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10 Taxes and Corporate Investment in Japanese Manufacturing

Fumio Hayashi

10.1 Introduction

Postwar Japan's rapid output growth has been characterized by a high level of investment exceeding 30% of gross national product for almost all years. The extent to which this sustained investment boom has been brought about by the Japanese corporate tax system is a very important issue for policymaking and deserves full analytical treatment. This paper attempts to cast the various aspects of the Japanese corporate tax system in the mold of modern investment theory with adjustment costs and to evaluate the role of tax incentives in the postwar capital accumulation of Japanese manufacturing.

Economic theory tells us that investment is governed by the cost and the benefit of incremental capital stock. Financial rate of return and taxes determine the cost of capital, while the benefit is the profitability of capital that depends on market opportunities and technology. The contribution of Hall and Jorgenson (1971) to neoclassical theory lies in showing exactly how taxes influence the cost of capital, whereas the essential feature of the Q theory of investment is that the determinants of investment can be summarized by a single index (called the "tax-adjusted Q") that combines the cost and benefit of capital. In order to understand the high level of investment in Japan, it is necessary to analyze the relative importance of the cost and the profitability of capital and the effect taxes have on them.

The basis of the Japanese corporate tax system is the Corporation Tax Law. In its treatment of depreciation accounting, inventory valuation, and some

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accruals, it does not differ qualitatively from its U.S. counterpart. One peculiarity of the Japanese system is that the corporate enterprise tax paid in the previous accounting year is tax deductible. Further elaboration of the Japanese corporate tax system is found in the Special Taxation Measures Law, which encompasses scores of tax breaks. The most important of these is probably the prevalent tax-free reserves. The Special Taxation Measures Law lists dozens of reserves and specifies the maximum amount that can be deducted from income and credited to the reserves. The law also provides for additional depreciation over ordinary depreciation, called "special depreciation." Special depreciation is easily accommodated in standard models of investment with or without adjustment costs. However, it is less obvious that the other major feature of the Special Taxation Measures Law, the tax-free reserves, can also be incorporated into the cost of capital and the tax-adjusted Q. In section 10.3, we demonstrate this, building on the expression for the value of a firm obtained in section 10.2. A rigorous derivation of the valuation formula is given in appendix A. Section 10.3 also discloses a close connection between the tax-adjusted Q and the cost of capital for the model that includes adjustment costs. In section 10.4, we calculate the tax-adjusted Q for the Japanese manufacturing sector and evaluate the impact of taxes on investment. Section 10.5 is a brief conclusion.

10.2 Taxes and the Valuation of a Firm

Our task in this section is to incorporate various aspects of the Japanese corporate tax system into a standard model of a firm's value-maximization problem. The next section will derive a one-to-one relationship between the investment-capital ratio and Q adjusted for various tax parameters. For the most part, we will ignore personal taxes and the financial side of the firm. Modifications of the investment-Q relationship that are necessary if those factors are considered will be discussed at the end of section 10.3. Thus for the time being we will consider a 100% equity-financed firm whose investment finance comes from retained profits. The notation will be rather complicated because of the many tax parameters. A glossary of symbols is provided in appendix B.

Consider a firm in period 0 whose objective is to maximize its market value, which is the present value of its net cash flow:

$$(1) \qquad V_0 = \sum_{t=0}^{\infty} C(0,t)(\pi_t - T_t - a_t I_t),$$

where $C(0,t) = (1+r_0)^{-1}(1+r_1)^{-1} \ldots (1+r_{t-1})^{-1}$ is the discounting factor at time 0 for a cash flow t periods hence (so, if the discount rate is constant at r_0, then $C[0,t]$ reduces to $[1+r_0]^{-t}$), r_t is the discount rate in period t, π_t is gross pretax profits (sales minus variable costs), T_t is corporate taxes, a_t is the price of investment goods, and I_t is the quantity of investment. Under Japanese tax law the following are the major items that are deductible from corporate income:[1]

1. *Depreciation allowances.* According to the financial statements filed by corporations with the Ministry of Finance, virtually all corporations employ either the straight-line or the declining-balance method of depreciation.

