Real Business Cycles and Automatic Stabilizers*

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Abstract

We show that in a standard, technology shock-driven one-sector real business cycle model, the stabilization effects of government fiscal policy depend crucially on how labor hours enter the household's period utility function and the associated labor-market behavior. In particular, when the household utility is logarithmic in both consumption and leisure, income taxes are destabilizing and government purchases are stabilizing. However, the results are reversed when preferences are instead convex in hours worked. That is, income taxes are now stabilizing and public spending is destabilizing. Furthermore, under both preference specifications, the magnitude of cyclical fluctuations in output remains unchanged when the income tax rate and the share of government purchases in GDP are equal (including laissez-faire).

Keywords*:* Real Business Cycles, Automatic Stabilizers.

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1 Introduction

The traditional Keynesian view of automatic stabilizers emphasizes the role of taxes and transfers in mitigating cyclical fluctuations in disposable income and consumption, without explicitly analyzing the effects of fiscal policy on the volatility of total output.[1] Partly motivated by this gap in the literature, Galí (1994) presents empirical evidence that demonstrates a discernible negative relationship between government size, as measured by the income tax rate or the share of government purchases in GDP, and the magnitude of output fluctuations in a sample of OECD countries between 1960 and 1990. Subsequently, Fatás and Mihov (2001) show that Galí's findings are robust to (i) an expanded data set that ends at 1997, (ii) the inclusion of a more extensive list of explanatory variables (i.e., potential omitted variables bias), and (iii) the possibility of reverse causality (i.e., potential endogeneity bias).[2] These empirical results illustrate that both income taxes and public spending have been effectively working as automatic stabilizers in OECD economies.

In this paper, we examine the effects of income taxes and government purchases on output variability in two versions of the canonical one-sector real business cycle (RBC) model driven by highly persistent technology shocks. The two models differ only in terms of how labor hours enter the household's period utility function, which is consistent with balanced growth in both cases. In particular, Model 1 follows Galí (1994) by postulating that the household utility is logarithmic in both consumption and leisure; and Model 2 exhibits a preference formulation that is also logarithmic in consumption, but convex in hours worked. It turns out that this small difference has an important impact on the business cycle effects of government fiscal policy.

As Galí (1994) has shown, income taxes are destabilizing and government purchases are stabilizing in our Model 1. To understand this result, we first note that the labor supply elasticity is inversely related to the steady-state labor hours under the "log-log" utility specification. Therefore, a higher income tax rate lowers the steady-state employment through its negative effect on the after-tax real wage, which in turn raises the labor supply elasticity and enhances the response of hours worked to a given technology shock (the *employment effect*).

[1] See, for example, Burns (1960), Baily (1978), and DeLong and Summers (1986), among many others.

[2] Rodrik (1998) argues that Galí's regressions of an economy's output volatility on the size of its government are misspecified because the causality should be reversed. Specifically, in open economies which are inherently more volatile, households will tend to vote for a larger government in order to minimize their exposure to external risk. In light of this criticism, Fatás and Mihov (2001), using the instrumental variable estimation method, show that the stabilization effects of government size actually become stronger after accounting for possible endogeneity.

As a result, output variability is positively related to the income tax rate.

On the other hand, an increase in the output share of government purchases shifts the labor supply curve outward because of a negative wealth effect. This will cause the steady-state labor hours to rise and the labor supply elasticity to fall, thereby resulting in a smaller employment effect. Hence, output variability is negatively related to the share of public spending in GDP. In sum, when the period utility function is logarithmic in both consumption and leisure, income taxes behave as *automatic destabilizers*, and government purchases behave as *automatic stabilizers*.

