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5 Debt Financing, Public Investment, and Economic Growth in Taiwan

Chen-Min Hsu

5.1 Introduction

In December 1990, the R.O.C. Council for Economic Planning and Development announced the Six-Year Plan for Economic Development. According to this plan, the government will issue NT$1,100 billion in bonds to finance public investment. In fact, the government will spend NT$8,238.2 billion over six years to restructure the economy. This amounts to raising public investment by NT$1,370 billion each year. Since public investment in 1990 was about 11 percent of GNP, this means that the ratio of government investment to GNP will be 0.435 if the plan is fully enforced. However, the government claimed that only part of the expenditure will be financed by debt, which will amount to 5 percent of GNP per year. Many controversies have arisen since the plan was announced. The popular view is that the plan is too ambitious and will disturb the economy by crowding out private investment and by worsening the fiscal structure of the government. Moreover, as shown by recent data, only one-third of the plan has been put into effect. This is due to the constraint of the government budget deficit. As we will see in table 5.1, the government budget has worsened during the past three years. Thus, in the following analysis, we will consider the case in which government investment increases by 1.67 percent of GNP per year for six years; in other words, we will take the size of government investment as given.

In the macroeconomics literature, it is well known that in Blinder and Solow's (1974) and Tobin and Buiter's (1976) models, public expenditure will not

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cause a large crowding-out effect on private expenditure. And in these models, output and employment effects are positive as long as stability conditions are satisfied. On the other hand, Barro (1989; 1990, chap. 14) showed that, under a neoclassical growth model, debt neutrality or the Ricardian equivalence theorem will not hold under an income tax scheme. In addition, as pointed out by Modigliani (see Haliassos and Tobin 1990), less capital will be accumulated as long as private investment is crowded out. This is also true even though public capital can be accumulated through public investment, as long as the productivity of public capital is less than that of private capital. Moreover, in an open economy foreigners will hold domestic public debt. This will induce more interest payments to foreigners. When the government budget deficit is large, a deficit in the current account is likely to appear.

Barro (1989) suggested that a calibrated equilibrium model be simulated to get more quantitative information about the consequences of fiscal policy (see also King, Plosser, and Rebelo 1988). In this paper, we set up a Solow-Cass-Koopmans growth model (in contrast to Blanchard 1985 and Matsuyama 1987) and follow Barro's suggestion and analyze the effects of public investment with deficit financing using Taiwanese data, given the size of government investment. This extends Barro's (1989) and King, Plosser, and Rebelo's (1988) work to the open economy case. We try to verify several points shown in these models.

This chapter will be organized as follows: In section 5.2, a closed economy model is set up to analyze the effects of deficit-financed public investment. Section 5.3 extends the model to a small open economy. Section 5.4 uses Taiwanese data to calibrate the models described in the preceding sections. Concluding remarks are given in the last section.

5.2 The Basic Model

As shown in table 5.1, the average annual growth rate of real per capita GNP in Taiwan has been about 7 percent during the last 25 years. The unemployment rate has been below 3 percent each year. It is reasonable to regard the Taiwanese economy as growing on the full-employment path. The main contributions to the growth of the economy are the growth of exports and national investment (including government investment). In this section, we follow Barro's neoclassical approach to fiscal policy and consider the effects of public investment through bond financing in a closed economy (see Barro 1989). The economy is divided into three sectors, i.e., households, firms, and the government. Each firm is assumed to be perfectly competitive and to have a Cobb-Douglas production function; i.e.,

$$Y_t = A_t(K_t^g)^{\theta_g}F(K_t, N_tX_t) = A_t(K_t^g)^{\theta_g}K_t^{\theta_k}(N_tX_t)^{\theta_n}, \tag{1}$$

where A_t is temporary technological shock, X_t is labor-augmenting or Harrod-neutral permanent technological shock, K_t^g is public capital, K_t is private capital, and θ_g, θ_n, and θ_k are output elasticities of K^g, NX, and K, respectively. It is

Table 5.1 Basic Statistics for the Taiwanese Economy

FY	*r*	Yg	Iy	GCy	GIy	GIi	*u*	BD
1965	11.520	7.9	22.7	16.9	7.1051	31.3	3.3	245
1966	11.520	6.1	21.2	17.4	7.3352	34.6	3.0	975
1967	10.800	7.9	24.7	17.5	9.2625	37.5	2.3	2,281
1968	11.880	6.6	25.2	17.9	9.2232	36.6	1.7	1,249
1969	10.800	6.6	24.5	18.4	10.2410	41.8	1.9	−924
1970	9.800	9.0	25.6	18.3	10.2656	40.1	1.7	866
1971	9.250	10.7	26.3	17.3	10.6252	40.4	1.7	1986
1972	8.500	11.3	25.6	16.1	10.0608	39.3	1.5	291
1973	10.750	10.7	29.1	15.2	10.0977	34.7	1.3	−2,425
1974	12.000	−.7	39.2	14.1	14.9352	38.1	1.5	−20,120
1975	10.750	2.5	30.5	15.9	17.5985	57.7	2.4	125
1976	9.500	11.4	30.8	15.3	16.4164	53.3	1.8	−6,130
1977	8.250	8.1	28.3	15.6	14.3481	50.7	1.8	12,268
1978	8.250	11.9	28.3	15.2	12.7350	45.0	1.7	10,732
1979	11.000	6.4	32.9	15.4	12.9626	39.4	1.3	−21,849
1980	11.000	5.1	33.8	15.9	16.3930	48.5	1.2	4,681
1981	11.750	3.8	30.0	16.2	14.8200	49.4	1.4	21,509
1982	7.750	2.2	25.2	16.9	13.2048	52.4	2.1	39,280
1983	7.250	6.9	23.4	16.2	10.9044	46.6	2.7	37,042
1984	6.750	10.0	21.9	15.7	8.7819	40.1	2.4	3,138
1985	5.250	4.1	18.7	15.9	7.9101	42.3	2.9	21,127
1986	4.500	11.3	17.1	14.5	6.7032	39.2	2.7	47,823
1987	4.500	10.7	20.1	14.1	7.4370	37.0	2.0	11,932
1988	4.500	6.6	22.8	14.8	7.4328	32.6	1.7	−13,509
1989	7.750	6.2	22.3	15.6	8.6524	38.8	1.6	317,979
1990	7.750	3.9	21.9	17.2	10.8405	49.5	1.7	74,346
1991	6.250	6.1	22.2	17.4	11.0778	49.9	1.5	366,694
1992	5.625	5.1	23.9	17.2	11.3286	47.4	1.5	417,809

Source: Council for Economic Planning and Development, R.O.C., *Taiwan Statistical Data Book* (Taipei, 1993).

Note: FY = fiscal year; *r* = rediscount rate (percent per annum); Yg = annual growth rate of real per capital GNP; Iy = the ratio of gross capital formation to GNP (percent per annum); GCy = the ratio of government investment to GNP (percent per annum); GIy = the ratio of government investment to GNP (percent per annum); GIi = the ratio of the government investment to total gross capital formation; *u* = unemployment rate (percent per annum); BD = government budget deficit for each fiscal year, starting from July 1 of the preceding year to June 30 of the designated year (million NT dollars).

assumed that $\theta_g + \theta_n + \theta_k = 1$; i.e., the production function gives diminishing returns with respect to total capital ($K + K^g$), but constant returns to scale with respect to total capital and effective labor.

