multipliers that encourage discretionary expansionary policy.

Wage rigidities have a strong effect on consumption multipliers. As can be seen from figure 2, sticky wages imply a significant drop in the negative substitution effect on consumption. This is because the wage substitution effect is now often positive (as real wages can increase), offsetting other negative price effects and causing the overall substitution effect to decrease in magnitude.

Introducing non-savers into the model (model 4) has sizeable effects on the fiscal multipliers. The fraction of non-savers is *the* most influential parameter on the output multiplier, as variations in this parameter are necessary to get median impact output multipliers greater than one (the black dotted lines of panel 1 of figure 2). Unlike savers, non-savers increase consumption following government consumption increases. Non-savers consume their entire income each period and do not take into account the negative wealth effects that savers consider. If wages are sticky, so that real wages increase on impact, than non-saver consumption increases as well. Depending on how large the fraction of non-savers are in the economy, the increase in non-saver consumption can be large enough to cause total consumption to increase on impact (the black dotted lines of panel 2 of figure 2), leading to larger output multipliers as well.

The open economy framework (model 5), reduces the probability of output multipliers being greater than one and of positive consumption multipliers. In the open economy, increases in government expenditures induce a substitution away from domestically produced goods towards imported goods. The increases in demand lead to higher production costs, which cause the price of the domestic good and the price of the domestic good in the foreign market to increase. Domestic households, in turn, reduce their demand for domestic production and increase imports. Foreigners also reduce their demand for domestic exports. Because of this import-substitution effect, output multipliers are smaller on average than they are in the closed economy. Multipliers are smaller when government spending is a traded good,[7] as part of the increase in government spending is "leaked" to the foreign

[6]See Monacelli and Perotti (2008) for a more detailed examination of the effect of habit formation and investment adjustment costs on multipliers in a simple RBC model.

[7]Results for this case are available in an additional appendix from the authors.

country. Impact consumption multipliers decrease by half in an open economy with a traded government spending good, as compared to the closed economy environment. This result can help explain some of the differences in multipliers in the models of IMF10/73 and Cwik and Wieland (forthcoming), as the open economy models considered by these papers make different assumptions about whether government spending is a traded good.

Looking across the specifications, a few observations emerge. First, real and nominal frictions, non-savers, and open economy considerations are instrumental for the multipliers qualitatively. Nominal rigidities and non-savers are key to achieving long run positive output multipliers. Although the model can produce output multipliers greater than one, it is difficult for the model to produce substantially large multipliers. Indeed, the 90-percent interval for the impact output multiplier for the closed economy with non-savers, the model producing the largest multipliers, ranges from 0.84 to 1.75, suggesting it is hard for the model to ever produce multipliers greater than 2.[8]

4.1 Individual Parameter Contributions

So far our analysis has largely ignored the effect a particular parameter has on the present value multipliers. To determine how much individual parameters affect the multipliers, we calculate a measure of root mean square deviation (RMSD) for each parameter. For each draw of parameters, $\tilde{\theta} = [\tilde{\theta}_1 \quad ... \quad \tilde{\theta}_n]'$, from $p(\theta)$, we calculate multipliers $\tilde{\omega}(\tilde{\theta})$. We then calculate multipliers, $\tilde{\omega}^i(\tilde{\theta}^i)\ \forall\ i = 1 : n$, when one parameter is held fixed at its prior mean, $\tilde{\theta}^i = [\tilde{\theta}_1 \quad ... \quad E[\theta_i] \quad ... \quad \tilde{\theta}_n]'$. The RMSD is the root mean square deviation between the two multipliers $\tilde{\omega}(\tilde{\theta})$ and $\tilde{\omega}^i(\tilde{\theta}^i)$ and gives a measure of how much the multiplier varies on average due to a particular parameter. In other words, it helps measure the contribution of a particular parameter to the entire multiplier. This value is largest for the parameters that are most influential for the multiplier. Tables 4 and 5 report the RMSDs for each parameter in the open economy New Keynesian model (model 5) at various horizons.

As previously mentioned, the fraction of non-savers μ is *the* most influential parameter on the output and consumption impact multipliers. Non-savers consume their entire income each period and do not take into account the negative wealth effects that savers consider. If real wages increase on impact, than non-saver consumption (and thus output) increases as well. Depending on how large the fraction of non-savers are in the economy, the increase in non-saver consumption can cause total consumption to increase on impact.

The persistence of the government spending process ρ_{GC} is the second most important parameter for impact multipliers. The larger the persistence, the more sizeable the negative wealth effects, as larger increases in taxes are required to finance the increase in the government spending process. This decreases the size of consumption and output multipliers.

The degree of habit formation θ_c and the capacity utilization cost ψ are also important for impact multipliers. A habit formation increases, households place greater importance on consumption smoothing, dampening the variation in consumption (and thus output) over time. Capacity utilization costs are important for output multipliers, as our measure of output depends directly on the utilization rate (this can be seen from the aggregate resource constraint).