2. *Special depreciation.* In addition to the ordinary depreciation, the Special Taxation Measures Law lists asset types for which additional depreciation is permitted for the first year (and for some assets, for several succeeding years). Since the cumulative amount of depreciation is unchanged, special depreciation amounts to deferred tax payments.

3. *Investment tax credits.* Currently, for certain types of equipment, corporations can choose between a special first-year depreciation of 30% and a tax credit of 7% of the acquisition cost. Since the amount of the investment tax credit is negligible relative to total investment expenditure, we will ignore it.

4. *Enterprise tax.* The amount of enterprise tax paid in the previous accounting year can be deducted from the current year's income. As seen below, the deductibility of the enterprise tax significantly reduces the "effective" corporate rate.

5. *Tax-free reserves.* The Corporate Tax Law and the Special Taxation Measures Law list a host of tax-free reserves that can be deducted from income. For most reserves, the amount deducted must be added back in to the next year's income. In the formulation below we assume this is the case for all tax-free reserves.[2] Thus tax-free reserves, another vehicle by which corporations may defer tax payments, are essentially a one-year interest-free loan granted by the government. The existence of tax-free reserves will influence firm behavior if the size of the interest-free loan depends on the firm's action.

The reserve for retirement allowances, the largest tax-free reserve, may not at first glance seem to conform to this assumption of adding back in full to the next year's income. Let R_t here be the balance at the end of period t of the reserve for retirement allowances, X_t be the amount credited to the reserve, and Y_t be the amount withdrawn from the reserve. This Y_t equals actual severance payments during period t and this must be added back to income for tax purposes. According to the law, for most of the corporations in Japan, the maximum tax-free amount that is creditable to the reserve (call that X_t') is the smaller of either (a) the change over the year in the hypothetical total severance pay that the firm would have to pay if all its employees were to retire (b) the difference between some specified amount (currently set at 40% of the hypothetical total severance pay in [a]) and $R_{t-1} - Y_t$. Unless the reserve in the previous year (R_{t-1}) is extraordinarily low, due, for example, to a mass exodus of employees, the second criterion is the relevant one because of the factor of 40%. The tax benefit derived from the existence of the reserve results from the decrease in taxable income, which equals $X_t' - Y_t$. Under (b) this equals:

$$X_t' - Y_t = (40\% \text{ of the hypothetical severance pay}) - (R_{t-1} - Y_t) - Y_t$$
$$= (40\% \text{ of the hypothetical severance pay}) - R_{t-1},$$

which shows that it is not rational for the firm to let X_t, the actual amount credited to the reserve, exceed X_t', the legal ceiling on the amount deductible. If it did allow X_t to exceed X_t', the amount deductible in period $t + 1$ would be less by $(X_t - X_t')$. Thus it is reasonable to suppose that $X_t' = X_t$. Two conclusions follow from this result. First, the decrease in taxable income $X_t' - Y_t$ equals $X_t - Y_t$, which equals $R_t - R_{t-1}$, which is equivalent to the assumption we made above: the firm can deduct from current income the entire amount R_t but that R_{t-1} must be added back in full. Second, R_t equals 40% of the hypothetical severance pay.

The variable that determines the maximum amount to be deducted from corporate income and credited to the reserve depends on the reserve. For example, for the reserve for retirement allowances it is the hypothetical severance pay, and for the bad debt reserve it is the amount of receivables. We will divide the various tax-free reserves into two groups. The first group is composed of employment-related reserves whose maximum allowable amount is a function of the wage bill. The second group consists of those reserves whose maximum allowable amount is a function of certain other variables pertaining to the firm. We will assume that these variables are a function of the "size" of the firm represented by the reproduction cost of the firm.

The expression for the tax payment T_t that incorporates these features of Japanese tax law is

(2a) $$T_t = (u_t + v_t) \times (\text{taxable income}),$$

(2b) $$\text{taxable income} = \pi_t - \text{DEP}_t - S_{t-1} - (R_t - R_{t-1}),$$

(2c) $$S_t = v_t \times (\text{taxable income}).$$

Here, S_t is the corporate enterprise tax and v_t is the corresponding tax rate. T_t is the total amount of corporate taxes for period t, including the national and local corporate tax and the enterprise tax. The overall tax rate is thus $u_t + v_t$. In the expression for taxable income, R is the maximum amount to be deducted from income and credited to the tax-free reserves in period t.[3] DEP_t is the sum of ordinary depreciation and special depreciation. This can be written as

(3) $$\text{DEP}_t = \sum_{x=0}^{\infty} D(x, t-x) a_{t-x} I_{t-x},$$

where the depreciation formula as of $t-x$, $D(x, t-x)$ includes special depreciation.

