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The effects of government spending in a model with a borrowing constraint

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Abstract

This paper explores the effects of government spending in a dynamic macroeconomic model that features a borrowing constraint as a financial friction. The main result from Bayesian estimation with U.S. data shows that dynamic response of output in the model with friction remains lower than that in the standard model without friction during transition period. This result translates into smaller output multipliers at all horizons. The takeaway from all the analyses is that considering financial frictions merits further analyses to provide a better understanding of the effects of various fiscal policies.

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1. Introduction

A growing literature has assigned a significant role to financial sectors for a better understanding of aggregate fluctuations since 2008. Unlike conventional wisdom, however, the macroeconomic profession has a long and well-established tradition to incorporate financial frictions in standard macroeconomic models to show the potential importance of the frictions for business cycles.[1]

This paper explores macroeconomic implications of government spending in a model that features a financial friction. The financial friction is modeled as a collateral constraint for firms that need working capital to pay for wage bill. An intratemporal loan that firms can take out is a fraction of the total value of collateral asset that firms own, and this is the linchpin of financial friction constructed in this paper.[2]

To highlight how the presence of financial friction can deliver different outcomes, I compare a model with collateral constraint to a standard model without friction.[3] Bayesian estimation on two models reveals that all the estimates fall within conventionally accepted values in macroeconomics. The estimated fraction of collateral is 0.07, implying that the firm finances labor cost by 7% out of the total value of collateral asset.

The quantitative analysis based on the estimated parameters shows considerably different dynamics of macroeconomic variables in two models. Of particular importance among these results are consumption and labor dynamics. C-model shows a smaller rise in labor and larger decline in consumption than S-model. Absent an immediate adjustment of capital, short-run dynamic behavior of labor translates into short-run output dynamics. As a result, output in C-model rises less than that in S-model, leading to a smaller multiplier of output in C-model at all horizons. This result suggests that fiscal multipliers reported in early studies using standard models without these frictions are likely to be overestimated. In this regard, considering financial frictions in other topics merits important analyses to check whether conventionally established results remain qualitatively intact.

This paper is germane to early studies that analyze interactions between fiscal multipliers and financial frictions in various models (e.g., Fernández-Villaverde 2010; Carrillo and Poilly 2013; Abo-Zaid and Kamara 2020; McManus et al. 2021; Klein et al. 2022; among others). This paper, however, has an important departure from those studies by taking a model comparison approach to elucidate different macroeconomic consequences so accentuate the crucial role of financial friction. In this sense, this paper puts theoretical flesh on the literature on fiscal policy.

This paper is organized as follows. Section 2 formulates C-model. Section 3 discusses dynamic response of macroeconomic variables and present-value multipliers of output based on Bayesian estimation. Section 4 concludes.

2. Model with a borrowing constraint

The model consists of households, firms and government. The representative household derives utility from consumption c_t adjusted by external habit C_{t-1} and disutility from labor

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[1] Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) are two important contributions to this literature as classic references.

[2] The idea behind this type of financial friction faced by firms comes from Jermann and Quadrini (2012), and Perri and Quadrini (2018). They focus on firms' limited ability to borrow due to the possibility of default. This leads firms to collateralize their asset to take a small amount of loan.

[3] For brevity, the former (latter) model is called C-model (S-model) hereafter.

h_t.[4] The household's optimization problem is given by

$$Max\, E_0 \sum_{t=0}^{\infty} \beta^t U\left(c_t, h_t\right), \text{ where } U = \frac{1}{1-\sigma}\left[\left(c_t - \mu C_t\right)^{\chi}\left(1-h_t\right)^{1-\chi}\right]^{1-\sigma}, \tag{1}$$

subject to

$$c_t + b_{t+1} = w_t h_t + R_t b_t + d_t, \tag{2}$$

where β denotes the discount factor, σ is the curvature parameter, μ is the degree of external habit, and χ is the relative weight to consumption. The variables b_t, w_t, R_t and d_t indicate government bonds, real wage, real gross interest rate on bonds and dividend distributions from firms.[5]