Quite interestingly, our Model 2 shows qualitatively opposite results to those in Model 1. That is, income taxes are now stabilizing and government purchases are destabilizing. To understand this finding, we first note that unlike in Model 1, the labor supply elasticity is a constant, governed by a preference parameter, under the "convex in hours" utility specification. Next, start with the equilibrium under laissez-faire, and suppose that the economy is subject to a positive technology shock. This shifts out the labor demand curve, and raises labor hours. Other things being equal, an increase in the income tax rate will cause a leftward shift of the labor supply curve. Hence, the initial response of employment to a positive productivity disturbance is dampened, resulting in a smaller change in hours worked and therefore output. On the contrary, an increase in the output share of public spending shifts out the labor supply curve, which reinforces the initial employment effect, and leads to a larger variation in labor hours and GDP. In sum, when the period utility function is logarithmic in consumption and convex in hours worked, income taxes behave as *automatic stabilizers*, and government purchases behave as *automatic destabilizers*.

We also find that in both models, the magnitude of cyclical fluctuations in output remains unchanged when the income tax rate and the share of government purchases in GDP are equal (including laissez-faire). Intuitively, identical changes in the above two fiscal variables do not affect the steady-state labor hours or the labor supply elasticity in Model 1; and generate offsetting leftward and rightward shifts of the labor supply curve in Model 2. As a result, output variability is independent of government size in this special case. Overall, our analysis illustrates that in the context of standard one-sector RBC models, the stabilization effects of fiscal policy depend crucially on how hours worked enter the household utility function and the associated labor-market behavior.

The remainder of this paper is organized as follows. Section 2 describes the model economy and analyzes the equilibrium conditions. Section 3 calibrates the model's parameters and

discusses simulation results. Section 4 concludes.

2 The Model

2.1 Firms

There is a continuum of identical competitive firms in the economy, with the total number normalized to one. Each firm produces output y_t using a constant returns-to-scale Cobb-Douglas production function

$$y_t = z_t k_t^{\alpha} h_t^{1-\alpha}, \quad 0 < \alpha < 1, \tag{1}$$

where k_t and h_t are capital and labor inputs, respectively. In addition, z_t represents the technology shock that is assumed to evolve according to

$$z_{t+1} = z_t^{\lambda} \varepsilon_{t+1}, \;\; 0 < \lambda < 1 \;\text{ and }\; z_0 \text{ is given}, \tag{2}$$

where ε_t is an i.i.d. random variable with unit mean and standard deviation σ_{ε}.[3]

Under the assumption that factor markets are perfectly competitive, the firm's profit maximization conditions are given by

$$r_t = \alpha \frac{y_t}{k_t}, \tag{3}$$

$$w_t = (1-\alpha) \frac{y_t}{h_t}, \tag{4}$$

where r_t is the capital rental rate and w_t is the real wage.

2.2 Households

The economy is populated by a unit measure of identical infinitely-lived households, each endowed with one unit of time. The representative household maximizes its expected lifetime utility

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t U(c_t, h_t) \right], \; 0 < \beta < 1, \tag{5}$$

[3] Galí (1994) also considers the cases with deterministic, exogenous labor-augmenting technical progress and permanent technology shocks ($\lambda = 1$). Our numerical analyses, presented in section 3, are not qualitatively sensitive to either modification.

where E is the conditional expectations operator, β is the discount factor, and c_t is consumption. In this paper, we consider the following two additively separable specifications of the period utility function $U(\cdot)$ that are commonly used in the real business cycle literature:

$$U_1 = \log c_t + A \log(1 - h_t), \ A > 0, \tag{6}$$

and

$$U_2 = \log c_t - B \frac{h_t^{1+\gamma}}{1+\gamma}, \ B > 0 \text{ and } \gamma \geq 0, \tag{7}$$

where γ denotes the inverse of the intertemporal elasticity of substitution for labor supply. Notice that U_2 becomes linear in hours worked when $\gamma = 0$, which corresponds to the "indivisible labor" formulation described by Hansen (1985) and Rogerson (1988). Moreover, it is worth emphasizing that U_1, also studied by Galí (1994), is a special case of the non-separable preferences that are consistent with balanced growth.[4] As a result, the quantitative results based on U_1, reported in section 3.1, are qualitatively robust to multiplicatively separable utility functions that exhibit CRRA consumption and are increasing in leisure (see Galí, 1994, p. 119, footnote 4).[5]