It is assumed that both private and public capital have the same depreciation rate. Their accumulations are

$$K_{t+1} = (1 - \delta)K_t + I_t, \tag{2}$$

$$K^g_{t+1} = (1 - \delta)K^g_t + I^g_t, \tag{3}$$

where I_t and I_t^g are private and public investment, respectively, and δ is the depreciation rate. Let τ_t be the tax rate on the output. The representative firm's net cash flow after taxes is

$$\Pi_t = (1 - \tau_t)A_t(K_t^g)^{\theta_g}K_t^{\theta_k}(N_t^dX_t)^{\theta_n} - W_tN_t^dX_t - r_{kt-1}K_t, \tag{4}$$

where W_t is the real wage rate and r_{kt-1} is the unit user or rental cost of capital. The quantity r_k is made up of three components: the interest cost, the depreciation cost, and the capital gain or loss of a unit of capital (see Jorgenson 1963). The interest cost is the opportunity cost of retaining earnings used to invest (see Abel and Bernanke 1992, chap. 6). Since the price of capital equals that of the private consumption good, we will not consider the inflation problem. Rather, we will assume no gain or loss on capital. We will also assume that there is no tax on interest income. Thus,

$$r_{kt-1} \equiv r_{t-1} + \delta, \tag{5}$$

where r is the interest rate of the loanable fund market. The firm maximizes after-tax net cash flows in each period by choosing optimal N_t^d and K_{t+1} (and therefore I_t).

The representative household maximizes its lifetime utility by choosing optimal leisure, labor supply, and consumption. The household consumes private and public goods. Following Barro (1989), we will assume that the household consumes a composite consumption good (C_t^*) which is the linear combination of private consumption (C_t) and public consumption C_t^g) goods. Let L_t and N_t^s be the leisure and labor supplies, and let β and ρ be the discount factor and the time preference rate. The household holds capital (K_t) and public debt (D_t) at the beginning of each period. Let r_d be the interest rate of public debt and S_t be the total real assets held by the household at the beginning of period t. Then, the household's optimization problem can be described by the following:

$$\max\sum_{t=0}^{\infty}\beta^t U(C_t^*, L_t) \tag{6}$$

such that

$$C_t^* = C_t + \psi C_t^g, \tag{7}$$

$$L_t + N_t^s = 1, \tag{8}$$

$$\beta \equiv (1 + \rho)^{-1}, \tag{9}$$

$$S_{t+1} \equiv K_{t+1} + D_{t+1} = (1 + r_{t-1})K_t + (1 + r_{dt-1})D_t + W_tN_t^sX_t - C_t, \tag{10}$$

where ψ is assumed to be positive and less than one, i.e., $0 < \psi < 1$ (for a detailed discussion see Barro 1989) and equation (10) is the household budget constraint. Following King et al. (1988) and Baxter and King (1990), we will assume that the utility function is in constant relative risk aversion (CRRA) form:

(11) $$U(C_t^*, L_t) = \frac{1}{1-(1/\sigma)}[(C_t^{*\theta}L_t^{1-\theta})^{1-1/\sigma} - 1], \quad \text{for } \sigma \neq 1, \sigma > 0,$$

(12) $$U(C_t^*, L_t) = \theta \ln C_t^* + (1-\theta)\ln L_t, \quad \text{for } \sigma = 1,$$

where $1/\sigma$ is the coefficient of relative risk aversion, while σ is the intertemporal elasticity of substitution in consumption.

The government budget constraint in real terms is

(13) $$Z_t \equiv D_{t+1} - D_t = r_{dt-1}D_t + I_t^g + C_t^g + G_t^b - \tau_t A_t (K_t^g)^{\theta_g} K_t^{\theta_k}(N_t K_t)^{\theta_n}$$

where I_t^g, C_t^g, and G_t^b are, respectively, public investment, public consumption goods, and basic government purchases without providing utility or productive services; D_t is public debt at the beginning of period t; and Z_t is the budget deficit. To avoid indebtedness, we impose a no-Ponzi-game (NPG) condition, i.e.,

(14) $$\lim_{t\to\infty} \prod_{s=0}^{t}(1 + r_s)^{-1}D_{t+1} \geq 0.$$

The economy-wide resource constraint is given by

(15) $$C_t + K_{t+1} - (1-\delta)K_t + I_t^g + C_t^g + G_t^b = A_t(K_t^g)^{\theta_g}K_t^{\theta_k}(N_t X_t)^{\theta_n}.$$

This is also the equilibrium condition for the commodity market. A no-arbitrage condition in the fund market implies that

(16) $$r_{kt} - \delta = r_t = r_{dt}.$$

We make the following definition:

DEFINITION. A *dynamic general equilibrium* is a set of initial conditions D_0, K_0, K_0^g, the process $\{C_t, L_t, N_t, K_{t+1}, S_{t+1}, \tau_t, I_t^g, C_t^g, G_t^b, D_{t+1}, A_t, K_t^g, X_t\}_{t=0}^{\infty}$, and the prices $\{W_t, r_{kt}, r_t\}_{t=0}^{\infty}$ such that

(i) Given the prices $\{r_{kt-1}, W_t\}$, $\{K_{t+1}^d, N_t^d X_t\}$ solves the firm's maximization problem.
(ii) Given the prices $\{r_{t-1}, r_{kt-1}, W_t\}$, $\{C_t, L_t, N_t^s, S_{t+1}\}$ solves the household maximization problem.
(iii) Under $\{W_t, r_t, r_{kt}\}$, all markets are in equilibrium; i.e., $K_{t+1}^d = K_{t+1}$, $N_t^d = N_t^s = N_t$, $D_{t+1}^d \equiv S_{t+1} - K_{t+1} = D_{t+1}$.
(iv) The government budget constraint (15) is satisfied.

Condition (iii) implies that the commodity market is also in equilibrium; i.e., equation (15) is satisfied by Walras's law. As shown by King, Plosser, and Rebelo (1990), labor and leisure will not grow under restrictions on preferences such as equations (11) and (12). In the steady state, C, I, K, Y, I^g, C^g, G^b, and D (all variables are in per capita terms) grow at the same rate as labor-augmenting technical progress. We follow the method used by King et al.

(1988, 1990) by dividing all variables in the system by the growth component X so that we get a stationary model.

In appendix A, we solve the problem and characterize the dynamic general equilibrium.

