《人文及社會科學集刊》
第十二卷第四期 (89/12), pp. 657-674

Evaluating the Revenue Effect of Public Investment*

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ABSTRACT

The complementarity between public goods and private goods has been a main focus in recent studies of optimal public good provision. Specifically, when one applies the cost-benefit analysis to a public expenditure project financed by distortionary taxes, the marginal cost of public funds (MCF) may depend on the revenue effect associated with the complementarity between public expenditures and private goods. The purpose of this paper is to investigate the effect of public investment on the revenue of consumption taxes in Taiwan. It follows the theoretical framework formulated by Wilson (1991) to set forth an empirical model for the estimation of the tax revenue function. The empirical results indicate that current public investment has a two- to three-year lag before it affects consumption tax revenue. During the period of observation, 1964 to 1996, the revenue effects of public investments in Taiwan are shown to be positive, implying that public investment in part self-finances and thus reduces the required public funds. From the perspec-

* This paper is dedicated to late Professor Ching-huei Chang, whose academic enthusiasm, creative mind and generosity of spirit will be kept alive in my mind forever. I am grateful to Professors John Riew, Sheng-Cheng Hu, Ping Wang, Wen-Hui Cheng, Chu-Wei Tseng, Chien-Chen Yang, and two anonymous referees for their insightful comments. Thanks also go to seminar participants at National Cheng-Chi University and Feng-Chia University for their helpful suggestions. Any remaining errors are my responsibility. I also acknowledge financial support from the National Science Council of ROC under grant NSC86-2415-H-005A-014.
Received: April 20, 1999; Accepted: October 5, 1999

tive of the cost-benefit analysis, raising the level of public investment is justified. However, in view the recent trends of rising pecuniary costs of public investment and falling revenue effects, the case for increasing public investment seems to have become less compelling than in earlier periods.

Key Words: Public Investment, Marginal Cost of Public Funds, Revenue Effects, Net Public Funds

1. Introduction

The complementarity between public goods and private goods is one of the central issues in recent studies of optimal public good provision. Specifically, when one applies the cost-benefit analysis to a public expenditure project financed by distortionary taxes, the marginal cost of public funds (MCF) may depend on the revenue effect[1] associated with the complementarity between public goods and private goods. According to Browning (1976), the MCF is defined as the social cost of financing an increase in the provision of public goods. If the increment of public good provision were financed by taxes, the MCF would be the direct tax burden plus the marginal welfare cost engendered in acquiring the tax revenue. Therefore, in a first-best economy such as Samuelson (1954) characterized, the provision of public goods can be financed by lump-sum taxes and the MCF must equal one. While in an economy with only distortionary taxation, public good provision can no longer be financed by lump-sum taxes and the MCF must be greater than one, implying that the optimal level of public good provision is smaller than it would have been with nondistortionary taxation.

However, as Atkinson and Stern (1974), Wilson (1991), Ballard and Fullerton (1992), and Sandmo (1998) indicated, this conclusion may not necessarily hold. If one considers the complementarity between public goods and private goods, then the MCF will ultimately depend not just on the tax, but also on the nature of the public good provision under consideration. In an economy with only consumption-type distortionary taxes, if public goods

1 Schöb (1994) refers the revenue effect associated with the complementarity between public goods and taxed private goods to as the 'self-financing effect' of public good provision.

are complements to most of the taxed private goods, then there will be a positive revenue effect associated with an increase in the provision of public goods. This will reduce the magnitude of the MCF and make the increase in public good provision to be socially desirable. On the other hand, if public goods are substitutes for most of the taxed private goods, then the MCF will increase in an association with the negative revenue effect, to leave the optimal level of public good provision below the first-best level.

Although the significance of the revenue effect of public good provision is theoretically well understood, the literature does not suggest any empirical measure for it. Therefore, it is of our interest to examine how the magnitude of the revenue effect of public good provision could be in an economy with distortionary taxes. This paper aims to investigate the effect of public investment[2] in Taiwan on the revenue from consumption taxes, including the value-added tax (VAT) and commodity taxes.[3] It follows the theoretical framework formulated by Wilson (1991) to set forth an empirical model for estimating the revenue function of consumption taxes in Taiwan. The empirical analysis incorporates Taiwan's annual data from tax revenue reports during 1961-1996 with the Generalized Method of Moments (GMM) estimation in econometrics. It finds that, during the period of observation all the revenue effects of public investment on consumption taxes are positive, implying that public investment in Taiwan is complement to most of the taxed private goods and it does have a self-financing effect. However, the revenue effect of public investment also displays a trend of decline during the period of observation, i.e., the self-financing effect in more recent decades were lower than in earlier decades.