The budget constraint faced by the representative household is

$$c_t + i_t + b_{t+1} = (1 - \tau)(w_t h_t + r_t k_t) + \left[1 + (1 - \tau) r_t^b\right] b_t + T_t, \ b_0 \text{ is given}, \tag{8}$$

where i_t is investment, b_t is the one-period riskless government bond, τ is the (constant) income tax rate, r_t^b is the interest rate on risk-free bonds, and T_t is a lump-sum transfer. The law of motion for the capital stock is

$$k_{t+1} = (1 - \delta) k_t + i_t, \ \ k_0 \text{ is given}, \tag{9}$$

where $\delta \in (0, 1)$ is the capital depreciation rate.

The first-order conditions for the household's optimization problem are given by

$$A \frac{c_t}{1 - h_t} = (1 - \tau) w_t, \tag{10}$$

[4] King, Plosser and Rebelo (1988, p. 202) show that the general expression for the momentary utility function that is compatible with steady-state growth is $U = \frac{1}{1-\sigma}\left[c_t^{1-\sigma} v(1 - h_t)\right]$, for (i) $0 < \sigma < 1$ and $v(\cdot)$ is increasing and concave; or (ii) $\sigma > 1$ and $v(\cdot)$ is decreasing and convex. Our U_1 corresponds to the case with $\sigma = 1$ and $v(\cdot) = (1 - h_t)^{A(1-\sigma)}$.

[5] Greenwood and Huffman (1991) confirms this point, although their analysis focuses exclusively on the quantitative business cycle and welfare effects of labor and capital income taxation in one-sector RBC models.

$$Bc_t h_t^{\gamma} = (1-\tau)\, w_t, \tag{11}$$

$$\frac{1}{c_t} = \beta E_t \left\{ \frac{1}{c_{t+1}} \left[1 - \delta + (1-\tau) r_{t+1}\right] \right\}, \tag{12}$$

$$\frac{1}{c_t} = \beta E_t \left\{ \frac{1}{c_{t+1}} \left[1 + (1-\tau) r_{t+1}^b\right] \right\}, \tag{13}$$

$$\lim_{t\to\infty} \beta^t \frac{k_{t+1}}{c_t} = 0, \tag{14}$$

$$\lim_{t\to\infty} \beta^t \frac{b_{t+1}}{c_t} = 0, \tag{15}$$

where (10) and (11) are intra-temporal conditions that equate the household's marginal rate of substitution between consumption and leisure, for U_1 and U_2 respectively, to the after-tax real wage. In addition, (12) and (13) are the standard Euler equations for intertemporal choices of consumption and bonds, and (14) and (15) are the transversality conditions.[6]

2.3 Government

The government sets the tax rate τ and $\{g_t, b_{t+1}, T_t\}_{t=0}^{\infty}$, subject to the following budget constraint:

$$b_{t+1} = \left[1 + (1-\tau)\, r_t^b\right] b_t + T_t + g_t - \tau y_t, \tag{16}$$

where g_t denotes government purchases, which are postulated to be a constant fraction θ of output, that is, $g_t/y_t = \theta$, for all t.[7] Finally, the aggregate resource constraint for the economy is given by

$$c_t + k_{t+1} - (1-\delta)k_t + g_t = y_t. \tag{17}$$

[6] Equations (12) and (13) imply that the after-tax returns to capital (net of depreciation) and government debt are equalized in each period.

[7] Galí (1994) also considers the "constant growth" rule in which g_t grows at a constant rate over time. None of our results are qualitatively sensitive to this alternative spending rule.

2.4 Solving the Model

As pointed out by Galí (1994, p. 120), a version of Ricardian equivalence holds in the above model. In particular, given the "constant share" government purchases rule and the initial capital stock, equilibrium allocations $\{c_t, k_{t+1}, g_t, y_t\}_{t=0}^{\infty}$ are completely independent of the infinite many debt/transfer sequences $\{b_{t+1}, T_t\}_{t=0}^{\infty}$ that satisfy the government budget constraint (16) and the transversality condition (15). As a result, our analysis is robust to allowing for a balanced-budget requirement where $b_t = 0$, for all t.