It is shown in appendix A that the expression for the value of the firm under equations (1), (2a), (2b), (2c), and (3) can be written as

$$V_0 = \sum_{t=0}^{\infty} C(0, t)\{(1-\tau_t)\pi_t - (1-z_t')a_t I_t + [\tau_t - \tau_{t+1}/(1+r_t)]R_t\} \tag{4}$$
$$+ A_0' - \tau_0(R_{-1} - S_{-1}),$$

where

$$y_t = \sum_{n=1}^{\infty} C(t, t+n)(u_{t+n}+v_{t+n})(-v_{t+1})(-v_{t+2}) \ldots (-v_{t+n-1}), \tag{5}$$

which equals

$$y_t = (u_t + v_t)/(1 + r_t + v_t) \tag{5'}$$

if

$$u_{t+n} = u_t,\ v_{t+n} = v_t,\ r_{t+n} = r_t \quad \text{for } n \geq 1,$$

and

$$\tau_t = u_t + v_t - y_t v_t, \tag{6}$$

$$z_t' = \sum_{x=0}^{\infty} C(t, t+x)\tau_{t+x} D(x, t), \tag{7}$$

$$A_0' = \sum_{t=0}^{\infty}\{C(0, t)\tau_t[\sum_{x=1}^{\infty} D(x, -x)a_{-x}I_{-x}]\}. \tag{8}$$

Some of these rather formidable expressions are standard: z_t' represents the present value of tax savings arising from depreciation allowances on one yen of new investment,[4] while A_0' is the present value of all assets purchased in the past.

Other expressions are new but easy to interpret. The effective tax rate τ is not simply the sum of u and v because of the tax deductibility of the enterprise tax. A one-yen increase in the current enterprise tax results in a tax saving of $u + v$ yen in the next accounting year. But part of the tax saving, v, which is the amount of reduction in the next year's enterprise tax, gives rise to a tax increase of $v(u+v)$ in the year after next. This, in turn, brings about a tax saving of $v^2(u+v)$ in the following year, and so forth. The expression (5′) for y is the present value of this tax change on one yen of the current enterprise tax, and the expression (6) for the effective tax rate τ takes this into account. This term is rather important: if $u = 40\%$, $v = 10\%$, and $r = 5\%$, its value is about 43%. That is, for every yen of the enterprise tax paid, the firm recovers 0.43 yen in the present value sense.

The third term in the braces in expression (4)—$[\tau_t - \tau_{t+1}/(1+r_t)]R_t$—represents a subsidy in the form of an interest-free loan through tax-free reserves. By deducting the amount R_t in period t, the firm can reduce the corporate tax in period t by $\tau_t R_t$. Since that amount R_t must be added back to income in period $t+1$, the resulting tax increase in period $t+1$ is $\tau_{t+1}R_t$. The term $[\tau_t - \tau_{t+1}/(1+r_t)]R_t$ is the present value of that change in the stream of corporate tax.

The last term in expression (4) for the value of the firm, $-\tau_0(R_{-1} - S_{-1})$, represents a liability to the government in period 0 due to the tax-free reserves and the enterprise tax incurred in the previous period (period -1). The enterprise tax paid in the previous period of S_{-1} entitles the firm to claim a tax rebate of $\tau_0 S_{-1}$. On the other hand, the amount credited to the tax-free reserves in the previous period of R_{-1} must be added back to current income, which increases current corporate tax by $\tau_0 R_{-1}$.

The expression (4) for the value of the firm neatly divides the effect of taxes (the present value of T_t in [1]) into two components. The first component can influence the firm's action from period 0 on. It is represented by τ_t, z_t', and $[\tau_t - \tau_{t+1}/(1+r_t)]$, which constitute tax incentives for the firm. The second component, represented by the last two terms, $A_0' - \tau_0(R_{-1} - S_{-1})$, is given to the firm in period 0. It is an invisible asset to the firm, and its value is invariant regardless of the behavior of the firm from period 0 and on.