5.3 Fiscal Policies and the Current Account

The model described in the previous section can be extended to a small open economy such as the Taiwanese economy. In this paper, the exchange rate is assumed to be fixed, since no currencies are formally introduced. We will assume that capital moves perfectly across countries. Foreign and domestic assets are perfect substitutes. However, interest income from foreign assets is taxed at the same rate as that on the capital stock. Let r^{f} be the interest rate in the foreign loanable fund market. Then, a no-arbitrage condition implies that

$$\Omega_t r_t^{\mathrm{f}} = r_t = \Omega_t r_{\mathrm{k}t} - \delta. \tag{17}$$

Following Buiter (1987) and Klundert and Ploeg (1989), we will specify tax rules and spending rules for the government sector so that the solvency of the economy can be satisfied:

$$T_t = \xi_1 f_t + \xi_2 f_{t+1}, \tag{18}$$

$$g_t^{\mathrm{b}} = \xi_3 f_t + \xi_4 f_{t+1}, \tag{19}$$

where f_t is foreign assets held by each household and T_t is the tax on foreign assets per capita. Proportional tax is imposed on foreign assets. Equations (18) and (19) imply that these taxes are used in basic government expenditure—national defense, foreign transfer payments, and so forth. In the following analysis, we will set $\xi_2 = \xi_4 = 0$. The household's budget constraint becomes

$$\gamma_x(f_{t+1} + k_{t+1} + d_{t+1}) = (1 + r_t)(k_t + d_t) + (1 + \Omega_t r^{\mathrm{f}} - \xi_1)f_t + W_t N_t - c_t. \tag{20}$$

And equation (17) can be rewritten as

$$\Omega_t r_t^{\mathrm{f}} - \xi_1 = \Omega_t r_{\mathrm{k}t} - \delta. \tag{21}$$

Moreover, the government budget constraint becomes

$$\begin{aligned} z_t &= r_t d_t + i_t^{\mathrm{g}} + c_t^{\mathrm{g}} + g_t^{\mathrm{b}} - \tau_t(y_t + f_t) - T_t \\ &= r_t d_t + i_t^{\mathrm{g}} + c_t^{\mathrm{g}} + (\xi_3 - 1)\xi_1 f_t - \tau_t(y_t + f_t). \end{aligned} \tag{22}$$

We define net export as the difference between the accumulation of foreign assets and interest income from foreign assets. That is,

$$e_t = \gamma_x f_{t+1} - (1 + r^{\mathrm{f}})f_t, \tag{23}$$

where e_t is the net export per capita. Thus, from the composition of the national income account, we have

(24)
$$\begin{aligned}\text{GDP}_t \equiv y_t &\equiv c_t + i_t + g_t + e_t \\ &= c_t + i_t + g_t + \gamma_x f_{t+1} - (1 + r^f)f_t\end{aligned}$$

and

(25)
$$\begin{aligned}\text{GNP}_t &\equiv y_t + r^f f_t \\ &= c_t + i_t + g_t + \gamma_x f_{t+1} - f_t,\end{aligned}$$

where $\gamma_x f_{t+1} - f_t$ is the current account balance. That is (see Sachs 1982),

(26)
$$\text{CA} \equiv \gamma_x f_{t+1} - f_t = r^f f_t + e_t.$$

The commodity market is in equilibrium under the condition

(27)
$$\begin{aligned}c_t^* + \gamma_x k_{t+1} - (1 - \delta)k_t + i_t^g + (1 - \psi)c_t^g + g_t^b + \gamma_x f_{t+1} \\ - (1 + r^f)f_t = y_t,\end{aligned}$$

or

(28)
$$\begin{aligned}c_t^* + \gamma_x k_{t+1} - (1 - \delta)k_t + i_t^g + (1 - \psi)c_t^g + \gamma_x f_{t+1} \\ - (1 + r^f - \xi_1\xi_3)f_t = y_t.\end{aligned}$$

To avoid explosive foreign debt, we impose the NPG condition, i.e.,

(29)
$$\lim_{t\to\infty}(1 + r^f)^{-t} f_t \geq 0.$$

Combining equations (27) and (29), we have the intertemporal resource constraint for the economy; that is,

(30)
$$\begin{aligned}f_0 &= \sum_{t=0}^{\infty}(1 + r^f)^{-(t+1)}[c_t^* + \gamma_x k_{t+1} - (1 - \delta)k_t + i_t^g + (1 - \psi)c_t^g + g_t^b - y_t] \\ &= -\sum_{t=0}^{\infty}(1 + r^f)^{-(t+1)}e_t.\end{aligned}$$

The solution of the model appears in appendix B.

5.4 Numerical Analysis

In the following, we will use Taiwanese data to simulate our model. The sources of the data are from the Directorate-General of Budget, Accounting and Statistics (DGBAS), *Quarterly National Economic Trends, Taiwan Area, The Republic of China* (Taipei, various issues), the *Yearbook of Financial Statistics of the R.O.C.* (Taipei, various issues), and *Aggregate Supply and Demand Quarterly Econometric Model in the Taiwan Area*, no. 8 (Taipei, November 1990) (i.e., DGBAS model no. 8). We use 1990 as the base year. Coefficient data are reported in tables 5.2 and 5.3.

It should be noted that the coefficients are chosen to match Taiwanese factor share data (see DGBAS model no. 8). $\theta_g + \theta_k = 1 - \theta_n = 0.4353$. Since there is no disaggregated data for the sectoral capital stock, we set $\theta_g = \theta_k = 0.21765$. This also matches the data, since in the most recent years the ratio of

Table 5.2 Parameters and Characteristic Roots for the Closed Economy Case

Parameters for the production function:
$\theta_g = 0.21765$
$\theta_k = 0.21765$
$\theta_n = 0.5647$
$\delta = 0.0138$
$\gamma_x = 1.07$

Parameters for the utility function:
$\sigma = 1$
$\beta = 0.9953$
$\theta = 0.36956$
$\phi = 0.25$

Other coefficients:
$s_{ig} = 0.11$
$s_{cg} = 0.15$
$s_{gb} = 0$
$d = 0.05$

Characteristic roots:
1.24203; 0.8567076

Table 5.3 Parameters and Characteristic Roots for the Open Economy Case

Parameters for the production function:
See table 5.2

Parameters for the utility function:
$\sigma = 1$
$\beta = 0.9953$
$\theta = 0.34982$
$\phi = 0.25$

Coefficients for the feedback rules:
$\xi_1 = -0.028$
$\xi_3 = 0$

Other coefficients:
$s_f = 0.629$
See table 5.2

Characteristic roots:
1.00378867; 0.9733067

investment to GNP in the government sector has been almost 50 percent each year (see table 5.1). We choose β so that the interest rate is 7.75 percent, i.e., $\beta = 0.9953$. This is the 1990 rediscount rate (see table 5.1). And we choose θ so that in the steady state $N = 0.3$, i.e., $\theta = 0.36956$. The tax rate can be found from the government budget constraint. We will assume that the ratio of government expenditure to GNP increases by 1.67 percent each year for six years. Originally, the ratio of government investment to GNP was supposed to have increased 5 percent each year for six years. However, according recent data, the Six-Year Plan has been slowed down because of financial problems. It turned out that only one-third of the plan was realized each year after 1991. Thus, the ratio of government investment to GNP became 1.67 percent each year. Government expenditure is financed through public debt and taxes. The public debts are five-year bonds which each year pay back one-quarter of the par value from the year following the issuing date. Interest payments are financed by taxation.

To see how well the basic structure mimics the actual Taiwanese data, we have examined standard deviations and correlations with output, which are presented in table 5.4. Here the first two columns report statistics for the Taiwanese economy using actual quarterly Taiwanese data for 1966.1–1992.4. These standard deviations are measured relative to the average values, with the departures from the average in percentage form. From these values it is apparent that actual consumption fluctuates less, and both private and public investment much more, than total output in percentage terms.

In the third and fourth columns, comparable figures are reported for a version of the closed economy model that was specified in section 5.2. The magnitude of output fluctuation is governed by the variance of the public investment shock financed by income taxes. From the data in the third column, it is clear that both consumption and private investment vary more than output. The higher fluctuation of consumption is partly due to income tax increases. However, the contemporaneous correlations of the other variables with output reported in table 5.4 show that the basic model matches the actual data rather well.