To analyze the model's business cycle properties, we first derive the unique interior steady state, and then take log-linear approximations to the equilibrium conditions in its neighborhood to obtain the following dynamic system:[8]

$$\begin{bmatrix} \hat{k}_t \\ \hat{c}_t \\ \hat{z}_t \end{bmatrix} = J \begin{bmatrix} \hat{k}_{t+1} \\ \hat{c}_{t+1} \\ \hat{z}_{t+1} \end{bmatrix} - \begin{bmatrix} \hat{k}_{t+1} - E_t\left(\hat{k}_{t+1}\right) \\ \hat{c}_{t+1} - E_t\left(\hat{c}_{t+1}\right) \\ \hat{\varepsilon}_{t+1} \end{bmatrix}, \ \hat{k}_0 \text{ and } \hat{z}_0 \text{ are given,} \tag{18}$$

where hat variables denote percent deviations from their steady-state values, and J is the Jacobian matrix of partial derivatives of the transformed dynamic system.

It is straightforward to show that our model exhibits saddle-path stability, hence two eigenvalues of J lie outside and the other inside the unit circle. To find the unique rational expectations solution to (18), we iterate the "stable" root (inside the unit circle) of J forward to obtain the stable branch of the saddle path, which expresses $\hat{c}_t$ as a linear function of $\hat{k}_t$ and $\hat{z}_t$

$$\hat{c}_t = q_1 \hat{k}_t + q_2 \hat{z}_t, \text{ for all } t, \tag{19}$$

where q_1 and q_2 are complicated functions of the model's parameters (including τ and θ).

3 Simulation Results

In this section, we compare and contrast the magnitudes of macroeconomic fluctuations generated by two versions of our model economy. Specifically, Model 1 exhibits the "log-log" period utility function given by (6), whereas the "convex in hours" preference formulation (7) is adopted in Model 2. Each period in the model is taken to be one quarter, and laissez-faire ($\tau = \theta = 0$) is regarded as the benchmark specification. As is common in the real business

[8] Notice that since Ricardian equivalence holds, government debt b_t does not enter (18). Moreover, equation (13) is used only to determine the interest rate on bonds $\{r_t^b\}_{t=0}^{\infty}$.

cycle literature, the capital share of national income, α, is chosen to be 0.3; the discount factor, β, is set equal to 1/1.01; and the capital depreciation rate, δ, is fixed at 0.025. Moreover, following Kydland and Prescott (1982) and Hansen (1985), we choose the persistence parameter for the technology shock, λ, to be 0.95; and the standard deviation of its innovations, σ_ε, to be 0.007.

Next, the preference parameters, A in (6), together with B and γ in (7), are calibrated so that the steady-state labor hours, denoted as $\bar{h}$, is equal to 0.3 in both economies. We also calibrate the two models to display the same labor supply elasticity. Setting $A = 2.079$ in Model 1 results in the desired steady-state hours worked; and the associated labor supply elasticity, given by $\frac{1-\bar{h}}{\bar{h}}$, is equal to 2.333. It follows that $B = 4.975$ and $\gamma = 0.4286$ in Model 2. Finally, we simulate each model, driven by an identical sequence of productivity disturbances, for $2,000$ periods.

3.1 Model 1: "Log-Log" Period Utility

Table 1 presents the standard deviations of $\hat{y}_t$, defined as the percent deviation of output from its steady-state value, under different τ and θ configurations in Model 1.[9] As in Galí (1994), we find that holding the share of government purchases in GDP constant, a higher tax rate raises the volatility of output $\left(\frac{\partial \sigma_{\hat{y}}}{\partial \tau} > 0\right)$. By contrast, holding the tax rate constant, a higher income share of public spending leads to a reduction in output variability $\left(\frac{\partial \sigma_{\hat{y}}}{\partial \theta} < 0\right)$. In sum, when the period utility function is logarithmic in both consumption and leisure, income taxes are destabilizing and government purchases are stabilizing.[10]

