Time-to-build, consumption complementarity, and fiscal stimulus

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Abstract

We show that time-to-build, which creates a time gap between government spending and the accumulation of public goods, is an important element that weakens the effectiveness of fiscal stimulus. In the environment where private consumption and public goods are Edgeworth complements, adding time-to-build to the model delays the timing of utility-enhancing effects of an increase in government expenditure, leading households to shift consumption from today to the future. The expansionary effect of government spending is hence dampened, which contrasts existing studies with Edgeworth complementarity between private and public consumption.

Keywords: time-to-build, consumption complementarity, government spending.
JEL Codes: E62, H50.

1 Introduction

The effects of fiscal stimulus via an increase in government spending have received considerable attention in the macroeconomic literature. The most widely recognized obstacles which prevent fiscal stimulus from being effective are the negative wealth effect and implementation lags in spending. The negative wealth effect crowds out private consumption by lowering households' permanent income. Implementation lags can potentially turn the output responses to be negative to an increase in government spending (Leeper et al., 2010 and Erceg

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and Linde, 2014), because it may miss the best timing to counteract economic downturns when resources are underutilized.

Recent development in macroeconomics has paid particular attention to finding mechanisms that overcome these obstacles and help to replicate the empirically relevant "crowding-in" effects of government spending.[1] In contrast, researchers pay less attention to searching for other possible obstacles that dampen the effectiveness of fiscal stimulus. However, finding out these obstacles is important in both fully understanding the effects of government spending and providing correct policy implications.

This paper contributes to the on-going debate by illustrating a new factor that can weaken the effects of fiscal stimulus: the time-to-build nature of public goods. Different from models with implementation lags that emphasize the time gap between the announcement and actual implementation of policies, we focus on the time gap between government spending and the accumulation of public goods. We show that the short-run effect of government spending on private consumption can be negative even with the factors that can generate "crowding-in" effects, if we take into account the time-to-build nature of public goods. In particular, this paper uses the complementarity between private and public goods as an example. Intuitively, an increase in current government spending will build up public capital in the future which will increase the marginal utility of private consumption not today but in the future. Given the anticipation of higher marginal utility, households will shift consumption from today to tomorrow, exhibiting a negative short-run response.

Another closely related paper is Bouakez et al. (2017) that studies the implications of time-to-build of public investment. It emphasizes the role of public investment on production, whereas the current paper focuses on the welfare-enhancing role of public goods.

2 The model

It is well recognized that traditionally defined government consumption, such as law and order and defence, directly influence households' utility derived from them. However, it is sometimes overlooked that public goods built out of government investment also provide utility services to households. The utility-enhancing role of public goods has been emphasized in Chatterjee and Ghosh (2011). For example, infrastructure such as roads and highways

[1] Existing factors include credit constrained or simply "rule-of-thumb" consumers, the zero lower bound, "deep habits", and Edgeworth complementarity between private and public goods (Galí et al., 2007; Eggertsson and Woodford, 2006; Woodford, 2011; Christiano et al., 2011; Ravn et al., 2006, 2012; Zubairy, 2014; Bouakez and Rebei, 2007; Féve et al., 2013).

could be a valuable source of utility to consumers. Moreover, better highways may increase vacations taken and therefore vacation spending. Hence they complement private consumption. Other aspects of public goods built from government investment such as parks, public transportation, and public education facilities, also provide utility services to households and can be complementary to private spending. Following Chatterjee and Ghosh (2011), we let both types of public goods enter households' utility function. Let G_t^C and G_t^P denote the amount of public goods formed from government consumption and investment, respectively. Hence, $G_t^C + G_t^P$ is the total amount of public goods in the economy. The representative household maximizes lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{1}{1-\gamma} \widetilde{C}_t^{1-\gamma} - \theta \frac{L_t^{1+\kappa}}{1+\kappa} \right)$$

where L_t denotes hours worked and $\widetilde{C}_t$ is a constant-elasticity-of-substitution (CES) composite of private consumption, C_t, and public goods, $G_t^C + G_t^P$.

$$\widetilde{C}_t = \left\{ \psi \left(C_t \right)^{\frac{\nu-1}{\nu}} + (1-\psi) \left(G_t^C + G_t^P \right)^{\frac{\nu-1}{\nu}} \right\}^{\frac{\nu}{\nu-1}}$$

where $\nu \in (0, \infty)$ measures the elasticity of substitution between private consumption and public goods.[2]