The representative firm maximizes the expected future stream of dividends based on the stochastic discount factor from the household. The firm's objective function is then given by

$$Max\;\; E_t \sum_{j=0}^{\infty} \Lambda_{t+j|t} d_{t+j}, \tag{3}$$

where $\Lambda_{t+j|t} = \beta^j \lambda_{t+j}/\lambda_t$ denotes the stochastic discount factor, and λ_t is the Lagrange multiplier for (2). The firm's budget constraint is given by

$$d_t = y_t - w_t h_t - x_t, \tag{4}$$

where x_t denotes investment, and y_t is output produced by the Cobb-Douglas production function:

$$y_t = \xi_t^z k_t^{\alpha} h_t^{1-\alpha}, \tag{5}$$

where k_t is capital. The variable ξ_t^z denotes a productivity shock that obeys a first-order stochastic process, $\ln \xi_t^z = \rho_z \ln \xi_{t-1}^z + \sigma_z \varepsilon_t^z$, where $\varepsilon_t^z \sim N(0,1)$. The evolution of capital with adjustment cost is given by

$$k_{t+1} = x_t + \left(1-\delta\right)k_t - \frac{\psi}{2}\left[\frac{x_t}{k_t} - \delta\right]^2 k_t, \tag{6}$$

where ψ and δ represent the intensity of adjustment cost and depreciation rate.[6]

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[4] A voluminous literature has corroborated that the presence of habit formation can explain various macroeconomic phenomena such as equity premium puzzle and stylized facts of aggregate fluctuations (i.e., hump-shaped response of macroeconomic variables to exogenous shocks). Based on a vast set of previous studies, I include habit formation in consumption. See, for example, Schmitt-Grohé and Uribe (2008) and Havranek et al. (2017) for detailed explanations about habit formation.

[5] The optimal choice of c_t, h_t and b_{t+1} using (1) and (2) solves the household's problem.

[6] The literature on capital adjustment cost has a long history of accounting for firms' investment behavior in various

The financial friction that the firm faces is modeled as a collateral constraint. The firm receives an intra-period loan as working capital for wage bill before it produces output and pays it back at the end of the period. If the firm reneges on its working-capital loan, the lender can only recoup up to a fraction of the firm's total asset (i.e., market value of capital). The fact that the lender can only sell a smaller value of the total asset makes the firm have a limited ability to borrow.[7] The collateral constraint is then given by

$$w_t h_t \le \theta q_t k_t , \tag{7}$$

where q_t is the asset price (value of capital). θ is a fraction that the firm can borrow with a range of $0 < \theta < 1$, and it captures the tightness of credit market.[8] The government's budget constraint is given by

$$b_{t+1} = R_t b_t + g_t , \tag{8}$$

where g_t is government spending that follows a first-order process, $\ln g_t = \rho_g \ln g_{t-1} + \sigma_g \varepsilon_t^g$, where $\varepsilon_t^g \sim N(0,1)$. Using the household's, firm's and government's budget constraints finally yields the aggregate resource constraint:

$$y_t = c_t + x_t + g_t . \tag{9}$$

3. Quantitative analysis

I estimate both C-model and S-model on U.S. data using the Bayesian method to see how actual data deliver different results from two models.[9] Actual data that come from FRED of St. Louis include two observables with a range of 1948:1 ~ 2019:4. The two observables are percent changes of real per-capita consumption and real per-capita government spending.[10] Table 1 presents the results.[11] The estimate without (inside) parenthesis indicates the result from C-model (S-model).

A glance at Table 1 reveals that the estimates in two models are quite similar and are not far off from conventionally accepted values in macroeconomics. Since the parameter related to the financial friction is the linchpin of this paper, however, it deserves mention: Actual data

important themes such as Tobin's Q and the strength of adjustment cost (e.g., Hayashi 1982; Abel and Blanchard 1983; Hall 2004; Cooper and Haltiwanger 2006; among others). Following a large number of early studies, I posit that the firm faces a convex capital adjustment cost when it adjusts capital stock over time.

[7] The fundamental structure of this financial friction stems from Jermann and Quadrini (2012), and Perri and Quadrini (2018).

[8] The choice of h_t, x_t and k_{t+1} using (3) ~ (7) yields the firm's optimality conditions. The absence of this constraint renders C-model standard.

[9] I use the random walk Metropolis-Hastings (HM) algorithm to sample from the posterior distribution. I create a sample of 500,000 draws and discard the first 100,000 draws.

[10] These are converted to real per-capita variables using GDP deflator (ID: GDPDEF) and civilian noninstitutional population (ID: CNP160V). Consumption is defined as the sum of consumption on nondurables (ID: PCND) and consumption on services (ID: PCESV). The government spending is government consumption expenditures and gross investment (ID: GCE).