Table 1: Output Variability $\sigma_{\hat{y}}$ in Model 1

τ / θ	0	0.1	0.2	0.3	0.4
0	3.880	3.835	3.774	3.694	3.585
0.1	3.919	3.880	3.829	3.758	3.661
0.2	3.953	3.923	3.880	3.821	3.737
0.3	3.983	3.960	3.928	3.880	3.811
0.4	4.007	3.992	3.969	3.934	3.880

To understand the results in Table 1, we first note that the expressions for the steady-state hours worked and labor supply elasticity are given by

[9] To maintain comparability with Galí (1994), our simulated time series have not passed through the Hodrick-Prescott filter.

[10] Galí (1994, p.122, Table 2) uses an annual benchmark parameterization with $\tau = 0.3, \theta = 0.2, \alpha = 0.25, \beta = 0.975, \delta = 0.1, A = 1.6, \lambda = 0.63$ and $\sigma_\varepsilon = 0.0132$, and obtains qualitatively identical results as our Table 1.

$$\bar{h} = \frac{1-\alpha}{A\left(\frac{1-\theta}{1-\tau}\right) + 1 - \alpha - \frac{\alpha\delta A}{\rho+\delta}}, \text{ where } \rho = \frac{1}{\beta} - 1, \tag{20}$$

and $\frac{1-\bar{h}}{\bar{h}}$, respectively. Therefore, an increase in τ lowers the steady-state employment through its negative effect on the after-tax real wage. This in turn raises the labor supply elasticity and enhances the employment response to a given technology shock (the *employment effect*). As a result, output volatility is positively related to the tax rate, i.e., income taxes behave as *automatic destabilizers*.

On the other hand, since government spending does not contribute to either production or the household utility, an increase in θ is equivalent to a pure resource drain that reduces the household's consumption and leisure through the negative wealth effect. This shifts out the labor supply curve, which causes the steady-state labor hours to rise and the labor supply elasticity to fall, thereby resulting in a smaller employment effect. Consequently, output variability is negatively related to the share of public spending in GDP, i.e., government purchases behave as *automatic stabilizers*.

Finally, the standard deviation of output remains unchanged along the diagonal of Table 1. Intuitively, identical changes in τ and θ do not affect the steady-state hours worked (see equation 20) or the labor supply elasticity. As a result, when $\tau = \theta$, the magnitude of output fluctuations is independent of government size (including laissez-faire).

3.2 Model 2: "Convex in Hours" Period Utility

Table 2 presents the standard deviations of $\hat{y}_t$ for Model 2, using the same values of τ and θ as in Table 1. Notice that the results are now qualitatively opposite to those in Model 1. That is, when the household utility is logarithmic in consumption and convex in hours worked, income taxes are stabilizing $\left(\frac{\partial \sigma_{\hat{y}}}{\partial \tau} < 0\right)$ and government purchases are destabilizing $\left(\frac{\partial \sigma_{\hat{y}}}{\partial \theta} > 0\right)$.

Table 2: Output Variability $\sigma_{\hat{y}}$ in Model 2

τ / θ	0	0.1	0.2	0.3	0.4
0	3.880	3.889	3.900	3.914	3.930
0.1	3.873	3.880	3.890	3.903	3.919
0.2	3.866	3.872	3.880	3.891	3.906
0.3	3.860	3.864	3.871	3.880	3.893
0.4	3.855	3.858	3.863	3.870	3.880

To understand the results in Table 2, we substitute (1) and (4) into (11), and then log-linearize around the steady state to obtain

$$\hat{h}_t = \frac{1}{\alpha+\gamma}\hat{z}_t + \frac{\alpha}{\alpha+\gamma}\hat{k}_t - \frac{1}{\alpha+\gamma}\hat{c}_t. \tag{21}$$