The rest of this paper is organized as follows. Section 2 presents a theoretical model of public goods provision as that of Wilson (1991) and then formulates the well-known Samuelson rule for public goods provision in an economy with distortionary taxes. Section 3 specifies an econometric model of the revenue function for consumption taxes. Section 4 shows the descriptive statistics for empirical data and analyzes econometric results. The last

2 In this study, we regard public investment as the provision of public goods.

3 Commodity taxes in Taiwan are levied on various selected items. Although its revenue has exhibited a significant reduction after the VAT was instituted in 1986, it remains an important part of consumption taxes. The revenues from VAT and commodity taxes as a percentage of total tax revenues were 18.3% and 12.4% in 1996, respectively.

section presents some concluding remarks.

2. The Theoretical Model

2.1. The Optimal Provision of Public Goods with Distortionary Taxes

Consider an economy with H individuals, N private goods, $\boldsymbol{x}=(x_1, x_2, \ldots, x_N)$, and a public good, G. The government aims to maximize the level of social welfare subject to the production feasibility of the economy, $F(\boldsymbol{x}, G)=0$, by providing the public good with distortionary taxes on private goods. Let $\boldsymbol{\tau}=(\tau_1, \tau_2, \ldots, \tau_N)$ be the vector of tax rates imposed on private goods. Then, following Wilson's (1991) expression, we may assume that all x_is need not to be taxed optimally and each of the τ_is can be regarded as a function of a vector of tax instruments, $\boldsymbol{b}$, i.e., $\tau_i=\tau_i(\boldsymbol{b})$.[4]

The government's problem thus can be expressed as the following:

$$\text{(1)} \qquad \max_{\{G, b\}} \Psi(V^1, V^2, \ldots, V^H) \qquad \text{S.t.} \quad F(\boldsymbol{x}(\boldsymbol{q}, \boldsymbol{Y}, G), G)=0,$$

where Ψ is the Bergson-Samuelson social welfare function which is assumed to be twice differentiable and concave in V^h, $h=1, 2, \ldots, H$. $V^h=V^h(\boldsymbol{q}, Y^h, G)$ is the indirect utility function that characterizes individual h's preference. $\boldsymbol{q}=(q_1, q_2, \ldots, q_N)$ is the vector of consumer prices for private goods. Y^h is individual h's income and $\boldsymbol{Y}=(Y^1, Y^2, \ldots, Y^H)$. It is assumed that the utility function is such that the individual's demand for a given private good i, x_i^h, is a well-defined function of $\boldsymbol{q}$, Y^h, and G. It is also assumed that all V^hs and F are twice differentiable and continuous functions of $\boldsymbol{q}$, G and all Y^hs.

Differentiating the Lagrangian for the government's optimization with respect to G and then manipulating with competitive equilibrium conditions and individual budget constraint, we have the optimal condition for public good provision in a second-best economy as the following:[5]

$$\text{(2)} \qquad \sum_{h=1}^{H} \frac{\beta^h}{\lambda} MRS_{G,Y^h}^h + \sum_{i=1}^{N} \tau_i x_{iG} = F_G,$$

4 In Wilson (1991), the provision of public goods can be partially financed by limited lump-sum taxation, which is not allowed in the current study.

5 It is a second-best economy because the provision of public good can be financed only by distortionary taxes.

where $\beta^h(=\Psi_{V^h} V^h_{Y^h})$ is the marginal social utility of consumption; MRS^h_{G,Y^h} $(=\frac{V^h_G}{V^h_{Y^h}})$ is h's marginal rate of substitution between G and Y^h; λ is the Lagrange multiplier; $x_{iG}=\frac{\partial x_i}{\partial G}$; and $F_G=\frac{\partial F}{\partial G}$.

Equation (2) represents the Samuelson rule for the optimal level of public good provision with distortionary taxes on the consumption of private goods. The term in the right-hand side reflects the marginal cost of public good provision. The first term in the left-hand side is the marginal social benefit of the public good, which equals the summation of individual MRS weighted by a proportion of social marginal utility of individual consumption. The second term in the left-hand side measures the revenue effect of public good provision associated with the complementarity in demand between the public good and taxed private goods. Intuitively, a positive revenue effect will reduce the net cost of public good provision and raise the optimal level of public good provision. The converse holds if the revenue effect is negative.