[11] The parameters β, δ and are α set at 0.99, 0.025 and 0.3 as calibrated values. The steady-state fiscal variables are computed by government spending over nominal GDP (ID: GDP) and the market value of privately held gross federal debt (ID: MVPHGFD027MNFRBDAL from Dallas Fed).

yield that the estimated proportion of loan is 0.07, implying that the firm needs working capital by 7% of the entire collateral asset.[12]

Figure 1 displays dynamic response of macroeconomic variables following a 1% increase in government spending, and the result is expressed in percentage deviations from the steady-state value of each model. The line with square (circle) denotes the result from C-model (S-model). Casual inspection of Figure 1 reveals that the neoclassical effect dominates in two models: Consumption and investment decline with a rise in hours in the short run, which translates into an increase in output.[13] Nonetheless, C-model shows a larger decline in consumption and smaller rise in hours than those in S-model.

Table 1. Parameter estimation on U.S. data

	Prior distribution			Posterior distribution		
Parameter	Density	Mean	SD	Mean	5%	95%
Curvature parameter (σ)	Γ	2.00	0.50	3.92	1.30	5.31
				(5.22)	(4.02)	(6.49)
Consumption share (χ)	B	0.30	0.02	0.33	0.31	0.35
				(0.32)	(0.30)	(0.35)
Habit persistence (μ)	B	0.50	0.02	0.51	0.48	0.55
				(0.57)	(0.53)	(0.60)
Capital adjustment cost (ψ)	Γ	5.00	0.50	5.36	4.53	6.25
				(6.16)	(5.12)	(7.22)
Fraction of collateral (θ)	B	0.04	0.02	0.07	0.03	0.08
Persistence of investment shock (ρ_g)	B	0.80	0.10	0.62	0.52	0.70
				(0.64)	(0.57)	(0.70)
Persistence of productivity shock (ρ_a)	B	0.80	0.10	0.21	0.10	0.34
				(0.28)	(0.16)	(0.41)
SD of investment shock (σ_g)	Γ^{-1}	1.00	2.00	1.42	1.31	1.53
				(1.46)	(1.34)	(1.58)
SD of productivity shock (σ_a)	Γ^{-1}	1.00	2.00	3.61	2.85	5.00
				(2.60)	(2.31)	(2.91)

Note: SD denotes standard deviation. The value without (inside) parenthesis indicates the result from C-model (S-model). The absence of estimate that is germane to the financial friction in S-model comes out of the fact that S-model is financially frictionless.

In Figure 1, an increase in the multiplier of collateral constraint in (7) suggests that the financial constraint is tighter, implying that the firm wants to increase labor payment by more than the total value of asset. However, the fall in asset price delivers a smaller value of collateral, which directly affects the firm's borrowing ability. Thus, though government spending leads the household to supply more labor, the financially constrained firm has difficulty hiring as much labor as possible. Absent an immediate adjustment of capital, the dynamic movement of hours is the core of determining output dynamics in the short run, and therefore output in C-model jumps up less on impact than S-model.

To quantify the dynamic impacts of government spending, I use present-value multipliers following Mountford and Uhlig (2009), Ilzetzk et al. (2013) and Zubairy (2014). It summarizes the cumulative effects of government spending on variables along the entire path of responses up to a given period. Table 1 reports output multipliers. A noticeable feature of the result is that the output multiplier in C-model remains smaller than that in S-model at all horizons. This result is intimately linked to output dynamics in Figure 1.

