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## Wagner-Keynesian Nexus in a DSGE Model

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## Abstract

This research integrates two longstanding controversies, Wagner's law and Keynesian hypothesis, into a dynamic stochastic general equilibrium (DSGE) model. The former perceives that government spending endogenously varies with output growth, while the latter considers that government spending exogenously triggers economic growth. We show that these two standpoints will gradually coincide as private consumption and public expenditure become more substitutable.

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# 1. Introduction

Keynes perceived government spending as an exogenous force to trigger economic growth. In the conventional dynamic stochastic general equilibrium (DSGE) model, government spending is usually assumed to be autonomous and exogenous, following an AR(1) process or a feedback fiscal policy rule (Christiano and Eichenbaum 1992, Gali et al. 2007, Davig and Leeper 2011, Feve and Sahuc 2015, Leeper et al. 2017). However, Wagner's law, named after the German economist Adolph Wagner (1883, 1893), states that the government expenditure endogenously increases with output. As the economy develops, the demand for public expenditures for social protection and regulation on private activities will expand. The government is also expected to manage natural monopolies and provide more public goods or income-elastic goods such as education and culture for helping the economy operate more efficiently (Irandoust 2019). Hence, from Wagner's perspective, government spending moves with output in a procyclical fashion. The expansion of government expenditure is deemed as an inevitable outcome of national income growth. Wagner's law has been empirically documented in the literature (Bird 1971, Lin 1995, Lane 2003, Antonis et al. 2013, Irandoust 2019, Sedrakyan and Varela-Candamio 2019, Sagdic et al. 2020).

Although abundant literature empirically examines the Wagner and Keynesian hypotheses, the theoretical analysis is still scarce. Wagner's law focuses on a long-term relationship between government spending and output; while the Keynesian considers government spending as an in-built automatic stabilizer to moderate short-run output fluctuations. Wagner's law predicts a causality running from the national income to government spending, while the Keynesian regards public expenditures as a cause of national income growth. Sedrakyan and Varela-Candamio (2019) analyze whether there exist unidirectional or bidirectional causal relationships between government spending and economic growth in Armenia and Spain. Their results provide evidences for Wagner's law in the long-term perspective and for the Keynesian hypothesis during recessions. The endogeneity or exogeneity of government spending affects the cyclicality of fiscal policy. Lane (2003) states that if government spending is endogenized into a household's utility function, government spending is expected to be countercyclical when government spending and private consumption are substitutes, and procyclical when government spending and private consumption are complements. Gali et al. (2007) show that when government spending is exogenous and financed with lump-sum taxes, an increase in government spending creates a negative wealth effect and reduces private consumption. Higher government spending generates an expansionary force, so government spending moves procyclically with output.

Our novelty in this paper is to integrate the aforementioned two standpoints into a DSGE model and investigate the impacts of a Keynesian shock (namely, one triggered by exogenous government spending) and a Wagner shock (namely, an increasing ratio of government expenditure to output growth) on the economy. We decompose the government spending into an autonomous component and a cyclical component. The autonomous (Keynesian) component focuses on the nonproductive government purchases of goods and services following a common AR(1) formulation. The cyclical (Wagner) component dwells on the public provision of income elastic services and moves procyclically with output.

Our results indicate that private consumption declines following positive Keynesian shocks and increases following positive Wagner shocks when private consumption and government spending have a low substitutability. Greater public expenditure associated with more taxes creates a negative wealth effect and decreases private consumption. Nevertheless, when cyclical government spending is incorporated into a household's utility function, the crowding-in effect on consumption in response to expansionary fiscal shocks is reinforced. Wagner shocks generate positive impact on consumption and larger impacts on output and inflation than Keynesian shocks. As private consumption and government spending become more substitutable, the effects of Keynesian shocks and Wagner shocks on the economy become more similar.

# 2. Model

## 2.1 Households

The objective of the representative household is to maximize

$$E_0\left\{\sum_{t=0}^{\infty}\beta^t\left[\frac{\left(X_t\right)^{1-\sigma}}{1-\sigma}-\chi\frac{N_t^{1+\eta}}{1+\eta}\right]\right\} \tag{1}$$

$$X_t=\left[\alpha_C^{\frac{1}{v}}\left(C_t\right)^{\frac{v-1}{v}}+\left(1-\alpha_C\right)^{\frac{1}{v}}\left(G_{I,t}\right)^{\frac{v-1}{v}}\right]^{\frac{v}{v-1}} \tag{2}$$

where $\beta$ is the discount factor, $X_t$ is a composite consumption good, $N_t$ represents labor hours, $\sigma$ is the inverse of the elasticity of intertemporal substitution, $\chi$ is the weight of work disutility and $\eta$ denotes the inverse of the Frisch elasticity of labor supply. The consumption bundle $X_t$ is given in (2) and includes private consumption $C_t$ and cyclical government expenditure $G_{I,t}$. $v$ governs the substitutability between private consumption and cyclical government expenditure. $\alpha_C$ is the steady-state share of private consumption in the consumption bundle.