The representative household earns labor and capital incomes and pays lump-sum taxes, T_t. The household's budget constraint is

$$C_t + I_t = w_t L_t + r_t K_t - T_t$$

where w_t is the real wage and r_t is the real rental rate of capital. The law of motion for private capital is given by

$$K_{t+1} = (1-\delta) K_t + I_t$$

The representative firm hires labor and rents capital to produce $Y_t = K_t^{\alpha} L_t^{1-\alpha}$ and maximizes periodic profit.

[2] As $\nu \to 0$, private goods and public goods become perfect complements. As $\nu \to \infty$, they become perfect substitutes. The complementarity between private consumption and public goods/spending has been explored in a number of papers, including Bouakez et al. (2017), Chatterjee and Ghosh (2011), and Féve et al. (2013).

The government's budget constraint is

$$G_t = G_t^C + G_t^I = T_t$$

where G_t^C is government consumption and G_t^I is government investment. Total government spending is assumed to follow the process

$$\ln G_t = (1 - \rho_G) \ln G + \rho_G \ln G_{t-1} + \varepsilon_t^G$$

We assume that in each period, the government allocates a constant fraction of total spending to consumption, i.e.

$$G_t^C = \xi G_t$$

It follows that $G_t^I = (1 - \xi) G_t$.

The law of motion for the stock of public goods built from government investment is given by

$$G_{t+1}^P = (1 - \delta) G_t^P + G_t^I$$

Note that in addition to G_t^C, this type of public goods also enters the utility function of households. However, it takes time for the stock to pile up. In contrast, in Bouakez and Rebei (BR) (2007) and Féve et al. (2013), government spending, which is essentially government consumption in this paper, enters the utility function. This gradual accumulation of public goods from government investment is the time-to-build feature of public goods.[3]

The resource constraint of the economy is

$$Y_t = C_t + I_t + G_t^C + G_t^I$$

Set the preference parameters β, γ, and θ to 0.99, 2, and 1, respectively. The elasticity of output with respect to capital, α, the depreciation rate, δ, and the weight of private consumption in the effective consumption composite, ψ, are set to 0.36, 0.025, and 0.8 respectively. The elasticity of wages with respect to hours, κ, is set to 0.2, consistent with an elasticity of wages with respect to output of 0.3 as in Rotemberg and Woodford (1997, 1999), combined with an elasticity of output with respect to hours of 0.67. The elasticity of substitution between private goods and public goods, ν, is set to 0.25, which is the value used in BR (2007). Next, the autocorrelation coefficient, ρ_G, is assumed to be 0.9. Finally,

[3]The time-to-build feature was first introduced in Kydland and Prescott (1982).

the steady-state ratio of government consumption to output, γ_g^C, and that of government investment to output, γ_g^I, are set to 0.144 and 0.038, which are means of U.S. quarterly data reported in Leeper et al. (2010). It follows that $\xi = \gamma_g^C / \left(\gamma_g^C + \gamma_g^I\right) = 0.7912$.

3 Effects of government spending shocks

Let λ_t denote the Lagrange multiplier associated with the household's budget constraint. Variables with a hat represent log-deviations from steady state. The effect of a change in the total quantity of public goods, $G_t^F \equiv G_t^C + G_t^P$, on the marginal utility of consumption is

$$\frac{\partial \hat{\lambda}_t}{\partial \hat{G}_t^F} = \left(\frac{1}{\nu} - \gamma\right) \left[1 - \frac{\psi \left(\gamma_c\right)^{1-\frac{1}{\nu}}}{\psi \left(\gamma_c\right)^{1-\frac{1}{\nu}} + (1-\psi)\left(\gamma_g^C + \gamma_g^I/\delta\right)^{1-\frac{1}{\nu}}}\right]$$

where γ_c is the steady state ratio of private consumption to total output. Recall that ν is the elasticity of substitution between private consumption and public goods. Consistent with BR (2007), as long as $\nu < \frac{1}{\gamma}$, we have that $\frac{\partial \hat{\lambda}_t}{\partial \hat{G}_t^F} > 0$ and hence private consumption and public goods are Edgeworth complements. In this case, an increase in the amount of public goods raises the marginal utility of private consumption.