10.3 The Tax-Adjusted Q and the Cost of Capital

We now derive a one-to-one relationship between investment and Q adjusted for various tax parameters for the value-maximizing firm. Assuming that the firm is a price taker, gross pretax profits (before deduction of accounting depreciation) can be written as

$$\pi_t = p_t F(K_t, L_t, I_t) - w_t L_t, \tag{9}$$

where p is the output price, F is the production function, K is the capital stock, L is labor input, and w is the wage rate. Adjustment costs are incorporated here because output is assumed to be inversely related to investment, that is, $\partial F/\partial I < 0$. "Bolting down" new machines is a resource-using activity; as the quantity of investment increases, a larger fraction of capital and labor has to be directed to the investment activity, which results in lower output.

As we indicated in the previous section, the tax-free reserves are divided into employment-related reserves (RL) and other reserves (RK). The former depends on the wage bill (wL) while the latter are a function of the reproduction cost of the firm (aK):

$$R_t = RL_t(w_t L_t) + RK_t(a_t K_t). \tag{10}$$

The firm is assumed to maximize its value, given by the expression (4), subject to the capital accumulation constraint

$$K_t = (1-\delta)K_{t-1} + I_t. \tag{11}$$

Since the last two terms in the expression (4) are predetermined at time 0, the value maximization is equivalent to maximizing the first term subject to equation (11). That is, the firm is assumed to maximize

(12) $$\sum_{t=0}^{\infty} C(0, t)\{(1-\tau_t)[p_t F(K_t, L_t, I_t) - w_t L_t] - (1-z_t')a_t I_t + [\tau_t - \tau_{t+1}/(1+r_t)][RL_t(w_t L_t) + RK_t(a_t K_t)]\},$$

subject to equation (11). Letting $C(0, t)\lambda_t$ be the Lagrange multiplier for (11), we obtain the following first-order conditions:

(13a) $$(1-\tau_t)p_t \frac{\partial F_t}{\partial K_t} + [\tau_t - \tau_{t+1}/(1+r_t)]\, a_t \frac{\partial RK_t}{\partial (a_t K_t)} - \lambda_t + (1-\delta)\lambda_{t+1}/(1+r_t) = 0,$$

(13b) $$(1-\tau_t)p_t \frac{\partial F_t}{\partial I_t} - (1-z_t')a_t = \lambda_t,$$

and

(13c) $$(1-\tau_t)(p_t \frac{\partial F_t}{\partial L_t} - w_t) + [\tau_t - \tau_{t+1}/(1+r_t)]\, w_t \frac{\partial RL_t}{\partial (w_t L_t)} = 0.$$

The last condition yields

(14) $$\partial F_t / \partial L_t = w_t^* / p_t,$$

where

(15) $$w_t^* = (1 - \frac{[\tau_t - \tau_{t+1}/(1+r_t)]}{1 - \tau_t} \frac{\partial RL_t}{\partial (w_t L_t)}) w_t.$$

This w^* allows for the reduction in wage rate induced by the employment-related tax-free reserves.

If there are no adjustment costs, so that $\partial F / \partial I = 0$, then we have, from (13b), $\lambda_t = (1-z_t')a_t$. Thus from (13a) we obtain the familiar condition that the marginal product of capital equals the *cost of capital:*

(16) $$\frac{\partial F_t}{\partial K_t} = c_t,$$

where

(17) $$c_t = \frac{(1-z_t')a_t - (1-\delta)(1-z_{t+1}')a_{t+1}/(1+r_t)}{(1 - \tau_t)p_t} - \frac{\tau_t - \tau_{t+1}/(1+r_t)}{(1 - \tau_t)p_t} a_t \frac{\partial RK_t}{\partial (a_t K_t)}.$$