It should be noted that before 1987 the central bank in Taiwan imposed strict foreign exchange controls on non-trade-related outward remittance by local residents. Both outward and inward remittances of direct capital investment were also subject to approval by the Investment Commission of the Ministry of Economic Affairs. Although the central bank allowed the exchange rate to

Table 5.4 Comparison of the Taiwanese Economy and the Basic Model

	Taiwanese Economy[a]		Basic Model	
Variables	Standard Deviation (%)	Correlation with Output	Standard Deviation (%)	Correlation with Output
Output	.65	1	.46	1
Consumption	.61	.99	.60	.99
Investment	.72	.95	.76	.94
Capital stock	.11	.88	.65	.96

[a]The Taiwanese quarterly data used are real GDP, private consumption, gross private investment, and total capital stock (all in 1986 NT dollars).

float in July 1978, it still managed the exchange rate quite tightly. In July 1987, foreign exchange control was released. Since October 1992, each person has been allowed to remit outward and inward up to an annual limit of U.S.$5 million. The central bank went further toward lifting restrictions and raised the ceiling on foreign liabilities of all commercial banks. It is easy to see that during the last few years foreign exchange controls have been almost completely relaxed. This is the reason why we chose the basic model for comparison with the actual data.

5.4.1 Simulation Results for the Closed Economy Case

It is easy to show that the dynamical system described in section 5.2 has two characteristic roots: the absolute value of one characteristic root is greater than one, while the other is less than one. The steady state of the system is thus a saddle point. This is obvious for a dynamical system with one predetermined variable (i.e., capital stock) and an unpredetermined variable (i.e., shadow price of real asset).

Suppose that public investment is financed through public debt. Since all individuals expect that future taxes will be raised to pay current debts, after-tax returns will decline. Private investment will thus be crowded out. As we can see from figure 5.1, taxes rise with public debt accumulation. This results in large crowding-out effects on private investment and consumption. The dynamic paths of the economy will gradually converge to a long-term equilibrium path once the principal of the debts is paid back. As we can see from figure 5.1, when public investment starts to increase initially, output also increases. However, private investment decreases slightly, since the after-tax return on private investment becomes lower. In a closed economy, since output equals total expenditure, total expenditure will go down, and therefore both private consumption and investment are crowded out. Compared to private investment, private consumption declines slowly. This reflects a consumption-smoothing pattern. In addition, labor also decreases with output. This causes higher labor productivity and a higher real wage rate. As consumption goes down, the marginal utility of consumption will rise, and therefore the intertemporal marginal value of assets (λ) also rises. This induces more savings and a greater desire by households to hold bonds. Although the private capital stock decreases with private investment, the real rental rate initially is lowered. This might be due to less labor and output.

We show the effects of tax-financed public investment in figure 5.2. Since it is income taxes rather than lump-sum taxes that are raised to finance government expenditure, there exists an intertemporal substitution effect on labor. Thus, the Ricardian equivalence theorem will not hold. Comparing these two cases in figures 5.1 and 5.2, we find that debt-financed public investment crowds out private expenditure less. In fact, public debt has a tax-smoothing effect and lessens the government's need for unusually high tax receipts when government expenditure increases (see Abel and Blanchard 1983).

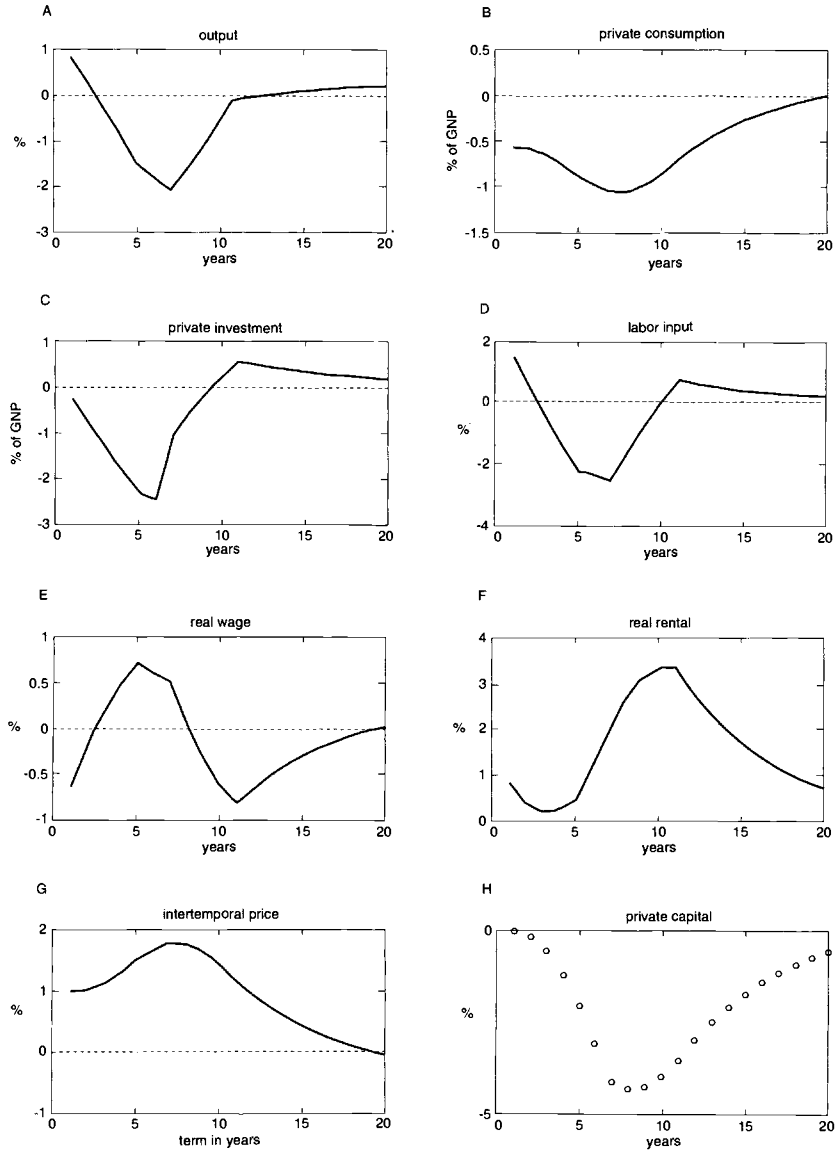

Fig. 5.1 Debt-financed case (closed economy). (*A*) output, (*B*) private consumption, (*C*) private investment, (*D*) labor input, (*E*) real wage, (*F*) real rental, (*G*) intertemporal price, (*H*) private capital.

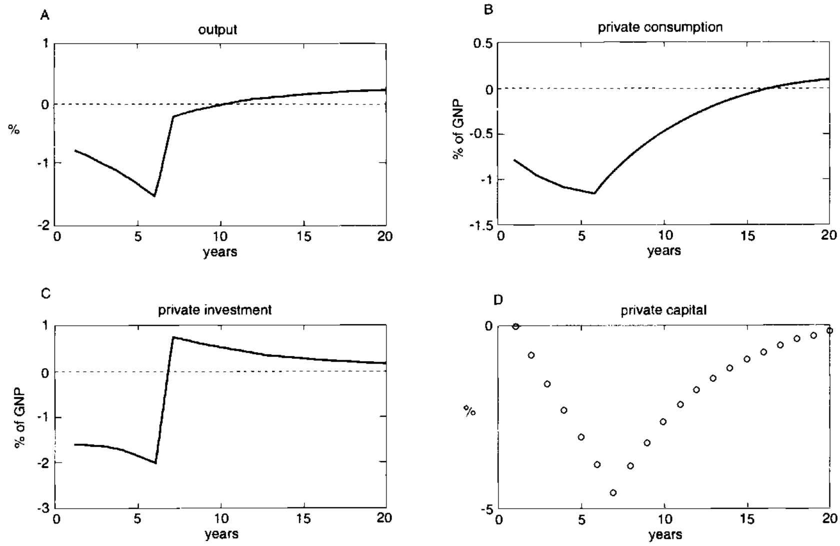

Fig. 5.2 Tax-financed case (closed economy). (*A*) output, (*B*) private consumption, (*C*) private investment, (*D*) private capital.