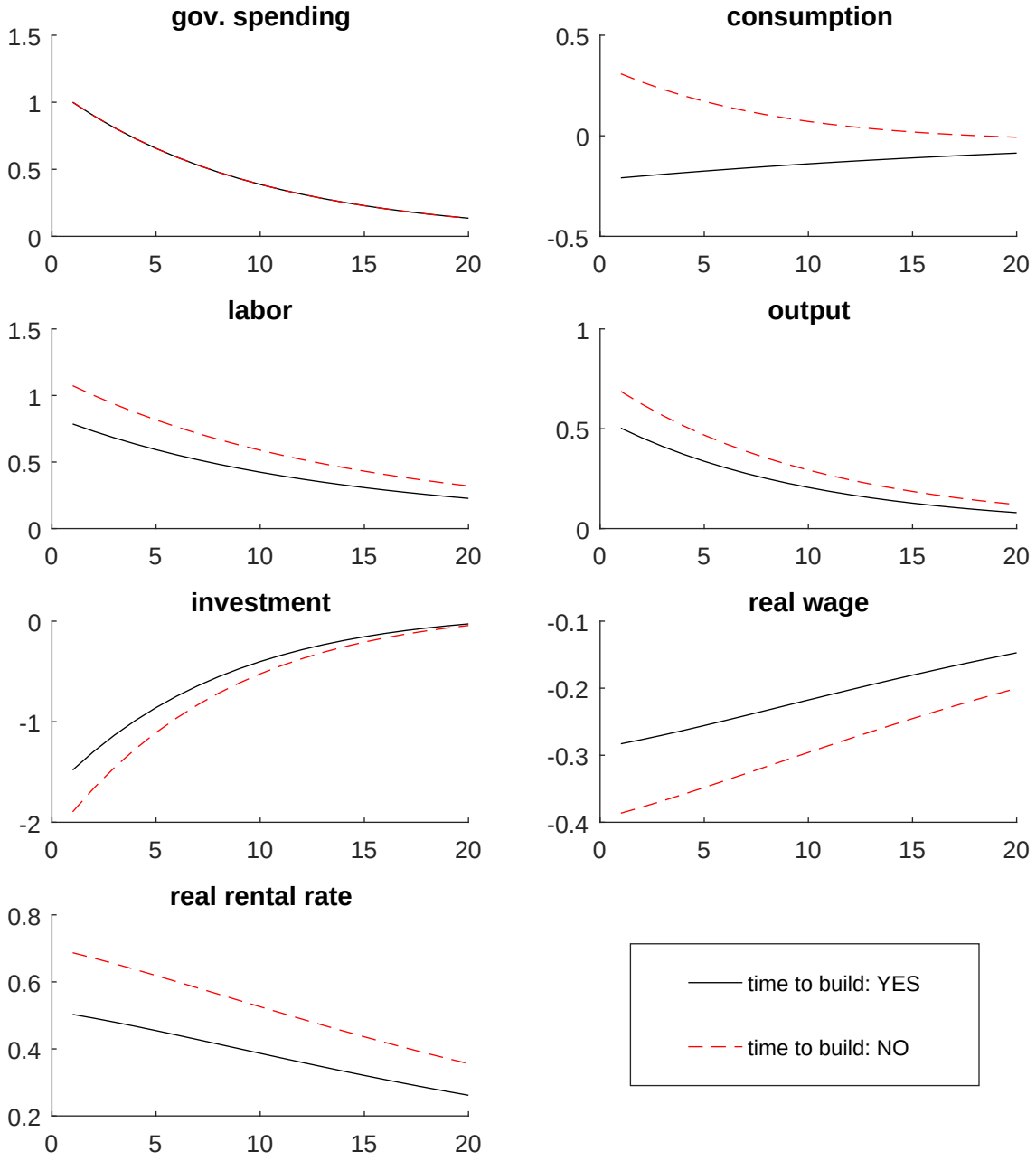
3.1 The role of time-to-build

First, we consider a variant of the model without the time-to-build feature. Set $\xi = 1$ so that $G_t = G_t^C$. Then the model essentially becomes the baseline model in BR (2007), where only one type of public goods enters the CES aggregator.[4] A strong complementarity ($\nu = 0.25$) is able to produce a positive response of private consumption, meaning that the complementarity effect dominates the negative wealth effect. The dashed lines in Figure 1 replicate impulse responses of the BR (2007) model with $\nu = 0.25$.