The household budget constraint is given by

$$C_t+b_t+\left[K_t-(1-\delta)K_{t-1}\right]=w_tN_t+\frac{\left(1+r_{t-1}\right)b_{t-1}}{\pi_t}+r_t^KK_{t-1}+\Pi_t+T_t \tag{3}$$

where $b_t$ is one-period real bond holdings with a risk-free nominal interest rate $r_t$, $K_t$ is the stock of physical capital, $\delta$ is the depreciation rate of capital, $w_t$ represents the real wage, $\pi_t\equiv P_t/P_{t-1}$ is the inflation rate between $t-1$ and $t$, and $P_t$ denotes the price of consumption goods. Households own capital, rent it to intermediate goods producers and receive a rate of return $r_t^K$. Households also receive profits $\Pi_t$ from the goods-producing sector and a lump-sum transfer $T_t$ from the government.

The first order conditions are derived in equations (4)-(6). Equation (4) shows the intra-temporal condition between consumption and labor choice. Equation (5) is the inter-temporal Euler equation. Equation (6) is the optimal condition for allocating resources between buying bonds and investing in capital.

$$\chi N_t^{\eta}=X_t^{-\sigma+\frac{1}{v}}\left(\frac{\alpha_C}{C_t}\right)^{\frac{1}{v}}w_t \tag{4}$$

$$X_t^{-\sigma+\frac{1}{v}} C_t^{-\frac{1}{v}} = \beta(1+r_t) E_t\left(\frac{X_{t+1}^{-\sigma+\frac{1}{v}} C_{t+1}^{-\frac{1}{v}}}{\pi_{t+1}}\right) \tag{5}$$

$$\frac{(1+r_t)}{\pi_{t+1}} = 1-\delta+r_{t+1}^K \tag{6}$$

## 2.2 Retailers and Intermediate Goods Producers

Retailers aggregate intermediate goods into final goods and sell them to consumers in a perfectly competitive market. No input is required to combine intermediate goods. There is a continuum of intermediate goods producers indexed by $j$ , $j \in (0,1)$ , operating in a monopolistically competitive market. Under Calvo's (1983) price stickiness setting, each period only a fraction $1-\lambda$ of all firms can adjust their prices. $\lambda$ is a measure of the degree of nominal rigidity. Each intermediate goods firm maximizes the expected discounted sum of profits (7) by choosing an optimal price subject to a market demand curve faced by individual firms (8) and a respective production function (9).

$$E_0 \sum_{t=0}^{\infty} (\beta\lambda)^t \frac{u'(C_{t+1})}{u'(C_t)}\left[\left(\frac{P_{j,t}}{P_t}\right) Y_{j,t} - mc_t Y_{j,t}\right] \tag{7}$$

$$Y_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\theta} Y_t \tag{8}$$

$$Y_{j,t} = Z_t N_{j,t}^{\varepsilon} K_{j,t}^{1-\varepsilon} \tag{9}$$

Here, $mc_t$ represents the marginal cost per unit and $\theta$ refers to the elasticity of substitution between any two differentiated goods. $Z_t$ is the total factor productivity and is assumed to be identical across firms. $\varepsilon$ governs the extent of the decreasing returns to scale for labor. Assuming that all firms have identical marginal costs, the marginal cost is given in (10).

$$mc_t = \frac{1}{Z_t}\left(\frac{w_t}{\varepsilon}\right)^{\varepsilon}\left(\frac{r_t^K}{1-\varepsilon}\right)^{1-\varepsilon} \tag{10}$$

In a symmetric equilibrium, firms which are able to adjust prices will charge the same optimal price $P_t^*$ . The price markup over nominal marginal cost is given by (11).

$$\frac{P_t^*}{P_t} = \frac{\theta}{\theta-1} mc_t \tag{11}$$

## 2.3 Monetary and Fiscal Authority

The government's budget constraint is expressed as equation (12). Government expenditure $G_t$ and lump-sum transfer $T_t$ are financed through debt insurance.