5.4.2 Simulation Results for the Small Open Economy Case

As shown in figure 5.3, the income tax rate also rises with public debt. Thus, private expenditure will again be crowded out. However, in contrast to the closed economy case, the private sector in an open economy is allowed to borrow abroad and to import foreign goods. Consumption is now smoother, since households can buy foreign goods. Decreases in the marginal utility of consumption imply low intertemporal asset value and thus low savings. Public debt is eventually held by foreigners. This implies a current-account deficit as well as a government budget deficit. Moreover, the intertemporal substitution effect of taxation on labor causes lower labor supply and therefore low productivity of capital.

Comparing this to the closed economy case, we find that output decreases more and the tax rate is higher in an open economy. In an open economy with more foreign debts and more imported goods, the demand for domestic goods will decrease. This will cause output production to decline. And the derived demand for domestic inputs will also fall. Since the tax base has become smaller, the tax rate should be raised so that the government budget can be balanced.

It is hard to compare the welfare levels of two different economies. Even though we choose private consumption as a guideline, we still cannot get a definite answer. Private consumption in the open economy converges after 35 years (not shown in fig. 5.3*B*), while in the closed economy it converges very quickly.

Suppose that public capital is unproductive; i.e., $\theta_g = 0$, while $\theta_k + \theta_n = 1$. This will not change the patterns of output, private consumption, private investment, and private capital. However, all of these variables decrease much more. For example, the lower bound of the output is four times less than in the former case.

Different values of the time preference rate affect the consumption path. The higher the rate of time preference, the lower the discount factor. And people become less patient. Thus, initial private consumption increases more than before and does not decline so quickly after the initial shock. However, the time patterns of other variables do not change significantly.

5.5 Conclusions

We have set up a market-clearing or neoclassical growth model to analyze the effects of public investment with debt financing. By utilizing Taiwanese data to simulate the model we have found that crowding-out effects on private investment do exist in both the open economy case and the closed economy case. Moreover, we have also confirmed a known result, that the Ricardian equivalence theorem does not hold when an income tax system is introduced.

It is also found that consumption is more smoothing and crowds out less in the open economy. However, it is because of capital outflows that private investment is crowded out more in the open economy than in the closed economy. We also found that public investment financed by debt causes both current-account and government budget deficits in the open economy. As for the effects on income and employment, this paper found that in the open economy deficit-financed public investment is more expensive in the long run. All these findings conform to recent Taiwanese experience as more labor shortages prevailed and more funds flowed out, especially to mainland China and south Asian countries.

From the preceding analysis we obtain implications for government policies. The analysis suggests that the government should not intervene too much in production and investment. Most projects of the Six-Year Plan could be opened to investment by private firms, and by foreign investors, since the main purpose of the plan is to induce more private investment and foreign technology transfer. Introducing foreign capital also lessens the stringent fund situation in the short run. However, the analysis also suggests that the government should not borrow abroad, since a lot of foreign reserves are held by the central bank and much of the money stock is still in the hands of the public. Instead, the foreign exchange reserves could be used to finance public investment as long as the domestic interest rate is not much higher than the world interest rate. In addition, this can lessen the fiscal budget deficit as well as the current-account deficit. From recent experience, the government has become aware of this situation. Through a development bank, the central bank has started to lend foreign reserves to the administration sector to purchase foreign goods.

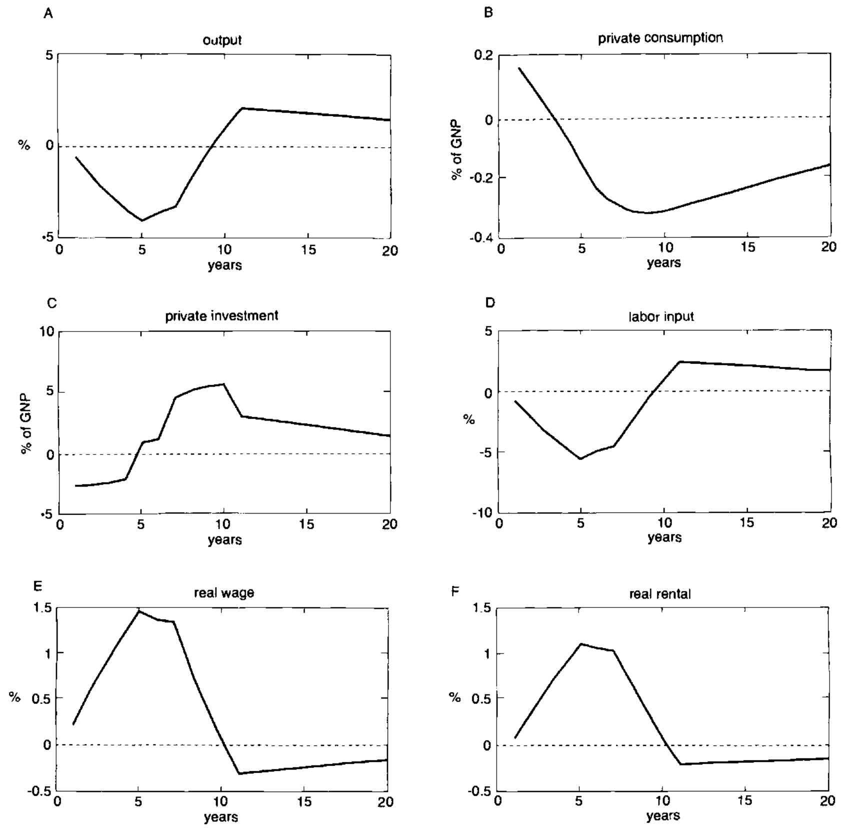

Fig. 5.3 Debt-financed case (open economy). (*A*) output, (*B*) private consumption, (*C*) private investment, (*D*) labor input, (*E*) real wage, (*F*) real rental, (*G*) intertemporal price, (*H*) foreign asset, (*I*) private capital, (*J*) current account.

Appendix A

In this appendix, we will solve the household's optimization problem given in section 5.2. And the dynamic general equilibrium of the model will be log-linearized.