The impact multipliers are increasing with risk aversion γ, as noted in Monacelli and

[8] This result is conditional on the fiscal-monetary policy specification assumed.

Parameter	RMSD $PV\frac{\Delta Y}{\Delta G}$				
	Impact	4 quart.	10 quart.	25 quart.	∞
Preference and HHs					
γ, risk aversion	0.035	0.053	0.042	0.041	0.058
ξ, inverse Frisch labor elast.	0.010	0.026	0.033	0.050	0.086
θ_c, habit formation	0.052	0.050	0.025	0.027	0.031
μ, fraction of non-savers	0.123	0.098	0.066	0.050	0.057
Frictions and Production					
ψ, capital utilization	0.095	0.088	0.067	0.054	0.059
s, investment adj. cost	0.017	0.036	0.038	0.036	0.041
ω_p, domestic price stickiness	0.010	0.007	0.005	0.006	0.007
ω_{px}, foreign price stickiness	0.005	0.002	0.002	0.002	0.002
ω_w, wage stickiness	0.013	0.036	0.049	0.064	0.086
η_p, price mark-up	0.011	0.008	0.006	0.008	0.020
η_w, wage mark-up	0.002	0.007	0.009	0.012	0.016
χ^p, domestic price partial indexation	0.006	0.002	0.001	0.002	0.002
χ^w, wage partial indexation	0.006	0.021	0.030	0.036	0.047
Openness					
ν^C, cons. import share	0.011	0.004	0.004	0.005	0.007
μ^C, cons. substitution btw brands	0.002	0.003	0.005	0.009	0.015
μ^I, inv. substitution btw brands	0.001	0.001	0.002	0.003	0.006
Monetary Policy					
ϕ_π, interest rate resp. to inflation	0.025	0.030	0.029	0.046	0.068
ϕ_y, interest rate resp. to output	0.015	0.024	0.028	0.032	0.034
ρ_r, lagged interest rate resp.	0.065	0.053	0.068	0.079	0.096
Fiscal Policy					
γ_G, govt consumption resp to debt	0.001	0.002	0.006	0.015	0.031
γ_K, capital tax resp to debt	0.002	0.002	0.008	0.028	0.034
γ_L, labor tax resp to debt	0.001	0.002	0.005	0.018	0.018
γ_{ZS}, saver tranfr resp to debt	0.003	0.003	0.004	0.015	0.060
γ_{ZN}, nonsaver tranfr resp to debt	0.001	0.002	0.002	0.005	0.018
ρ_G, lagged govt cons resp.	0.120	0.163	0.222	0.307	0.427
ρ_K, lagged capital tax resp.	0.001	0.003	0.015	0.026	0.016
ρ_L, lagged labor tax resp.	0.001	0.005	0.016	0.029	0.013
ρ_C, lagged cons tax resp.	0.000	0.000	0.000	0.000	0.000
ρ_{ZS}, lagged saver tranfr resp.	0.001	0.002	0.003	0.014	0.023
ρ_{ZN}, lagged nonsaver tranfr resp.	0.001	0.006	0.003	0.009	0.019

Table 4: RMSDs for model 5, New Keynesian open economy model.

Parameter	RMSD $PV\frac{\Delta C}{\Delta G}$				
	Impact	4 quart.	10 quart.	25 quart.	∞
Preference and HHs					
γ, risk aversion	0.035	0.055	0.051	0.043	0.055
ξ, inverse Frisch labor elast.	0.004	0.010	0.011	0.017	0.042
θ_c, habit formation	0.048	0.046	0.018	0.010	0.016
μ, fraction of non-savers	0.115	0.097	0.072	0.032	0.029
Frictions and Production					
ψ, capital utilization	0.013	0.016	0.011	0.009	0.010
s, investment adj. cost	0.004	0.007	0.007	0.005	0.012
ω_p, domestic price stickiness	0.007	0.005	0.004	0.004	0.005
ω_{px}, foreign price stickiness	0.001	0.001	0.001	0.001	0.001
ω_w, wage stickiness	0.005	0.015	0.019	0.027	0.044
η_p, price mark-up	0.008	0.007	0.006	0.004	0.011
η_w, wage mark-up	0.001	0.003	0.004	0.005	0.008
χ^p, domestic price partial indexation	0.004	0.001	0.001	0.001	0.001
χ^w, wage partial indexation	0.004	0.008	0.012	0.016	0.025
Openness					
ν^C, cons. import share	0.005	0.007	0.010	0.017	0.029
μ^C, cons. substitution btw brands	0.002	0.003	0.006	0.010	0.020
μ^I, inv. substitution btw brands	0.001	0.001	0.002	0.003	0.007
Monetary Policy					
ϕ_π, interest rate resp. to inflation	0.017	0.016	0.015	0.024	0.038
ϕ_y, interest rate resp. to output	0.009	0.012	0.013	0.017	0.020
ρ_r, lagged interest rate resp.	0.047	0.032	0.023	0.031	0.047
Fiscal Policy					
γ_G, govt consumption resp to debt	0.001	0.001	0.002	0.004	0.015
γ_K, capital tax resp to debt	0.002	0.003	0.003	0.004	0.008
γ_L, labor tax resp to debt	0.001	0.002	0.007	0.023	0.019
γ_{ZS}, saver tranfr resp to debt	0.002	0.002	0.003	0.004	0.023
γ_{ZN}, nonsaver tranfr resp to debt	0.001	0.002	0.003	0.014	0.009
ρ_G, lagged govt cons resp.	0.065	0.066	0.074	0.090	0.202
ρ_K, lagged capital tax resp.	0.001	0.002	0.003	0.003	0.007
ρ_L, lagged labor tax resp.	0.001	0.003	0.015	0.030	0.012
ρ_C, lagged cons tax resp.	0.000	0.000	0.000	0.000	0.000
ρ_{ZS}, lagged saver tranfr resp.	0.002	0.002	0.002	0.005	0.010
ρ_{ZN}, lagged nonsaver tranfr resp.	0.001	0.003	0.009	0.017	0.003