2.2. The Revenue Effect of Public Good Provision

Equation (2) may implicitly give the optimal level of public good provision, G^*. This in turn leads the revenue effect associated with the provision of public good to the following:[6, 7]

$$\frac{\partial T}{\partial G}=F_G(G^*, \boldsymbol{Y}, \boldsymbol{q})-\sum_{h=1}^{H}\frac{\beta^h}{\lambda}MRS^h_{G,Y^h}(G^*, Y^h, \boldsymbol{q}), \tag{3}$$

where $\frac{\partial T}{\partial G}=\sum_{i=1}^{N}\tau_i x_{iG}$ measures the revenue effect of public good provision and T denotes the revenue of consumption taxes.

It implicitly follows from equation (3) that the revenue from consumption taxes can be expressed as a function of the form as the following:

$$T=T(\boldsymbol{Y}, \boldsymbol{p}, \boldsymbol{\tau}, \frac{\boldsymbol{\beta}}{\lambda}, G^*), \tag{4}$$

where $\boldsymbol{p}=\boldsymbol{q}-\boldsymbol{\tau}$ is the vector of producer prices for private goods and $\boldsymbol{\beta}=(\beta^1, \beta^2, ..., \beta^H)$. It is worth noting that since $\beta^h=\Psi_{V^h} V^h_{Y^h}$, the values and pat-

6 As shown by Wilson (1991), the second term in the right-hand side of equation (3) can be decomposed into an income effect and an equity effect.

7 With this traditional framework of optimal public good provision, there involves only the revenue effect on consumption taxes. Consequently, the following analyses focus on the consumption taxation only.

tern of elements in (β/λ) will depend on the actual distribution of income.[8] In addition, increases in $\boldsymbol{Y}$ and $\boldsymbol{p}$ will also result in changes in the distribution of income. Hence, the revenue effects of Y, $\boldsymbol{p}$ and (β/λ) may be correlated.

Other things being equal, if there are proportional increases in incomes of all individuals or proportional increases in producer prices for all taxed goods, then the distribution of income will remain unchanged. There will be only a revenue effect associated with income growth or inflation. If increases in individual incomes or producer prices are not proportional, then there will be a direct revenue effect resulting from income growth or inflation and an indirect revenue effect through changes in income distribution. Finally, if per capita income and the general price level remain constant, a relative change in individual incomes or producer prices can only give rise to a revenue effect associated with a change in the income distribution. In order to clarify these revenue effects, we may rewrite the revenue function as follow:

$$RT = f(y, P, IDX, \boldsymbol{\tau}, G^*), \tag{5}$$

where RT is real tax revenue; y is real income per capita; P is the general price level; and IDX is the income distribution index. Holding others being equal, the revenue effect of public good provision evaluated at G^* is thus given by $\frac{\partial RT}{\partial G^*}$.

3. The Econometric Model

3.1. Econometric specification

In the light of equation (5), this section sets forth an empirical model for estimating the revenue function of consumption taxes in Taiwan. Before proceeding further, some assertions about the measurement of public good provision need to be explained. First, since infrastructures usually contain characteristics of public goods, we may consider public investment in infrastructure to be the provision of public good. Second, since infrastructures continue to be available for all individuals and producers, the revenue effect of public investment may last for periods. Finally, the observed level of in-

8 This allows us to translate the normative notions characterized in equations (3) and (4) into a positive notion shown in equation (5) below.

frastructure investment is generally not equal to its optimal level, G^*, because of the partial adjustment process in public investment. Hence, the current tax revenue that depends on the optimal level of public investment in the current period will also depend, in part, on the tax revenue of the last period.

In accordance with these assertions, we can rewrite the revenue function for consumption taxes in a given period of time, t, as the following:

$$(6) \quad RT_t = f(y_t, P_t, IDX_t, G_t, G_{t-1}, ..., G_{t-J}, \tau_t, RT_{t-1}), \qquad \forall t = 1, 2, ..., T,$$

where τ_t denotes the rate structure of consumption taxes in time t. Under the premise of constant elasticity, the revenue function can be specified as a log-linear form characterized by the following stochastic difference regression:

$$(7) \quad lnRT_t = \alpha_0 + \alpha_1 lny_t + \alpha_2 lnP_t + \alpha_3 lnIDX_t + \sum_{j=0}^{J} \alpha_{4,j} \ lnG_{t-j} + \gamma lnRT_{t-1} + \sum_{m=1}^{M} d_m D_{m,t} + \varepsilon_t, \qquad \forall t = 1, 2, ..., T,$$