Let $c_t \equiv C_t/X_t$, $k_t \equiv K_t/X_t$, $i_t \equiv I_t/X_t$, etc., and $\gamma_x \equiv X_{t+1}/X_t$. The household's lifetime utility function becomes

$$\sum_{t=0}^{\infty}\beta^t U(c_t^*, L_t) = (X_0)^{\theta(1-1/\sigma)}\sum_{t=0}^{\infty}\{\beta^{*t}\frac{1}{1-1/\sigma}[(c_t^{*\theta}, L_t^{1-\theta})^{1-1/\sigma} - 1] + \sigma V(X_t)\},$$

(A1) if $\sigma \neq 1, \sigma > 0,$

$$= \sum_{t=0}^{\infty}\beta^t[\theta \ln c_t^* + (1-\theta)\ln L_t + \theta \ln X_t],$$

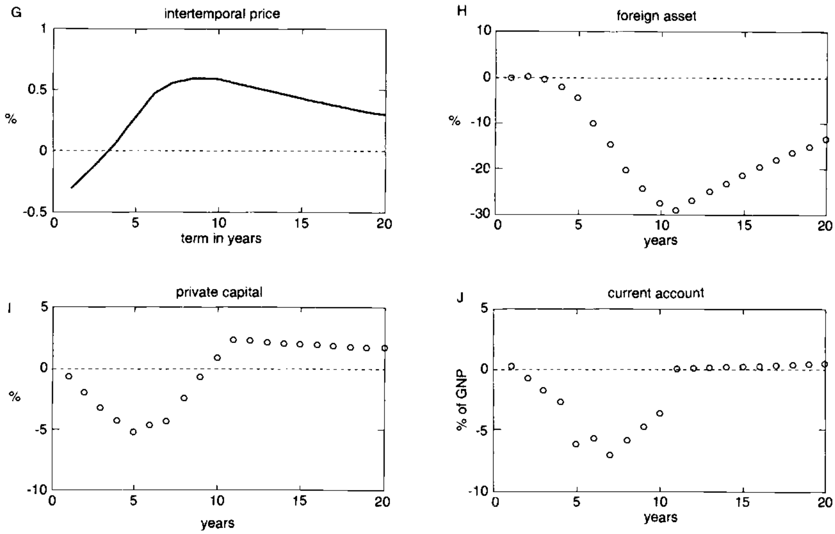

Fig. 5.3 (continued)

$$\text{if } \sigma = 1,$$

where

$$V(X_t) \equiv \beta^t \frac{1}{1 - 1/\sigma}(X_t^{\theta(1-1/\sigma)} - 1),$$

and $\beta^* \equiv \beta\gamma_x^{\theta(1-1/\sigma)}$, while X_0 is given. We will assume that $\beta^* < 1$ so that the expression in equation (A1) is bounded. The transformed optimization problem of the household can be described as follows:

$$\max \sum_{t=0}^{\infty} \beta^{*t}[U(c_t^*, 1 - N_t^s) + V(X_t)]$$

such that

(A2) $$\gamma_x s_{t+1} = (1 + r_{t-1})s_t + W_t N_t^s + c_t,$$

(A3) $$s_t \equiv k_t + d_t.$$

Let the Lagrangian be

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^{*t}\{U(c_t^*, 1 - N_t^s) + \lambda_t[W_t N_t^s + (1 + r_t)s_t - c_t - \gamma_x s_{t+1}]\}.$$

The first-order condition becomes

(A4) $$U_1(c_t^*, 1 - N_t^s) = \lambda_t,$$

(A5) $$U_2(c_t^*, 1 - N_t^s) = \lambda_t W_t,$$

(A6) $$\beta^* \lambda_{t+1}(1 + r_{t+1}) = \lambda_t \gamma_x,$$

(A7) $$W_t N_t^s + (1 + r_t)s_t - c_t - \gamma_x s_{t+1} = 0,$$

(A8) $$\lim_{t \to \infty} \beta^{*t} \lambda_t s_t = 0,$$

where λ_t is the Lagrange multiplier and $U_1(\cdot)$ and $U_2(\cdot)$ are the partial derivatives of $U(\cdot)$ with respect to c_t^* and $1 - N_t^s$. Equations (A4) and (A5) describe the trade-offs among consumption, leisure, and saving. Equation (A6) is the Euler equation or the intertemporal efficiency condition. Equation (A7) is the household's budget constraint. And equation (A8) is the transversality condition.

The production function and the capital accumulation become

(A9) $$y_t = A_t (k_t^g)^{\theta_g} k^{\theta_k} N_t^{\theta_n},$$

(A10) $$\gamma_x k_{t+1} = (1 - \delta)k_t + i_t.$$

The optimization condition for the firm is thus

(A11) $$\Omega_t A_t (k_t^g)^{\theta_g} F_1(k_t^d, N_t^d) = r_{kt-1} = r_{t-1} + \delta,$$

(A12) $$\Omega_t A_t (k_t^g)^{\theta_g} F_2(k_t^d, N_t^d) = W_t,$$

where $\Omega_t \equiv 1 - \tau_t$ and $F_1(\cdot)$ and $F_2(\cdot)$ are the marginal productivities of capital and labor, respectively. Equations (A11) and (A12) are the marginal conditions for the firm.

A dynamic general equilibrium can be described as follows:

(A13) $$U_1(c_t^*, 1 - N_t) = \lambda_t,$$

(A14) $$U_2(c_t^*, 1 - N_t) = \lambda_t \Omega_t A_t (k_t^g)^{\theta_g} F_2(k_t, N_t),$$

(A15) $$\beta^* \lambda_{t+1}[1 + \Omega_{t+1} A_{t+1} (k_{t+1}^g)^{\theta_g} F_1(k_{t+1}, N_{t+1}) - \delta] = \lambda_t \gamma_x,$$

(A16) $$z_t = [\Omega_t A_t (k_t^g)^{\theta_g} F_1(k_t, N_t) - \delta] d_t + i_t^g + c_t^g + g_t^b - \tau_t A_t (k_t^g)^{\theta_g} F(k_t, N_t),$$

(A17) $$c_t^* + \gamma_x k_{t+1} - (1 - \delta)k_t + i_t^g + (1 - \psi)c_t^g + g_t^b = A_t (k_t^g)^{\theta_g} F(k_t, N_t).$$

From equations (A13)–(A17) and the definition of $\Omega \equiv (1 - \tau)$, we can solve for c_t^*, N_t, k_t, λ_t, τ_t, and Ω_t, which are functions of exogenous variables. However, these functions will be nonlinear. In order to do further analysis, we will follow King et al. (1990) by using the log-linearization method. From equation (A16) we can find the wedge function Ω_t. Approximation of Ω_t near stationary levels (k, N, A, B, i^g, c^g, g^b, d, z), where $B \equiv (k^g)^{\theta_g}$, yields

(A18) $$\hat{\Omega}_t = \omega_K \hat{k}_t + \omega_N \hat{N}_t + \omega_A \hat{A}_t + \omega_B \hat{B}_t + \omega_1 \hat{i}_t^g + \omega_2 \hat{c}_t^g + \omega_3 \hat{g}_t^b + \omega_D \hat{d}_t + \omega_Z \hat{z}_t,$$

where the values of ω are elasticities of the wedge function $\Omega_t = 1 - \tau_t$ and $\hat{k}_t \equiv \log(k_t/k)$, etc. Also, we can take the log-linearization of equations (A13), (A14), and (A15) to get

$$\text{(A19)} \qquad \xi_{cc}\hat{c}^*_t - \xi_{cl}\frac{N}{1-N}\hat{N}_t = \hat{\lambda}_t,$$

$$\text{(A20)} \quad \xi_{lc}\hat{c}^*_t - \xi_{ll}\frac{N}{1-N}\hat{N}_t = \hat{\lambda}_t + (\omega_A + 1)\hat{A}_t + (\omega_B + 1)\hat{B}_t + (\omega_K + \xi_{NK})\hat{k}_t + (\omega_N + \xi_{NN})\hat{N}_t + \omega_1\hat{i}^g_t + \omega_2\hat{c}^g_t + \omega_3\hat{g}^b_t + \omega_D\hat{d}_t + \omega_Z\hat{z}_t,$$

$$\text{(A21)} \quad \hat{\lambda}_{t+1} + \eta_A\hat{A}_{t+1} + \eta_B\hat{B}_{t+1} + \eta_K\hat{k}_{t+1} + \eta_N\hat{N}_{t+1} + \eta_1\hat{i}^g_{t+1} + \eta_2\hat{c}^g_{t+1} + \eta_3\hat{g}^b_{t+1} + \eta_D\hat{d}_{t+1} + \eta_Z\hat{z}_{t+1} = \hat{\lambda}_t,$$

where the values of ξ on the left-hand sides of equations (A19) and (A20) are elasticities of marginal utility, while those on the right-hand sides are elasticities of marginal productivities (see King et al. 1990). The values of η in equation (A21) are elasticities of the net after-tax marginal product of capital.