Next, plugging the stable branch of the saddle path (19) into (21), and totally differentiating both sides yields

$$\frac{d\hat{h}_t}{d\hat{z}_t} = \left(\frac{\alpha - q_1}{\alpha+\gamma}\right)\frac{d\hat{k}_t}{d\hat{z}_t} + \frac{1-q_2}{\alpha+\gamma}, \tag{22}$$

where $\frac{d\hat{k}_t}{d\hat{z}_t} = 0$ because k_t is predetermined at period $t-1$. Therefore, the sign and magnitude of $\frac{d\hat{h}_t}{d\hat{z}_t}$ depend crucially on q_2. As mentioned earlier, q_2 is a complicated function of the model's parameters, thus we first numerically verify that

$$0 < q_2 < 1, \ \frac{\partial q_2}{\partial \tau} > 0, \ \text{and} \ \frac{\partial q_2}{\partial \theta} < 0, \tag{23}$$

for all the (τ, θ) settings under consideration. Combining (22) and (23) shows that (i) labor hours respond procyclically to technology shocks $\left(\frac{d\hat{h}_t}{d\hat{z}_t} > 0\right)$; (ii) a higher income tax rate reduces the volatility of output through a smaller response of employment to a given productivity disturbance; and (iii) in contrast, a higher share of public spending in GDP raises output variability because of a stronger employment effect.

The intuition for how the above mechanism works is depicted in Figure 1, which illustrates the labor market in Model 2. It is straightforward to show, after taking logarithms on both sides of (4) and (11), that the slope of the labor demand curve is $-\alpha$, while the slope of the labor supply curve is given by γ. Start with the equilibrium A under laissez-faire ($\tau = \theta = 0$), and suppose that the economy is subject to a positive technology shock. This shifts out the labor demand curve, and raises labor hours from h_A to h_B. Next, an increase in τ causes a leftward shift of the labor supply curve, and moves the equilibrium from B to C. Hence, the initial response of employment to a positive productivity disturbance is dampened, resulting in a smaller variation in hours worked and therefore output. On the contrary, an increase in θ shifts out the labor supply curve, which reinforces the initial employment effect and increases labor hours to h_D. As a result, output variability is positively related to the income share of public spending. In sum, other things being equal, income taxes behave as *automatic stabilizers*, and government purchases behave as *automatic destabilizers* in Model 2.

Finally, as in Table 1, the standard deviation of output does not change along the diagonal of Table 2.[11] Intuitively, q_2 is invariant to identical changes in τ and θ, which generate offsetting leftward and rightward shifts of the labor supply curve. Therefore, when $\tau = \theta$, the employment response to a given technology shock and the resulting output variability are both independent of government size (including laissez-faire).

4 Conclusion

Empirical evidence documents a strong negative relationship between government size, as measured by the income tax rate or the share of government purchases in GDP, and the magnitude of output fluctuations in OECD countries since 1960. Motivated by this stylized fact, we have explored the interrelations between the above-mentioned two fiscal variables and output variability in the context of a prototypical one-sector real business cycle model with two different utility specifications. It turns out that income taxes are destabilizing, and government purchases are stabilizing when the household's period utility function is logarithmic in both consumption and leisure. By contrast, income taxes become stabilizing, and public spending is destabilizing when the household utility is logarithmic in consumption and convex in hours worked. Finally, under both preference formulations, the volatility of total output is independent of government size when the income tax rate and the share of government purchases in GDP are equal (including laissez-faire).

This paper can be extended in several directions. For example, it would be worthwhile to examine whether our results are qualitatively robust to incorporating labor hoarding, variable capital utilization, multiple productive sectors, aggregate increasing returns in production, and demand shocks etc. into the analysis. Moreover, we can consider a richer tax structure that consists of a depreciation allowance and progressive income taxation, as is observed in the U.S. economy. This would allow us to further identify model features and parameters that govern the stabilization effects of government fiscal policy. We plan to pursue these projects in the near future.

[11] Notice that the diagonals of Tables 1 and 2 display the same magnitude of output fluctuations. This is expected because our simulations start with the same k_0 and z_0 in both models, and then are driven by identical sequences of technology shocks.