Table 5: RMSDs for model 5, New Keynesian open economy model.

Perotti (2008). The larger the degree of risk aversion (or the smaller the intertemporal elasticity of substitution), the less willing households are to postpone consumption into the future. This decreases the variation of consumption, and thus output, following government spending changes. Consumption multipliers are substantially influenced by the risk aversion parameter in the short and long runs.

Monetary policy is also influential for the multipliers. As noted in Woodford (2011) and IMF10/73, the more accommodative monetary policy is, the larger the multipliers are. Thus, multipliers are decreasing in ρ_r, ϕ_π, and ϕ_y. Variations in ρ_r is particularly important for the multipliers.

4.2 Influence of Priors Our priors are informative and influence the distribution of multipliers implied by the model specifications. To get a sense of how the multipliers depend on our priors, we calculate multipliers conditional on diffuse, uniform priors (see table 6). Table 7 reports multiplier p-values at various horizons for the model specifications when the uniform priors are employed.

The uniform priors increase the probability of parameter draws from a larger region of the parameter space. This, in turn, allows a larger range of multipliers and increases the probabilities of output multipliers greater than one and consumption and investment multipliers being positive. Comparing the probabilities under the two priors reveals that the prior specification is most informative about multipliers over longer horizons. However, model specifications often still imply tight multiplier ranges, and the general conclusions from above still hold. It remains difficult to generate positive investment multipliers over any horizon. In addition, nominal rigidities and non-savers are still key to achieving long run positive output multipliers.

4.3 Alternative Fiscal-Monetary Interactions As shown by Davig and Leeper (2009) and Christiano, Eichenbaum, and Rebelo (2009), multipliers can be much larger with alternative fiscal-monetary scenarios. To get a sense of how the multipliers depend on the fiscal-monetary specification, we calculate multipliers conditional on model 5 (the open economy New Keynesian model) in a passive monetary and active fiscal (PMAF) policy regime.[9] In this specification, the monetary authority raises the interest rate less than one-for-one with inflation deviations, and the fiscal authority does not adjust fiscal instruments sufficiently to control debt growth. To ensure this, we modify our priors by assuming ϕ_π has a uniform distribution on the unit interval, and γ_g, γ_k, γ_l, γ_{zs}, and γ_{zn} have normal distributions with zero means and standard deviations of 0.03.

Table 3 reports multiplier p-values at various horizons conditional on the PMAF regime (columns labeled Open Economy PMAF). The multiplier probabilities vary drastically conditional on this fiscal-monetary specification: it is impossible in the short run for output multipliers to be less than one and for consumption multipliers to be negative. In addition,

[9] An active authority is defined as an authority which is not constrained by current budgetary conditions and may choose a decision rule dependent on any variables it wants. In contrast, a passive authority is constrained by the consumers' and firms' optimizations and by the actions of the active authority. The passive authority must ensure that current budgetary conditions are satisfied, and thus, must ensure the intertemporal government budget constraint is satisfied. See Leeper (1991), Sims (1994), Cochrane (1999), and Woodford (2003) for more discussion.

the probability of investment multipliers being positive is substantial at all horizons. Following an increase in government consumption, current and future demand rise (as the increase is persistent), as well as inflation expectations. Under passive monetary policy, the monetary authority responds to the increase in inflation less than one-for-one, which allows the real interest rate to fall. Declining real interest rates lower the return to saving, encouraging households to consume more and leading consumption to increase. This increase in private demand, along with a decrease in the rental cost of capital, encourages firms to demand more capital, leading investment to rise on impact in most cases as well. The results highlight the importance of fiscal-monetary interactions for policy conclusions. Although the results differ substantially from the benchmark specification (active monetary and passive fiscal policy), it is important to note that the PMAF specification also imposes a tight multiplier range.