Finally, differentiation of the commodity-market equilibrium condition implies

$$\text{(A22)} \quad \hat{A}_t + \hat{B}_t + s_n\hat{N}_t + s_k\hat{k}_t = s_c\hat{c}^*_t + s_{ig}\hat{i}^g_t + (1 - \psi)s_{cg}\hat{c}^g_t + s_{gb}\hat{g}^b_t + s_i\phi\hat{k}_{t+1} - s_i(\phi - 1)\hat{k}_t,$$

where s_n, s_k, s_c, s_{ig}, s_{cg}, s_{gb}, and s_i are output shares of labor, capital, consumption (c^*), government expenditure, and investment and $\phi \equiv K_{t+1}/I_t$.

Appendix B

The first-order conditions for the household's optimization problem in section 5.3 are

$$\text{(B1)} \qquad U_1(c^*_t, 1 - N^s_t) = \lambda_t,$$

$$\text{(B2)} \qquad U_2(c^*_t, 1 - N^s_t) = \lambda_t W_t,$$

$$\text{(B3)} \qquad \beta^*\lambda_{t+1}(1 + r_{t+1}) = \lambda_t\gamma_x,$$

$$\text{(B4)} \qquad W_tN^s_t + (1 + r_t)s_t - c_t - \gamma_x s_{t+1} = 0,$$

$$\text{(B5)} \qquad W_tN^s_t + (1 + r_{t-1})s_t - c_t - \gamma_x s_{t+1} = 0,$$

where $s_t \equiv k_t + d_t + f_t$. And the firm's optimization conditions are

$$\text{(B6)} \qquad \Omega_tA_t(k^g_t)^{\theta_g}F_1(k^d_t, N^d_t) - \delta = r_t,$$

$$\text{(B7)} \qquad \Omega_tA_t(k^g_t)^{\theta_g}F_2(k^d_t, N^d_t) = W_t.$$

From equations (B1)–(B7) and market equilibrium conditions, we have

(B8) $$U_1(c_t^*, 1 - N_t) = \lambda_t,$$

(B9) $$U_2(c_t^*, 1 - N_t) = \lambda_t \Omega_t A_t (k_t^g)^{\theta_g} F_2(k_t, N_t),$$

(B10) $$\beta^* \lambda_{t+1}[1 + \Omega_{t+1} r^f - \xi_1] = \lambda_t \gamma_x,$$

(B11) $$\Omega_t r_t^f - \xi_1 = \Omega_t r_{kt} - \delta = \Omega_t A_t (k_t^g)^{\theta_g} F_1(k_t^d, N_t^d) - \delta,$$

(B12) $$z_t = (\Omega_t r^f - \xi_1) d_t + i_t^g + c_t^g + (\xi_3 - 1)\xi_1 - \tau_t [A_t (k_t^g)^{\theta_g} F(k_t, N_t) + f_t],$$

(B13) $$c_t^* + \gamma_x k_{t+1} - (1 - \delta) k_t + i_t^g + (1 - \psi) c_t^g + \gamma_x f_{t+1} - (1 + r^f - \xi_1 \xi_3) f_t = A_t (k_t^g)^{\theta_g} F(k_t, N_t).$$

Equations (B8)–(B13) solve the processes $\{c_t^*, N_t, k_{t+1}, \lambda_t, \tau_t, \Omega_t, f_{t+1}\}$. Following the linearization method we used in appendix A, we have

(B14) $$\hat{\Omega}_t = \omega_K' \hat{k}_t + \omega_N' \hat{N}_t + \omega_A' \hat{A}_t + \omega_B' \hat{B}_t + \omega_1' \hat{i}_t^g + \omega_2' \hat{c}_t^g + \omega_f' \hat{f}_t + \omega_d' \hat{d}_t + \omega_z' \hat{z}_t,$$

(B15) $$\xi_{cc} \hat{c}_t^* - \xi_{cl} \frac{1}{1 - N} \hat{N}_t = \hat{\lambda}_t,$$

(B16) $$\xi_{lc} \hat{c}_t^* - \xi_{ll} \frac{1}{1 - N} \hat{N}_t = \hat{\lambda}_t + (\omega_A' + 1) \hat{A}_t + (\omega_B' + 1) \hat{B}_t + (\omega_k' + \xi_{NK}) \hat{k}_t + (\omega_N' + \xi_{NN}) \hat{N}_t + \omega_1' \hat{i}_t^g + \omega_2' \hat{c}_t^g + \omega_D' \hat{d}_t + \omega_Z' \hat{z}_t + \omega_f' \hat{f}_t,$$

(B17) $$\hat{\lambda}_{t+1} + \eta_A' \hat{A}_{t+1} + \eta_B' \hat{B}_{t+1} + \eta_K' \hat{k}_{t+1} + \eta_N' \hat{N}_{t+1} + \eta_1' \hat{i}_{t+1}^g + \eta_2' \hat{c}_{t+1}^g + \eta_D' \hat{d}_{t+1} + \eta_Z' \hat{z}_{t+1} + \eta_f' \hat{f}_{t+1} = \hat{\lambda}_t,$$

(B18) $$(\omega_A' + \kappa_A) \hat{A}_t + (\omega_B' + \kappa_B) \hat{B}_t + (\omega_K' + \kappa_K) \hat{k}_t + (\omega_N' + \kappa_N) \hat{N}_t + \omega_1' \hat{i}_t^g + \omega_2' \hat{c}_t^g + \omega_D' \hat{d}_t + \omega_Z' \hat{z}_t + \omega_f' \hat{f}_t = 0,$$

(B19) $$\hat{A}_t + \hat{B}_t + s_n \hat{N}_t + s_k \hat{k}_t = s_c \hat{c}_t^* + s_{ig} \hat{i}_t^g + (1 - \psi) s_{cg} \hat{c}_t^g + s_i \phi \hat{K}_{t+1} - s_i (\phi - 1) \hat{k}_t + \gamma_x s_f \hat{f}_{t+1} - (1 + r^f - \xi_1 \xi_3) s_f \hat{f}_t,$$

where the values of ω' are the elasticities of Ω' with respect to its arguments, while

$$1 + \tau_t \equiv \Omega_t = \Omega'(N_t, k_t, f_t; \psi_t'),$$

$$\psi_t' \equiv (A_t, k_t^g, i_t^g, c_t^g, d_t, z_t),$$

the values of η' are the elasticities of $(1 + \Omega_t r^f - \xi_1)$ with respect to each variable, the values of κ are the elasticities of $[r^f - A_t (k_t^g)^{\theta_g} F_1(k_t, n_t)]$ with respect to each variable, and $s_f \equiv f/y$.