$$b_t - (1+r_{t-1})b_{t-1} = G_t + T_t \tag{12}$$

Modified from Feve and Sahuc's version (2015), the decomposed government expenditure is defined in (13). $G_{A,t}$ represents an autonomous component capturing the insight rooted in Keynesian principles that exogenous government spending produces a multiplier effect on aggregate demand. We assume that $G_{A,t}$ follows an AR(1) process and consider the shock to $G_{A,t}$ as a Keynesian shock. $G_{I,t}$ represents the cyclical component focusing on the provision of income-elastic public goods. It varies with output and is given by (14).

$$G_t = G_{A,t} G_{I,t} \tag{13}$$

$$G_{I,t} = \gamma_t \left(Y_t\right)^{\alpha_G} \tag{14}$$

Here, $\gamma_t$ is a time-varying share of government expenditure in output. $\alpha_G$ governs responsiveness of government spending to output. Wagner's law predicts that the share will increase as the economy develops over time. We assume $\gamma_t$ follows an AR(1) process and describe the shock imposed on $\gamma_t$ as a Wagner shock.

## 2.4 Equilibrium

Equation (15) represents the equilibrium condition in the goods market. Equation (16) defines investment. Equation (17) implies the net supply of debt issued by the government is zero.

$$Y_t = C_t + I_t + G_t \tag{15}$$

$$I_t = K_t - (1-\delta) K_{t-1} \tag{16}$$

$$b_t = 0 \tag{17}$$

# 3. Calibration Methodology

Table 1 presents the baseline parameters for the benchmark model. Most parameters are set in accordance with the standard DSGE literature (Smets and Wouters 2007, Monacelli 2009, Ireland 2014). Noteworthily, the elasticity of substitution between private consumption and cyclical government spending is set to be 0.25 in order to strengthen the Edgeworth complementarity between private and public spending (Bouakez and Rebei 2007). Alternative values of 0.50 and 0.80 are used for comparison. The steady-state share of private consumption in the consumption bundle is 0.80 in accordance to Bouakez and Rebei (2007). The persistency of the government spending shocks is set to be 0.50. The standard deviations of the shocks are 0.1. Referring to Feve and Sahuc (2015), the responsiveness of cyclical government spending to output is set to be 0.80. The calibrated steady-state values are summarized in Table 2.

# 4. Results

Figure 1 shows the impulse responses of major variables to Keynesian shocks and to Wagner shocks of a 10% standard deviation in the benchmark case ($v = 0.20$). Solid lines represent Keynesian shocks and dashed lines represent Wagner shocks. Output and labor hours increase and wage falls on impact. Expansionary government spending is associated with increasing taxes and creates a negative wealth effect. Households respond by working more so that real wage decreases. Private consumption declines following Keynesian shocks and increases following Wagner shocks when private consumption and public expenditure have a low substitutability. Since marginal cost is a driving force behind inflation in a New Keynesian model, an increase in government spending boosts the marginal cost and inflation. An increase in the rate of return on capital (equivalently, borrowing cost) dampens capital investment and capital accumulation. When the substitutability between private consumption and public spending increases to 0.5 and 0.8, as in figures 2 and 3, respectively, the effects of Keynesian and Wagner shocks on major variables are similar. They both reduce consumption, wage and capital stock. Output, labor hours, interest rate, rate of return on capital and inflation increase on impact.

As implied by the optimality conditions (4) and (5), a higher (lower) degree of substitutability between private consumption and government expenditure decreases (increases) the marginal benefit of an additional hour of work and decreases (increases) the marginal benefit of an additional unit of current consumption. Hence, private consumption tends to increase in response to a Wagner shock when private consumption and government expenditure have a low degree of substitutability. Intuitively, when government expenditure is less substitutable to private consumption, households are more reluctant to pay taxes for financing government expenditure. The negative wealth effect of increasing government expenditure on private consumption is mitigated. When government expenditure becomes more substitutable to private consumption, households are willing to pay taxes for financing government expenditure so that private consumption decreases and the effect of a Wagner shock on private consumption coincides with that of a Keynesian shock.

## 5. Conclusions

This research provides a theoretical framework to investigate a longstanding dispute concerning government spending and economic growth. By decomposing government spending into two components and embodying the cyclical component into a household's utility, we show that these two standpoints can be reconciled with greater substitutability between private consumption and government expenditure.