In the regression, αs are respective coefficients to be estimated for real income, the price level, income distribution index, and real public investment. The revenue effect of public investment is characterized by $\alpha_{4,j}$. γ is the unknown coefficient for last period's revenue, and it is expected that $|\gamma| \leq 1$. Ds are dummy variables for the effects of structural changes associated with external shocks to the economy and statutory changes in the rate structure of consumption taxes. ds represent unknown coefficients for respective dummy variables and ε is the disturbance term in the regression.

By construction, a dollar increase in the current public investment can lead the tax revenue in each of the next $J+1$ periods to rise by the following amount:

$$(8) \quad dRT_{t+j} = \alpha_{4,j} \left(\frac{RT_{t+j}}{G_t} \right), \qquad \forall j = 0, 1, 2, ..., J.$$

The revenue effect of a dollar increase in public investment ($RVEG_t$) thus can be measured by the sum of dRT from period t to $t+J$, i.e.,

$$(9) \quad RVEG_t = \sum_{j=0}^{J} dRT_{T+j} = \sum_{j=0}^{J} \alpha_{4,j} \left(\frac{RT_{t+j}}{G_t} \right).$$

Intuitively, public investment is a complement to most of the taxed private goods and revenue productive to the government treasury as long as $RVEG_t$ is positive.

Subtracting the revenue effect from the one-dollar increase in the current public investment, we obtain the net pecuniary cost of public investment as the following:

$$NPCG_t = 1 - \sum_{j=0}^{J} \alpha_{4,j} \left(\frac{RT_{t+j}}{G_t} \right). \tag{10}$$

The net pecuniary cost can be regarded as the net public funds (NPF_t) spent on public investment. The revenue effect of public investment will reduce the amount of funds required to finance the same quantity of public investment. The greater is the revenue effect, the smaller the net pecuniary cost of public investment will be. Moreover, since the MCF decreases with the revenue effect of public investment, it may justify increase in public investment from the perspective of the cost-benefit analysis.

3.2. The Method of Estimation

The estimation method applied to this study is the Generalized Method of Moments (GMM) (Hansen, 1982). There are two reasons for using the GMM estimation. First, GMM is a procedure of instrumental variables that aims to avoid any possible bias associated with the reverse causation between dependent and independent variables. Second, it is appropriate to regressions with autocorrelated errors. The criterion for GMM estimation is to choose a set of parameter estimators that minimizes the following function:

$$M(\boldsymbol{\alpha}) = \boldsymbol{\varepsilon}(\boldsymbol{\alpha})' \boldsymbol{W} (\boldsymbol{W}' \boldsymbol{\Omega} \boldsymbol{W})^{-1} \boldsymbol{W}' \boldsymbol{\varepsilon}(\boldsymbol{\alpha}), \tag{11}$$

where

$$\varepsilon_t(\boldsymbol{\alpha}) = lnRT_t - f(y_t, P_t, IDX_t, G_t, ..., G_{t-J}, D_{1,t}, ..., D_{M,t}, RT_{t-1}), \tag{12}$$

$\boldsymbol{\alpha}$ is the vector of regression coefficients, $\boldsymbol{W} = (\boldsymbol{w}_1, \boldsymbol{w}_2, ..., \boldsymbol{w}_T)$ is a (NxK) matrix of instrumental variables,[9] and Ω is the expected value of $(1/T)\sum_t \boldsymbol{w}_t \varepsilon_t^2 \boldsymbol{w}_t'$.

When proceeding to estimate the revenue function for consumption taxes, it is important to avoid misspecifying the dimension of parameter space. This study employs the information criterion suggested by Schwarz

9 The instrumental variables in W include y_{t-1}, P_{t-1}, G_{t-1}, ..., G_{t-J}, $D_{1,t}$, ..., $D_{M,t}$, RT_{t-1}.

(1978) to specify appropriate model. Schwarz's criterion chooses the model that minimizes the following function:

$$SC(K) = log\frac{SSE}{T} + \frac{KlogT}{T}, \tag{13}$$

where K is the number of independent variables in regression, SSE is the error sum of squared for the regression, and T is the number of observations.