The second term on the right-hand side of equation (17) represents the reduction in the cost of capital arising from the capital-related tax-free reserves. It is easily seen that, if the tax-free reserve RK is ignored, and if static expectations $a_{t+1} = a_t$ and $z'_{t+1} = z'_t$ are assumed, then equation (17) reduces to the familiar expression for the cost of capital: $(1 - z'_t)a_t(r_t + \delta)/[(1 - \tau_t)p_t]$.[5]

We now reintroduce adjustment costs. Noting that the optimal labor input is a function of w^*/p and solving the condition given in (13b) for investment, we obtain the investment-Q relation

$$(18) \qquad I_t = I_t(Q_t, K_t, w_t^*/p_t),$$

where Q_t is defined by

$$(19) \qquad Q_t = \frac{\lambda_t - (1 - z'_t)a_t}{(1 - \tau_t)p_t}.$$

This Q is referred to as the tax-adjusted Q. It is the real value of the gap between the shadow price of capital λ and the effective price of investment goods $[(1 - z')a]$, grossed up by the corporate tax rate. We note from equation (18) that optimal investment also depends on the adjusted real wage w^*/p. It is clear from the derivation of this optimal investment rule that if the production function F in equation (9) has the separable form $F(K, L, I) = G(K, L) - C(I, L)$, the optimal investment rule does not involve the real wage rate.

There is a simple connection between the tax-adjusted Q and the cost of capital. By definition, the cost of capital c satisfies the conditions

$$(20) \qquad \begin{aligned} &(1 - \tau_t)p_t c_t + [\tau_t - \tau_{t+1}/(1 + r_t)]a_t \frac{\partial RK_t}{\partial(a_t K_t)} \\ &- (1 - z'_t)a_t + (1 - \delta)(1 - z'_{t+1})a_{t+1}/(1 + r_t) = 0. \end{aligned}$$

Subtracting equation (20) from (13a) we obtain

$$(21) \qquad \begin{aligned} &(1 - \tau_t)p_t(\partial F_t/\partial K_t - c_t) - [\lambda_t - (1 - z'_t)a_t] \\ &+ (1 - \delta)[\lambda_{t+1} - (1 - z'_{t+1})a_{t+1}]/(1 + r_t) = 0. \end{aligned}$$

This can be solved for $\lambda_t - (1 - z'_t)a_t$ as

$$(22) \qquad \lambda_t - (1 - z'_t)a_t = \sum_{s=t}^{\infty} C(t,s)(1 - \delta)^{s-t}(1 - \tau_s)p_s(\partial F_s/\partial K_s - c_s).$$

That is, the tax-adjusted Q is the present value of the gap between the marginal product of capital and the cost of capital. Thus, in the model with adjustment costs, the cost of capital continues to be an important channel through which taxes influence investment.

As shown in Hayashi (1982), the shadow price of capital λ in the expression (19) for the tax-adjusted Q can be made observable if we assume that (1) the firm is a price taker and (2) the environment represented by the production function is linearly homogeneous. In the present situation, this latter homogeneity assumption must include the assumption that *RL* and *RK* in equation (10), the maximum tax-free accumulation of reserves, are also linearly homogeneous in their respective variables, namely, that

$$\frac{\partial RL_t}{\partial(w_t L_t)} = \frac{RL_t}{w_t L_t}, \tag{23a}$$

and

$$\frac{\partial RK_t}{\partial(a_t K_t)} = \frac{RK_t}{a_t K_t}. \tag{23b}$$

Under this set of assumptions it seems obvious that the maximized value of expression (12) (which is the first term in [4]) is proportional to the initial capital stock $(1-\delta)K_{-1}$. Therefore, the *marginal* value of capital λ_0 is equal to the *average* value of capital

$$\lambda_0 = \frac{V_0 - A_0' + \tau_0(RL_{-1} + RK_{-1} - S_{-1})}{(1-\delta)K_{-1}}. \tag{24}$$

Thus the tax-adjusted Q as defined in equation (19) is connected to the value of the firm. Furthermore, under the homogeneity assumption the investment-Q relation becomes

$$I_t/K_t = \phi_t(Q_t, w_t^*/p_t). \tag{25}$$

This yields a new result showing that the connection between the tax-adjusted Q and the value of the firm involves tax-free reserves and the enterprise tax in the previous year.