Next, we move to our time-to-build model. The solid lines in Figure 1 represent impulse responses of the model where both types of public goods enter the utility function. When government spending increases, there are two opposing forces affecting private consumption. On the one hand, an increase in G_t^C increases private consumption, which is the same mechanism as in BR (2007). On the other hand, an increase in G_t^I decreases private consumption. Because of the time-to-build feature, G_t^P cannot change on impact. Since

[4] BR (2007) also add habit formation to their baseline model in order to generate a hump-shaped response of private consumption. We abstract from habit formation and focus on the sign of the consumption response.

Figure 1: Response of economy to a government spending shock



Notes: The size of the spending shock is normalized to 1% of steady state output. All other variables are measured in percentage deviation from the steady state.

households anticipate that the stock of public goods will pile up in the future, they reduce their current consumption accordingly, aiming at shifting today's consumption into the future. Therefore, the complementarity between private consumption and the stock of public goods built from government investment actually works towards reducing contemporaneous private consumption.

As shown in Figure 1, the time-to-build mechanism dominates and it flips the sign of private consumption. The dominance of time-to-build is not surprising. Although the size of government consumption is four times as large as that of government investment, the amount of public goods built out of government investment is much larger than that formed from government consumption. This is because the former is a stock variable whereas the latter is a flow variable.

With time-to-build turning consumption from positive to negative, households' motivation of supplying more labor to support larger consumption is mitigated, leading to a smaller increase in labor supply. As a result, the increase in output is also smaller and firms face a higher real wage. Moreover, households do not have to dissave as much as in the BR (2007) model to back up more consumption. Hence, investment decreases less and the real rental rate increases to a smaller extent. Overall, adding time-to-build weakens the effects of a positive fiscal shock.[5]

3.2 Productive public goods

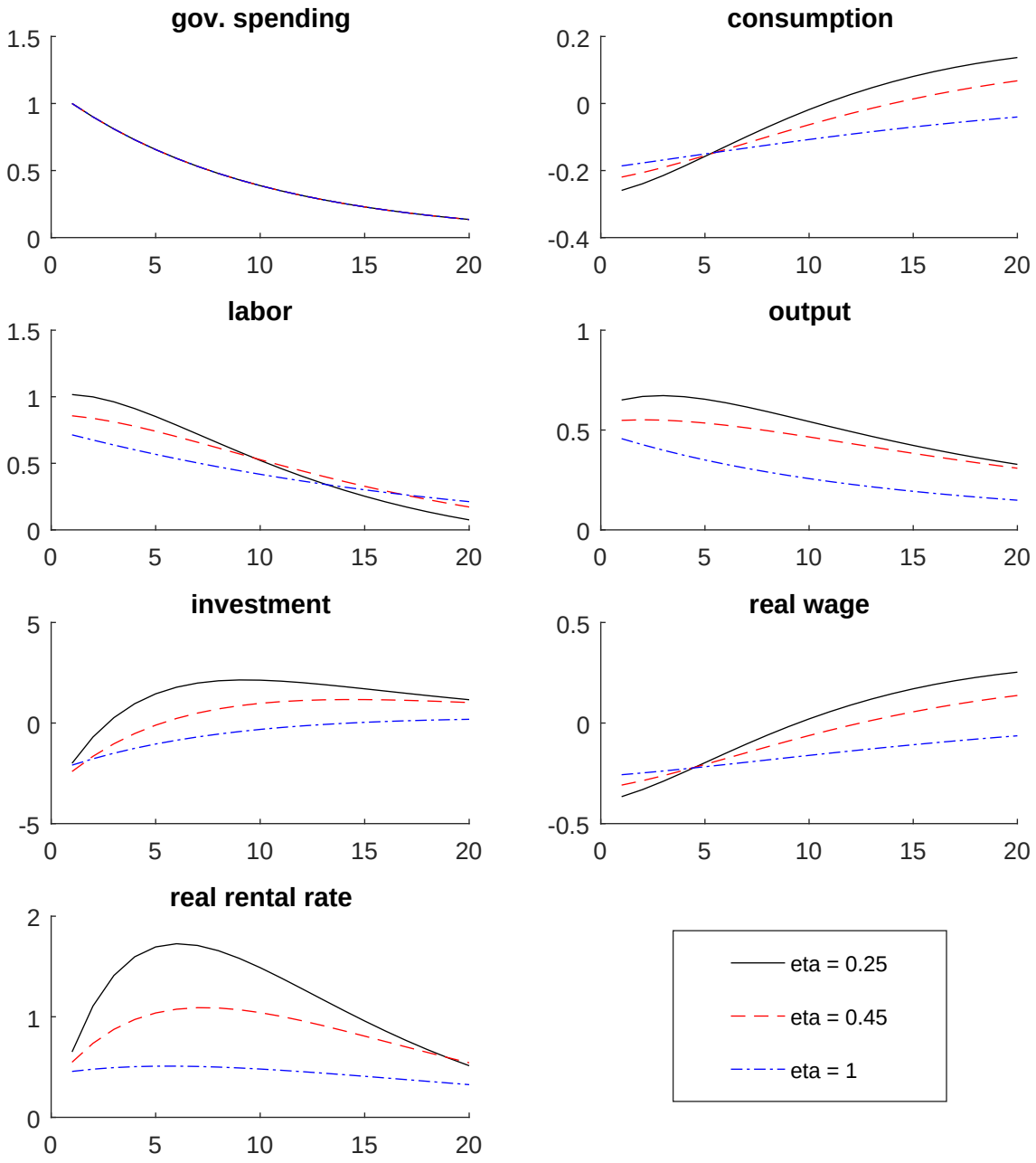
The other role of public goods is to serve as an external input in the production function. We model this role by assuming that private capital and public goods built out of government investment serve as factors of production using a CES technology.