4. Empirical Analysis

4.1. Sources of Data

This study uses annual data from 1961 to 1996 to conduct the estimation of the revenue function for consumption taxation (the VAT and commodity taxes) in Taiwan.[10] Data sources for variables other than dummies are three government publications in Taiwan. Investment in infrastructure (G_t), general price level (P_t), and national income per capita (y_t) were obtained from *National Income in Taiwan* (1996), published by the Directorate-General of Budget, Accounting and Statistics. Revenues for consumption taxes (RT_t) were extracted from *Yearbook of Tax Statistics* (1997), published by the Ministry of Finance. The index for the inequality of income distribution (IDX_t) is measured by the ratio of annual personal income in the top quintile households to that in the bottom quintile. Its annual values were obtained from *Taiwan Statistical Databook* (1982-1997) of the Council for the Economic Development and Planning.

To capture the effects of the structural changes arising from the exogenous economic shocks and the statutory changes in consumption taxes, dummy variables are employed. OLC74 and OL8182 are variables representing the effect of structural changes resulting from the first and second worldwide oil crises in 1974 and during 1981-1982, respectively. FNC8586 purports to capture the effect of structural change associated with the financial scandal of Taipei Tenth Trust Cooperative in 1985.[11] The

10 All the values of annual data are based on calendar year (from January 1st to December 31st in the same year) rather than on fiscal year (from July 1st in the current year to June 30 in the next year).

11 The scandal involved the illegal loans to the president of the trust cooperative, and resulted in a national-wide financial crisis. Although it occurred in 1985, Taiwan's economy took almost two years to recover from its negative impacts.

variable YR9496 was meant to account for the structural change effect along with the economic downturn during 1994-1996. During the period of observation, there are also many statutory changes in consumption taxes. These include changes in commodity tax rates during 1965-1968, 1968-1970, 1972-1979, 1979-1981, 1986-1989, and a tax reform from a general sales tax to a VAT in 1986. The respective variables for these statutory changes, along with their definitions and sample statistics for variables in the regression, are shown in Table 1.

4.2. Estimation Results

Presented in Table 2 are the GMM regressions for the revenue function of consumption taxes in Taiwan. Comparing values of the Schwarz criterion among all regressions shown in the table, we note that the Model 6 has the lowest value for the criterion. Therefore, we will use this regression to represent the revenue function and analyze the revenue effect of public investment in Taiwan.

The Income Elasticity, Price Elasticity, and the Effect of Income Distribution

The coefficient for national income per capita (y_t) in the regression is 0.23993, which is less than one, indicating that the revenue from consumption taxes is inelastic to changes in income and thus, according to Musgrave and Musgrave (1989), is a regressive tax. The regressivity arises mainly from the fact that the fraction of income spent decreases as income rises.[12] The coefficient for the general price level (P_t) is negative and statistically significant, reflecting the negative effect of a change in the general price level on the consumption tax base; other things being equal, the demand for taxed goods falls as the price level increases.

The inequality of income distribution (IDX_t) also exhibits a negative effect on the revenue of consumption taxes. Its coefficient in the regression is -0.41727. Since lower income individuals tend to spend a greater fraction of their incomes on consumption than higher income individuals do, the marginal propensity to consume out of national income will decrease with the inequality of income distribution at a given level of income per capita. The revenue and base of consumption taxes may thus fall with rising inequality of income distribution.

12 See Bruce (1998), p.616.

Table 1. Definitions and Sample Statistics for Regression Variables

Variable	Definition	Mean	Standard Dev.
$lnRT_t$	the logarithm of real revenue of from consumption taxes	25.07995	.94688
lny_t	the logarithm of real national income per capita	11.42909	.63682
lnP_t	the logarithm of national income deflator	4.01041	.61636
$lnIDX_t$	the logarithm of income distribution index	1.55472	.09421
lnG_t	the logarithm of real public investment	25.02338	1.18584
OLC74	dummy variable for the first oil crisis in 1974. OLC74=1 if year=1974; else OLC74=0.	—	—
OLC8182	dummy variable for the second oil crisis during 1981-82. OLC8182=1 if year=1981-82; else OLC8182=0.	—	—
FNC8586	dummy variable for the financial scandal during 1985-86. FNC8586=1 if year=1985-86; else FNC8586=0.	—	—
YR6568	dummy variable for the tax rate increases and new taxes imposed on some commodities during 1965-68. YR6568=1 if year=1965-68; else YR6568=0.	—	—
YR6870	dummy variable for the tax rate increases and new taxes imposed on some commodities during 1968-70. YR6870=1 if year=1968-70; else YR6870=0.	—	—
YR7279	dummy variable for the tax rate increases in textile materials and non-alcohol beverages during 1972-79. YR7279=1 if year=1972-79; else YR7279=0.	—	—
YR7981	dummy variable for the repealing of taxes on textile materials, new taxes imposed on electrical products, and tax rate increases in automobiles during 1979-81. YR7981=1 if year=1979-81; else YR7981=0.	—	—
YR8689	dummy variable for the tax rate reduction and repealing in some commodity during 1986-89. YR8689=1 if year=1986-89; else YR8689=0.	—	—
VAT8696	dummy variable for the tax reform from a general sales tax to a VAT since 1986. VAT8696=1 if year=1986-96; else VAT8696=0.	—	—
YR9496	dummy variable for the economic downturn during 1994-96. YR9496=1 if year=1994-96; else YR9496=0.	—	—