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Table 1 Baseline Parameters (Benchmark model)

| Parameters | Values | Description |
|---|---|---|
| $\beta$ | 0.99 | Discount factor |
| $\eta$ | 1 | Inverse of the Frisch elasticity of labor supply |
| $\chi$ | 3.70 | Weight of work in the utility function |
| $\theta$ | 6 | Elasticity of substitution between any two differentiated goods |
| $\lambda$ | 0.75 | Degree of nominal price rigidity |
| $\alpha_C$ | 0.80 | Steady-state share of private consumption in consumption bundle |
| $\alpha_G$ | 0.80 | Responsiveness of government spending to output |
| $\nu$ | 0.20 | Substitutability between private and public consumption |
| $\sigma$ | 2 | Inverse of the elasticity of intertemporal substitution |
| $\varepsilon$ | 0.70 | Degree of decreasing returns to scale for labor |
| $\rho_R$ | 0.80 | Weight imposed on the lagged policy rate |
| $\kappa_\pi$ | 1.50 | Coefficient of inflation in the Taylor rule |
| $\kappa_Y$ | 0.50 | Coefficient of output gap in the Taylor rule |
| $\delta$ | 0.025 | Depreciation rate of capital |

Table 2 Calibrated Steady-State Values (Benchmark model)

| Variables | Steady-State Values | Description |
|---|---|---|
| $\bar{N}$ | 0.33 | Hours worked |
| $\bar{\pi}$ | 1 | Inflation rate |
| $\bar{r}$ | 1.01 | Interest rate |
| $\bar{r}^K$ | 0.035 | Rate of return for providing capital |
| $\bar{w}$ | 1.355 | Real wage |
| $\bar{Z}$ | 1 | Productivity |
| $\bar{Y}$ | 1 | Total production |
| $\bar{C}$ | 0.586 | Private consumption |
| $\bar{X}$ | 0.509 | Total consumption |
| $\bar{K}$ | 8.571 | Stock of capital |
| $\bar{I}$ | 0.214 | Investment in capital stock |
| $\bar{G}_A$ | 1 | Autonomous government spending |
| $\bar{G}_I$ | 0.20 | Cyclical government spending |
| $\bar{\gamma}$ | 0.20 | Steady-state share of government expenditure in output |
| $\overline{mc}$ | 0.833 | Marginal cost |

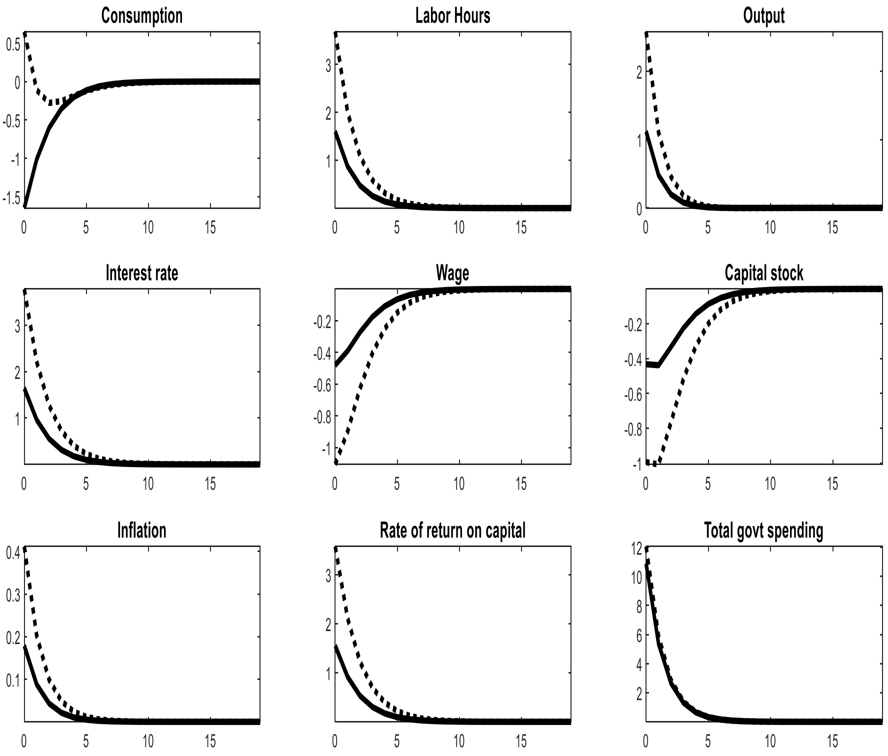


Figure 1 Impulse Responses to Government Spending Shocks ($v = 0.20$)
Solid Line: Keynesian shocks. Dotted Line: Wagner shocks. Impulse responses shown on the graph are multiplied by 100. Each government spending shock has a standard deviation of 0.10 and a persistency of 0.50.