$$\widetilde{K}_t = \left\{ \omega \left(K_t\right)^{\frac{\eta-1}{\eta}} + (1-\omega) \left(G_t^P\right)^{\frac{\eta-1}{\eta}} \right\}^{\frac{\eta}{\eta-1}}$$

where η is the elasticity of substitution between private capital and public goods. An increase in government investment then has additional effects similar to those of an anticipated technology shock. On the one hand, it exerts upward pressure on the return of private savings, encouraging households to raise investment and cut current consumption. On the other

[5]Montgomery (1995) finds that it takes five to six quarters on average for U.S. nonresidential structures to be constructed over the period 1961-1991. We have examined impulse responses of the economy by varying the time span it takes for the stock of public goods to be accumulated from government investment. We find that the longer it takes to pile up public goods, the smaller private consumption will be before returning to steady state.

Figure 2: Impulse responses under productive public goods



Notes: The size of the spending shock is normalized to 1% of steady state output. All other variables are measured in percentage deviation from the steady state.

hand, it increases aggregate demand even before public goods become productive by increasing expected income of households. The effectiveness of fiscal stimulus hence depends on the relative importance of these two forces, as well as the forces generated by the utility-enhancing role of public goods.

Following Chatterjee and Ghosh (2011), we set ω to 0.8. We consider different scenarios by setting η to 0.25, 0.45, and 1, respectively. Figure 2 shows that in all cases, private consumption and the real wage still exhibit negative responses on impact. The long-run responses depend on the elasticity of substitution between private capital and public goods. When this elasticity is smaller, the real rental rate increases by more, bringing a larger substitution effect between savings and consumption on impact and a stronger wealth effect in the long run. Hence, private consumption and the real wage decrease more in the short run, whereas they increase in the long term. The responses of labor, investment, and output are also governed by the real rental rate. Overall, our main result is robust to the inclusion of productive public goods.

4 Conclusion

We have shown that adding the time-to-build feature to BR (2007) and Féve et al. (2013) reverses the sign of private consumption from positive to negative. Anticipating a larger stock of pubic goods in the future, households shift current consumption into the future, because private consumption and public goods are Edgeworth complements. This paper proposes time-to-build as a potential factor that mitigates the stimulative effects of fiscal policy. The role of time-to-build can also be explored under other contexts which generate a positive consumption response following a spending shock, such as the presence of rule-of-thumb consumers. This is left to future research.

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