5 Conclusion

This paper has shown, through prior predictive analysis, that many model specifications impose a very tight range for the multiplier before the models are taken to data. Although multipliers vary substantially across various monetary-fiscal policy specifications, conditional on a particular policy specification a model still imposes a tight range for multipliers. The results give a warning to policymakers forming conclusions about multipliers from particular calibrated or estimated models. The tight multiplier range often imposed by models prior to conditioning on data is tantamount to biasing results.

Parameter	Prior	
	func.	interval
Preference and HHs		
γ, risk aversion	U	[0, 6]
ξ, inverse Frisch labor elast.	U	[0, 6]
θ_c, habit formation	U	[0, 1]
μ, fraction of non-savers	U	[0, 0.6]
Frictions		
ψ, capital utilization	U	[0, 1]
s, investment adj. cost	U	[0, 10]
ω_p, domestic price stickiness	U	[0, 1]
ω_{px}, foreign price stickiness	U	[0, 1]
ω_w, wage stickiness	U	[0, 1]
η_p, price mark-up	U	[0, 0.5]
η_w, wage mark-up	U	[0, 0.5]
χ^p, domestic price partial indexation	U	[0, 1]
χ^{px}, foreign price partial indexation	U	[0, 1]
χ^w, wage partial indexation	U	[0, 1]
Openness		
ν^C, consumption import share	U	[0, 1]
ν^I, investment import share	U	[0, 1]
μ^C, cons. substitution btw brands	U	[1, 4]
μ^I, invest. substitution btw brands	U	[1, 4]
Monetary policy		
ϕ_π, interest rate resp. to inflation	U	[1, 4]
ϕ_y, interest rate resp. to output	U	[0, 0.5]
ρ_r, lagged interest rate resp.	U	[0, 1]
Fiscal policy		
γ_G, govt consumption resp to debt	U	[0, 0.5]
γ_K, capital tax resp to debt	U	[0, 0.5]
γ_L, labor tax resp to debt	U	[0, 0.5]
γ_{ZS}, saver tranfr resp to debt	U	[0, 0.5]
γ_{ZN}, nonsaver tranfr resp to debt	U	[0, 0.5]
ρ_G, lagged govt cons resp.	U	[0, 1]
ρ_K, lagged capital tax resp.	U	[0, 1]
ρ_L, lagged labor tax resp.	U	[0, 1]
ρ_C, lagged cons tax resp.	U	[0, 1]
ρ_{ZS}, lagged saver tranfr resp.	U	[0, 1]
ρ_{ZN}, lagged nonsaver tranfr resp.	U	[0, 1]

Table 6: **Uniform Prior distributions.**

Prob$\left(PV\frac{\Delta Y}{\Delta G} > 1\right)$

	Impact	4 quart.	10 quart.	25 quart.	∞
Model 1: Basic RBC	0.00	0.00	0.00	0.00	0.00
Model 2: RBC Real Frictions	0.11	0.03	0.01	0.07	0.13
Model 3: NK Sticky Price & Wage	0.43	0.17	0.09	0.08	0.10
Model 4: NK Nonsavers	0.76	0.46	0.26	0.20	0.20
Model 5: NK Open Economy	0.69	0.42	0.24	0.19	0.19

Prob$\left(PV\frac{\Delta C}{\Delta G} > 0\right)$

	Impact	4 quart.	10 quart.	25 quart.	∞
Model 1: Basic RBC	0.00	0.00	0.00	0.00	0.00
Model 2: RBC Real Frictions	0.00	0.00	0.01	0.07	0.11
Model 3: NK Sticky Price & Wage	0.00	0.00	0.02	0.04	0.07
Model 4: NK Nonsavers	0.73	0.57	0.32	0.15	0.15
Model 5: NK Open Economy	0.73	0.60	0.37	0.16	0.16

Prob$\left(PV\frac{\Delta I}{\Delta G} > 0\right)$

	Impact	4 quart.	10 quart.	25 quart.	∞
Model 1: Basic RBC	0.01	0.01	0.01	0.00	0.00
Model 2: RBC Real Frictions	0.01	0.01	0.03	0.06	0.11
Model 3: NK Sticky Price & Wage	0.00	0.02	0.05	0.07	0.09
Model 4: NK Nonsavers	0.00	0.03	0.10	0.22	0.27
Model 5: NK Open Economy	0.00	0.03	0.13	0.27	0.33

Table 7: Government spending multiplier probabilities implied by prior predictive analysis with uniform priors.

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