Sources: (1) *National Income in Taiwan Area of the Republic of China*, DGBAS, 1996.
(2) *Yearbook of Tax Statistics*, Ministry of Finance, 1997.
(3) *Taiwan Statistical Databook*, CEDP, 1982-97.

Table 2. GMM Regressions for the Revenue Function of Consumption Taxes in Taiwan

Indep. Vars.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	1.1206	1.97078***	1.05166***	1.11137***	1.83166***	.98779**
	(.373)	(3.006)	(1.992)	(2.450)	(3.629)	(1.943)
lny_t	.01773	.10726	.24574*	.22094**	.146089	.23993**
	(.047)	(.568)	(1.582)	(1.645)	(1.249)	(1.823)
lnP_t	−.07621	−.16154***	−.26622***	−.25926***	−.19395***	−.27623***
	(−.638)	(−1.255)	(−3.216)	(−4.691)	(−3.044)	(−4.095)
$lnIDX_t$	−.09759	−.46205***	−.41369***	−.41921***	−.48535***	−.41727***
	(−.268)	(−3.264)	(−3.55)	(−3.587)	(−4.824)	(−3.661)
lnG_t	−.13973	−.06819	−.01381	—	−.04384	—
	(−1.121)	(−.798)	(−.326)		(−1.130)	
lnG_{t-1}	.17556	.01994	—	.05026	—	—
	(1.160)	(.272)		(.979)		
lnG_{t-2}	−.18482	—	−.07509	−.15042**	—	−.08319**
	(−1.113)		(−1.169)	(−1.697)		(−1.812)
lnG_{t-3}	.24262***	.20613***	.30335***	.33587***	.22352***	.31577***
	(2.310)	(2.716)	(4.210)	(5.858)	(6.327)	(6.827)
$lnRT_{t-1}$	.87614***	.76578***	.70494***	.69186***	.74257***	.69395***
	(6.117)	(7.530)	(8.681)	(13.176)	(14.162)	(13.578)
OLC74	−.27973***	−.22120***	−.19447***	−.18658***	−.20836***	−.18708***
	(−7.988)	(−4.045)	(−4.805)	(−9.377)	(−7.563)	(−7.853)
OLC8182	−.09797***	−.08397**	−.06184***	−.06867***	−.07776***	−.06172***
	(−4.125)	(−3.347)	(−3.575)	(−4.531)	(−4.979)	(−4.065)
FNC8586	−.08181***	−.08257***	−.08682***	−.09161***	−.08467***	−.08758***
	(−2.624)	(−3.748)	(−3.059)	(−3.200)	(−3.929)	(−3.225)
YR6568	.03510**	.03160***	.03801***	.04531***	.03275***	.03854***
	(1.725)	(2.134)	(2.350)	(2.508)	(2.218)	(2.458)
YR6870	.11047***	.13170***	.13093***	.12657***	.13253***	.13135***
	(3.676)	(6.520)	(7.257)	(6.757)	(6.756)	(7.356)
YR7279	.07819***	.04227***	.05167***	.04601***	.04006***	.04891***
	(2.856)	(2.162)	(2.817)	(2.853)	(2.73)	(2.763)
YR7981	.00497	—	—	—	—	—
	(.146)					
YR8689	.04079	—	—	—	—	—
	(.392)					
YR9496	−.16550**	−.15655***	−.17887***	−.18555***	−.15869***	−.18404***
	(−1.757)	(−3.927)	(−5.105)	(−5.078)	(−4.042)	(−5.535)
VAT8689	.14701*	.20558***	.15931***	.16253***	.19868***	.15991***
	(1.623)	(4.924)	(3.952)	(4.489)	(6.663)	(4.469)
T	33	33	33	33	33	33
GMM Criterion	16.28868	15.34893	16.73961	16.33206	15.68912	16.89639
SC	−1.89731	−1.97763	−2.01588	−2.01783	−2.02691	−2.06189

Notes: (1)*, ** and *** indicate that the coefficients are significant at 15%, 10% and 5% significance level, respectively.