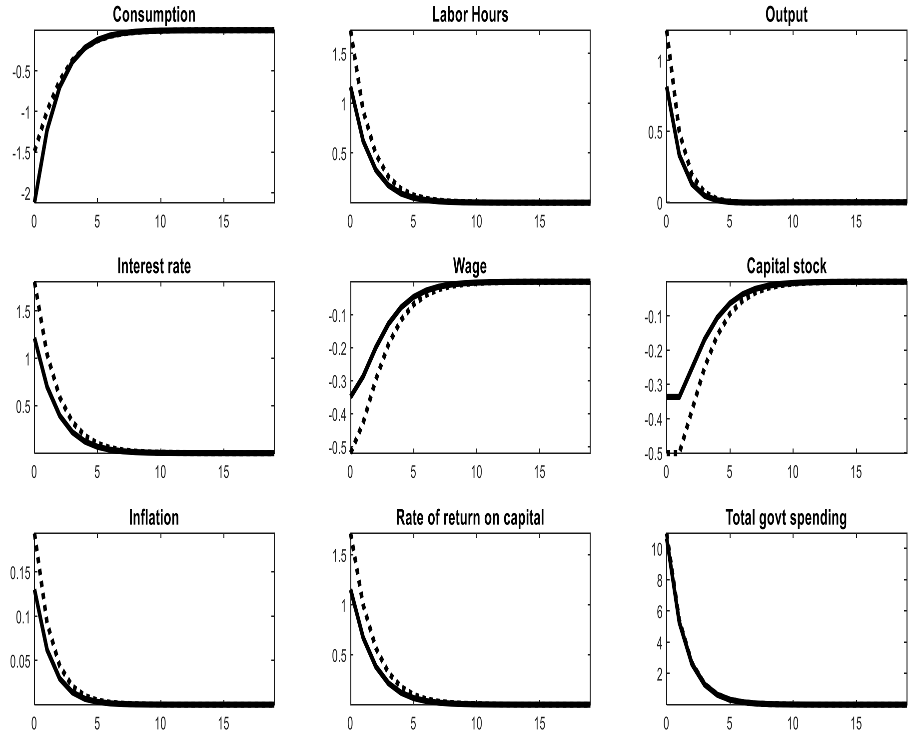


Figure 2 Impulse Responses to Government Spending Shocks ($v = 0.50$)
Solid Line: Keynesian shocks. Dotted Line: Wagner shocks. Impulse responses shown on the graph are multiplied by 100. Each government spending shock has a standard deviation of 0.10 and a persistency of 0.50.

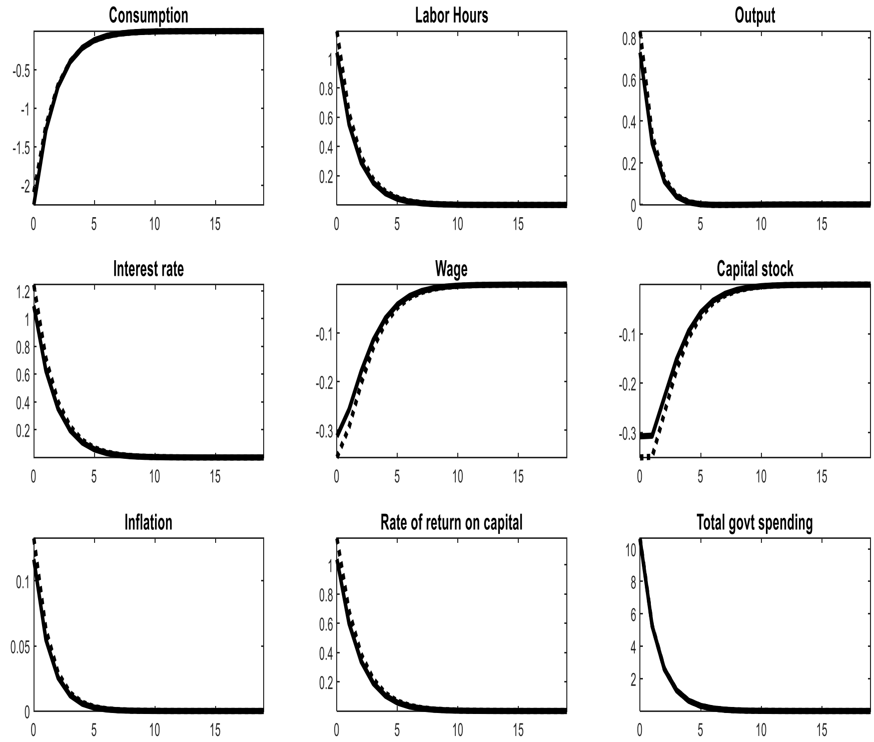


Figure 3 Impulse Responses to Government Spending Shocks ($\upsilon = 0.80$)
Solid Line: Keynesian shocks. Dotted Line: Wagner shocks. Impulse responses shown on the graph are multiplied by 100. Each government spending shock has a standard deviation of 0.10 and a persistency of 0.50.