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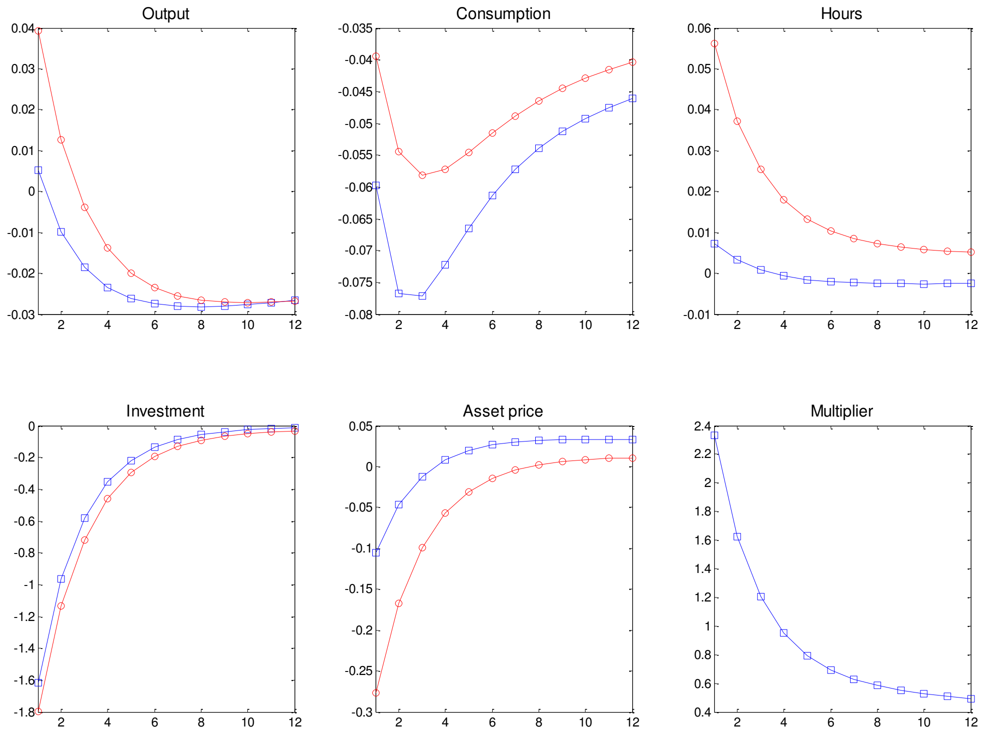
[12] Appendix derives the upper bound of this value. The average of the resulting value is chosen as the prior in Table 1.

[13] This result in both models follows from the fact that they share the neoclassical model structure that has the negative income and crowding-out effects.

Figure 1. Dynamic response of macroeconomic variables



Note: The line with square (circle) indicates the result from C-model (S-model). The x-axis and y-axis denote quarters and percentage deviations from the steady-state value of each model. The multiplier is the one for collateral constraint.

Table 2. Present-value output multiplier

Period	Impact	4^{th} qrt	8^{th} qrt	12^{th} qrt	Long run
C-model	0.01	-0.05	-0.14	-0.23	-0.88
(S-model)	(0.09)	(0.03)	(-0.05)	(-0.13)	(-0.78)

Note: Long-run multiplier is based on 200 quarters.

4. Conclusion

This paper explores macroeconomic implications of government spending in a business-cycle model that features a financial friction. The financial friction is modeled as a collateral constraint for the firm's need for working capital. The quantitative result based on Bayesian estimation suggests that all the estimates in C-model and S-model fall within the perceived values in macroeconomics, and actual data show that the firm needs working capital by 7% out of the value of the entire asset. The different dynamic responses of output follow from the different dynamic responses of hours in the short run: C-model shows a smaller increase in hours than S-model, resulting in a smaller rise in output. This result translates into the smaller output multiplier in C-model. The fact that the presence of financial friction delivers different macroeconomic outcomes implies that taking account of this friction can help give a better grasp of the effects of fiscal policy as well as other topics.

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Appendix: Steady-state cutoff value of the collateral constraint

The Lagrange multiplier φ for the collateral constraint should be positive for a binding constraint. The firm's first-order conditions for capital and labor deliver

$$\frac{y}{k} = \frac{1-\beta\left(1-\delta\right)-\beta\varphi\theta}{\alpha\beta} \text{ and } \frac{y}{h} = \frac{1+\varphi}{1-\alpha} w \,. \tag{A1}$$

Using the production function, collateral constraint and real wage yields

$$\frac{y}{k} = \frac{\theta\left(1+\varphi\right)}{1-\alpha} \,. \tag{A2}$$

Plugging y/k in (A1) into (A2) and solving for φ give

$$\varphi = \frac{\left(1-\alpha\right)\left(1-\beta+\beta\delta\right)-\alpha\beta\theta}{\theta\beta} \,. \tag{A3}$$

The binding-constraint restriction $\varphi > 0$ finally produces the upper limit of a fraction of the total value of collateral asset:

$$\theta < \frac{\left(1-\alpha\right)\left(1-\beta+\beta\delta\right)}{\alpha\beta} \,. \tag{A4}$$