(2)The numbers in parentheses are asymptotic z values for respective coefficients.

The Effects of Structural Changes

As mentioned above, the structural change effects result mainly from exogenous shocks and statutory changes in consumption taxes. Obviously, the increase in tax rates and the imposition of taxes on added items of commodities during 1965-1968, 1968-1970 and 1972-1979 did cause positive and statistically significant structural changes in the tax revenue function,[13] helping to raise revenues in the respective periods. During 1979-1981, the government repealed commodity taxes on textile materials and imposed taxes on electrical products, which might have offset one another and resulted in insignificant structural change effect on tax revenue. Although the tax rates on some of the taxed goods were reduced further or repealed during 1986-1989, it also did not give rise to a significant revenue effect.

The adoption of the VAT was one of the major tax reforms in Taiwan, and as indicated by the coefficient of VAT8696 in Table 2, it had a positive and statistically significant revenue effect. In 1986, the government replaced the existing sales tax with a consumption-type VAT and removed a large portion of taxed goods from commodity taxes. The removal of commodity taxes on some commodities may reduce the consumption tax base; however, since the VAT is applicable to most of the consumption goods and services, it broadens the consumption tax base and helps raise revenues. The coefficients for OLC74, OLC8182, FNC8586, and YR9496 are all negative and statistically significant. Our finding indicates that the exogenous shocks caused by the two worldwide oil crises in 1974 and 1981, the financial scandal in 1985, and the economic downturn during 1994-1996 did bring about reductions in revenues from consumption taxes during the respective periods.

The Revenue Effects of Public Investment

As for the coefficients of public investments, only two- and three-year lagged public investments have significant effects on the current revenue of consumption taxes. Intuitively, when public investment was initiated, it would engender a rise in demand for taxed goods that serve as its inputs on the one hand and a crowding out effect on private investment and consumption on the other hand. These two effects could offset one another and in

13 These refer to the respective coefficients for dummy variables YR6568, YR6870 and YR7279 in Model 6 of Table 2.

turn lead the current and one-year lagged public investments to have no significant effects on consumption tax revenue. The coefficient for two-year lagged public investment is statistically significant and negative, indicating that the crowding out effect may dominate. Three years after its initiation, public investment starts to generate significantly positive effects. The reason is twofold. After a period of construction, public infrastructure begins to operate and serves as complement to the consumption of taxed goods on the one hand, and it could be a critical input for the production of taxed goods on the other hand. Both would bring in positive revenue effects on consumption taxes.

Table 3 shows the revenue effect ($RVEG_t$) and the net pecuniary cost ($NPCG_t$) of a dollar increase in real public investment during the period of observation. We note that the revenue effect shows a clear trend of decline, especially highlighted during the periods of economic recession such as 1974-1975, 1980-1986, and 1994-1996. This in turn leads the net pecuniary cost or the net public funds for public investment to rise over period. On the average, the revenue effect and the net pecuniary cost of public investment in the 1960s are higher and lower, respectively, than those in the rest period of observation. The reason is that during the 1960s, Taiwan's economy was in a highly expanding stage while there was a deficiency in public infrastructure. A dollar increase in public investment during that period would have induced a greater increment in the consumption tax base. The Big-Ten Infrastructure Construction project, which began in 1972, soon led to strong revenue effects during the earlier part of 1970s, but then it declined significantly following the first worldwide oil crisis during 1974-1975. In 1980, in the aftermath of the second worldwide oil crisis, the effect was to its historical low.

The revenue effect continued to decline during the first half of the 1980s because of the persisting of economic recession attributable to the oil crisis and the financial scandal of the Tenth Trust Cooperative in Taipei, reaching another historical low of 0.21783 in 1985. During the second half of 1980s, the revenue effect showed a reversing trend, rising to 0.40239 in 1990 and then declined gradually thereafter. Eventually, it significantly fell to all-time low of 0.18959 in 1996. On the average, the revenue effect in the 1980s and 1990s were lower than those in previous decades. In addition to the economic recession, one other reason may help explain this result: the increasing cost of land and materials for infrastructure construction which became increasingly more pronounced during the 1980s and the early 1990s.