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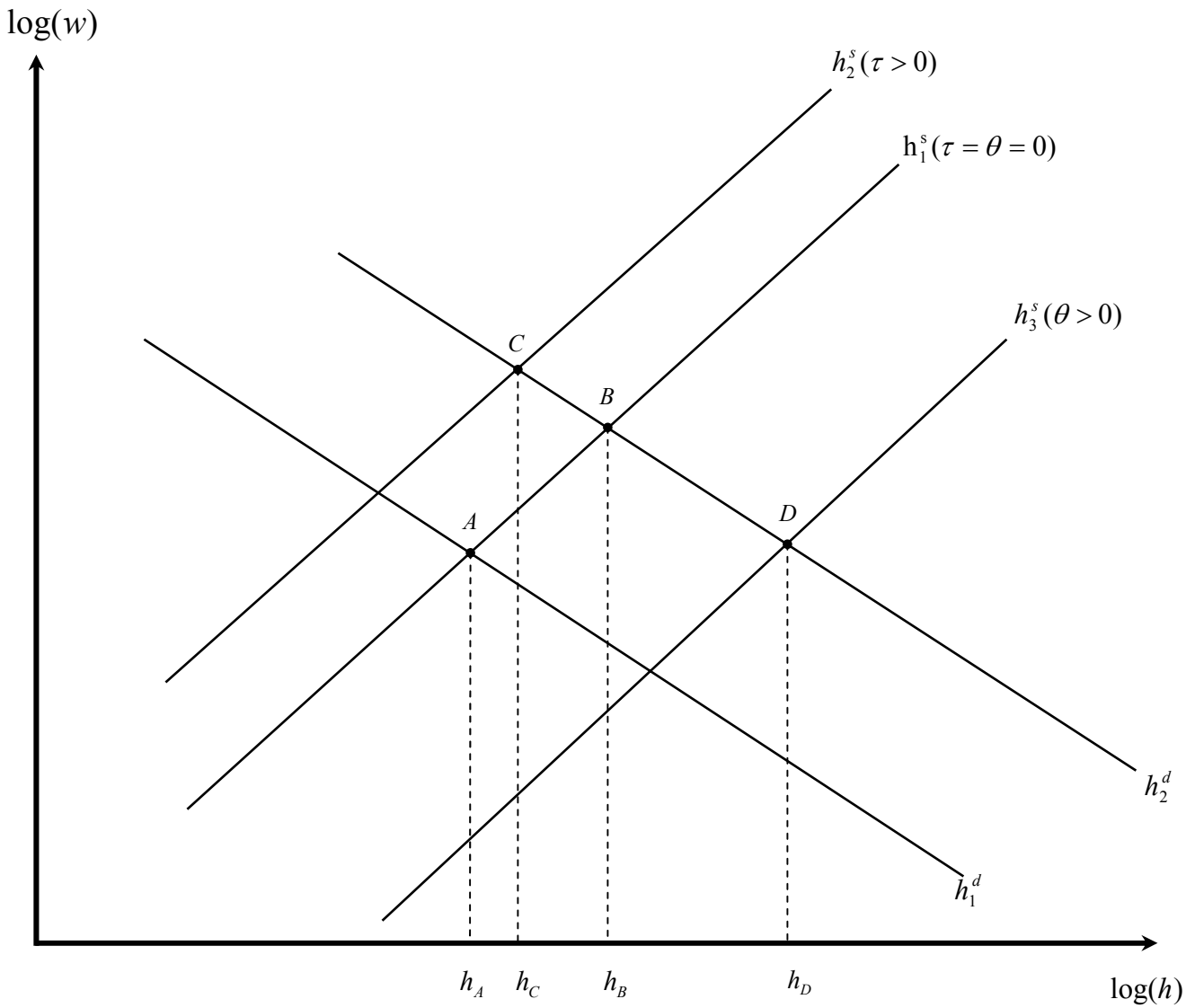

Figure 1: Labor Market in Model 2