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Comment Ponciano S. Intal, Jr.

Chen-Min Hsu utilizes a Barro-type continuous market-clearing intertemporal one-sector growth model in evaluating Taiwan's planned public investment program under the Six-Year Plan for Economic Development. The simulation re-

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sults are interesting because they are counterintuitive. Specifically, Hsu's simulations indicate that Taiwan's increased government expenditures under the Six-Year Plan would lead to lower growth of national income, albeit not quite contemporaneously. Why?

Hsu's simulation results stem from the crowding out of private expenditures, especially private investment, arising from the government's public investment program. The "crowding-out" result does not conform to the traditional crowding-out literature, however. In the literature, crowding out is caused by a policy-induced rise in the real interest rate, thereby leading to a lower than desired ratio of capital stock to real GNP and lower investment flows. In contrast, Hsu's simulations show declines in the real interest rate in the first few years which, given the marginal condition for the firm in the model, should indicate higher private capital stock and positive private investment. Thus, there appears to be some inconsistency between the results of the simulations and the analytical underpinnings of the standard crowding-out hypothesis.

Hsu's analysis appears to use a different notion or mechanism of crowding out. Specifically, the increased government expenditures crowd out private expenditures because:

1. the reallocation of resources from the private sector to the government sector entails a misallocation of resources (resulting in deadweight productivity and income loss) because the productivity of capital in the government sector is presumed less than the productivity of capital in the private sector, and

2. the concomitant tax rate increases in the future which are needed to pay back loans incurred from increased government expenditures are presumed to have "distortionary effects" on the marginal productivities of labor and capital, thereby resulting in lower than desired capital stock (hence lower private investment flow) and labor input.

It is apparent that given items 1 and 2 above, the magnitude of the public investment program is irrelevant; i.e., any incremental public expenditure will crowd out private expenditure in Hsu's model.

The results of the simulations for the small, open economy case are especially counterintuitive: they indicate that government expenditures reduce income and savings and raise the tax burden in an open economy more than in a closed economy. This is counterintuitive because the general presumption is that the free flow of capital in an open economy reduces the crowding-out effect that government expenditures may have in the domestic capital market. The simulations show decline in the real interest rate, which is inconsistent with the small, open economy case, wherein the domestic interest rate is equal to the exogenously given world interest rate assuming no exchange rate change and uniform taxation between foreign and domestic assets. The behavior of the real interest rate in the simulations can be explained only by currency appreciation during the early years of the simulation period, followed by currency depreciation later on. The paper does not state anything, however, on exchange rate changes. Indeed, by explicitly assuming no inflation and no capital gains, the model implicitly assumes a fixed exchange rate regime.

The above discussion brings out the question of whether the Barro-type one-sector intertemporal model significantly helps clarify the issues related to Taiwan's public investment program. For the most part, the answer is no, because the model, at least as specified in Hsu's paper, assumes away the more important policy issues in Taiwan's expenditure program:

1. Proponents of the government's public investment program emphasize the view that increased government expenditures, which are primarily for infrastructure, have positive externality on private capital. That is, the marginal productivity of private capital would be higher, the higher the level of public capital stock (i.e., infrastructure). The formulation of the production function in the model and the specification of the simulations negate this possibility and hence do not objectively address this critical, if contentious, issue.

2. For a small, export-oriented economy like Taiwan's, the issue of the impact of a significant government expenditure program on its international competitiveness looms large. Taiwan's economic sectors face different degrees of competitive pressures from abroad and have different rates of productivity growth. Given Taiwan's already very tight labor market, there is a danger that large government investment shocks may push Taiwan's wage rates substantially higher than the rate of growth of labor productivity in the tradeable goods sector, thereby endangering Taiwan's international competitiveness unless there is a corresponding depreciation of the NT dollar. In addition, for Taiwan's numerous small-scale firms, the concomitant wage rate pressures may force them to merge or reorganize or to relocate (part of) their operations offshore (e.g., to China or Southeast Asia). It may be noted that Taiwan has started importing contract labor primarily from Southeast Asia in order to dampen wage rate pressures. Nevertheless, this measure can be expected to be merely a palliative since a large expenditure shock can be expected to further raise domestic wage rate pressures. Thus, a two-sector (e.g., tradeable and nontradeable sectors) intertemporal model would provide deeper policy insights into the planned government investment program than a one-sector intertemporal model.

3. With respect to the issue of the magnitude of the government expenditure program, Hsu estimates the program to be equal to 5 percent of GNP per year for six years. Note that during 1986–90, Taiwan's gross domestic saving averaged about 33 percent of GNP, its gross domestic investment averaged about 21 percent of GNP, the central government surplus averaged about 0.5 percent of GNP, and the inflation rate averaged 2.2 percent per year. Taiwan's large domestic saving surplus explains the sharp rise in its international reserves and the growing investment outflows to China, Southeast Asia, and the United States in recent years. Thus, it seems that crowding out is not as important an issue as the issue of whether the productivity of the government's public investment program (funded from international reserve drawdown and domestic saving) is higher than the returns of Taiwan's savings and investments abroad (e.g., international reserves and foreign direct investment).

In sum, the Barro-type continuous market-clearing one-sector intertemporal fiscal model may not be the most appropriate model with which to evaluate the key policy issues surrounding Taiwan's public investment program.

Comment Yun-Wing Sung

Chen-Min Hsu extends Barro's (1989) work to the open economy of Taiwan. The paper is interesting as the very ambitious Six-Year Plan for Economic Development of Taiwan probably has significant macroeconomic impacts.

While the macroeconomic impacts of Taiwan's Six-Year Plan are certainly an important subject, however, the parameter values adopted in the paper artificially cast the public sector in a very unfavorable light. According to the specification of the production function, public capital and private capital are complementary, but the output elasticity of private capital is much higher than that of public capital. As a result, output falls appreciably when the government invests more and the crowding-out effect on private investment is very serious.

The empirical relevance of such a characterization of the Taiwanese economy is doubtful. The congestion and overcrowding of Taiwan's infrastructural facilities are well known to visitors, and Galbraith's famous phrase "private affluence, public squalor" may be applicable to Taiwan. While the productivity of public projects should be analyzed case by case, there are undoubtedly public projects in Taiwan that can be very productive.

As the parameter values of such a highly aggregated model cannot be very accurate, sensitivity analysis would be very important. However, there is no sensitivity analysis in the paper.

Two of the conclusions of the paper, that the projects of the plan should be open to private investors and that the government should use its foreign exchange reserves rather than foreign borrowing, do not follow from the model. In fact, such conclusions cannot be obtained from a one-sector neoclassical growth model.

Public projects must generate revenue in order to attract private investment, but such revenue has not been taken into account in the government's budget constraint (eq. [13]). Opening public projects to private investment would decrease government borrowing to finance the projects, but government revenue would also be decreased. Privatization cannot be recommended unless private investors are more efficient than the government in running such projects. Whether private investors are efficient or not cannot be gauged from a one-sector growth model.

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If the government uses its foreign exchange reserves rather than borrowing to finance the projects, it may save interest costs, as the borrowing rate is usually higher than the rate of return on the reserves. However, there are good reasons to maintain reserves in case of contingency. Whether Taiwan's reserves are too high cannot be determined from a one-sector growth model.