Table 3. The Revenue Effect and Net Pecuniary Cost of a Dollar Increase in Public Investment (1964-96)

Year	$RVEG_t$	$NPCG_t$
1964	.42683	.57317
1965	.45660	.54339
1966	.50098	.49902
1967	.48305	.51695
1968	.58888	.41111
1969	.64024	.35976
1970	.61825	.38175
1971	.59004	.40997
1972	.57152	.42848
1973	.54512	.45479
1974	.44654	.55346
1975	.43689	.56311
1976	.44162	.55838
1977	.47385	.52615
1978	.35705	.64294
1979	.31190	.68809
1980	.26628	.73372
1981	.28209	.71791
1982	.26849	.73151
1983	.26201	.73799
1984	.25556	.74443
1985	.21783	.78217
1986	.29261	.70739
1987	.34269	.65731
1988	.34747	.65253
1989	.39651	.60349
1990	.40239	.59761
1991	.35494	.64506
1992	.35531	.64469
1993	.30997	.69003
1994	.27264	.72736
1995	.22878	.77122
1996	.18959	.81041
1964-1970 average	.53069	.46931
1971-1980 average	.44409	.55591
1981-1990 average	.30677	.69323
1991-1996 average	.28521	.71479
1964-1996 average	.39196	.60804

Note: The calculations of $RVEG_t$ and $NPCG_t$ (of equation (9) and (10), respectively) are based on the regression coefficients of Model 6 in Table 2 and annual values of public investment and tax revenue.

In sum, the revenue effects of public investment on consumption taxes in Taiwan were all positive during the period of observation, 1964-1996. It signifies that public investment has been complement to most of the taxed goods, and increases in public investment have been socially desirable. However, since the effect displays a trend of decline, the net pecuniary cost shows to increase over time.

5. Concluding Remarks

The complementarity between public goods and private goods has been a focus in recent studies of optimal public good provision. Having examined the revenue effect of public good provision with the second-best Samuelson rule formulated by Wilson (1991) and having transformed the rule into an empirical revenue function for consumption taxes in Taiwan, this paper contains its own distinctive features with rich policy implications. It finds that the income elasticity of consumption taxes in Taiwan is less than one, signifying that the consumption taxation is regressive. Most of the rate changes in commodity taxes, the adoption of VAT, the exogenous shocks from worldwide oil crises, and the financial scandal have significant structural-change effects on the revenue from consumption taxes in Taiwan.

Most importantly, the current public investment takes two- to three-year lags to affect the revenue from consumption taxes. During the period of observation, 1964-1996, all the revenue effects of public investments on consumption taxes in Taiwan are positive, implying that public investment is able to self-finance and accordingly reduce the net public funds. From the perspective of cost-benefit analysis, it justifies a higher level of public investment. However, with the observed trend of rising pecuniary costs of public investment and falling revenue effects, the case for increasing public investment seems to have less compelling than in earlier periods.

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公共投資之稅收效益評估

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摘　要

公共財與私有財間的互補性是當今最適公共財提供理論的中心課題之一，尤其當吾人利用成本效益分析來評估以扭曲性租稅融通的公共投資計畫時，其公共資金的邊際成本更需視公共投資與私有財間之互補性所產生的稅收效果大小而定。本文之目的即在探討台灣之公共投資支出對消費稅（貨物稅與營業稅）稅收的影響效果，文中以 Wilson (1991) 的最適公共財提供量決定模型爲依據，建立台灣消費稅稅收函數的實證模型，並結合 1964 至 1996 年間的時間數列資料，以 GMM 的計量方法進行實證估計。根據實證結果得知，在樣本觀察期間，台灣的公共投資支出的確對其消費稅稅收產生正向的效果。換言之，公共投資可透過其與被課稅財貨間之互補性所帶來的稅收效果而產生自我融通的功效，從而可減少每一元公共投資的淨資金成本。就成本效益分析的觀點而言，此一稅收效果使公共投資支出的增加有正面而合適的學理依據。然而，由於在近年來臺灣公共投資的成本逐漸上升，使得所產生的稅收效果相對減弱，而無法如 1960 年代與 1970 年代的相對高水準。

關鍵詞：公共投資、公共資金的邊際成本、稅收效果、淨公共資金