Until now we have assumed that there is only one kind of capital. The theoretical model can allow for other kinds of capital provided that there are no adjustment costs associated with investment in these other assets. It is fairly straightforward to show that the marginal value of the first asset (with adjustment costs) is given by equation (23) if the market value of other assets (which equals their reproduction cost because there are no adjustment costs for those assets) is already subtracted from V_0. In our empirical implementation in the next section, the first asset is depreciable assets (buildings, structures, and equipment), while the other assets consist of land and inventories.

We close this section by briefly discussing the issue of investment finance. We have assumed an equity-financed firm that finances investment by retained profits. Thus the discount rate r is equal to the expected equity return and the value of the firm is the total equity value. How should we modify the expressions for the tax-adjusted Q? The following results concerning the investment-Q relation have been obtained in Hayashi (1985) for a model of a firm with adjustment costs under uncertainty and with personal taxes in which dividends are taxed more heavily than capital gains: (1) the investment-Q relation can be derived when at least part of incremental investment is financed either by retained profits or by new equity; (2) if new equity is used for investment finance, the value of the firm in the model is simply the sum of equity and debt outstanding; (3) if retained profits are used, the equity value receives a higher weight than debt, provided that the capital gains tax rate is lower than the dividend tax rate; and (4) when incremental investment is financed entirely by debt, the investment-Q relation cannot be derived. A corollary of all these is that if dividends and capital gains are taxed equally heavily or if personal taxes do not exist, then the investment-Q relation holds, with the value of the firm being the sum of equity and debt.

10.4 Empirical Results

The impact of taxes on the incentive to invest can be evaluated by examining how taxes enter the expressions for the tax-adjusted Q and the cost of capital. Since the expressions involve the present value of various forms of tax savings, certain assumptions are necessary concerning how future tax rates and discount rates are anticipated. In our empirical implementation we will assume static expectations for the tax rates (u, v, τ) and the discount rate. Thus z', A', and τ can now be written as

(26) $$z'_t = \tau_t z_t, \quad \text{where } z_t = \sum_{x=0}^{\infty} (1+r_t)^{-x} D(x, t),$$

(27) $$A'_0 = \tau_0 A_0, \quad \text{where } A_0 = \sum_{t=0}^{\infty} (1+r_0)^{-t} [\sum_{x=1}^{\infty} D(x, -x) a_{-x} I_{-x}],$$

and

(28) $$\tau_t = u_t + v_t - (u_t + v_t) v_t / (1 + r_t + v_t).$$

The z here coincides with Hall and Jorgenson's (1971) z. The expression for the tax-adjusted Q (eq. [19] with eq. [24]) becomes

(29) $$Q = \frac{\left[\frac{V - \tau A + \tau R_{-1} - \tau S_{-1}}{a(1-\delta)K_{-1}} - (1-\tau z)\right] a}{(1 - \tau)p},$$

where the time subscript "0" is dropped for ease of notation.

The measurement of the tax-adjusted Q for the Japanese manufacturing sector as a whole requires data on: V (market value of equity plus debt minus land and inventories), u (corporate tax rate), v (enterprise tax rate), r (discount rate), A (present value of depreciation allowances on past investment), R (tax-free reserves), S (enterprise tax), a (investment goods price), K (capital stock), aI (nominal investment), z (present value of depreciation allowances on new investment), and p (output price). The two principal data sources are the Ministry of Finance (for various fiscal years) and the Tax Bureau (various fiscal years). The Ministry of Finance keeps statistics compiled from financial statements aggregated over all corporations by industry. The aggregation is done by blowing up the sample aggregates by the sampling ratio. These data will be referred to as the financial statements data. The Tax Bureau keeps records of taxes paid by corporations and of tax-free reserves allowed by the Tax Bureau. These data will be referred to as the tax data. Since the time interval for these two primary sets of data is the fiscal year (beginning 1 April and ending 30 March), all calculations that follow are for fiscal years.

The data on V, A, z, al, and K are taken from a study by Homma, Hayashi, Atoda, and Hata (1984), in which the tax-adjusted Q for various Japanese industries was calculated. The study did not, however, take into account tax-free reserves and the tax deductibility of the enterprise tax.[6] The data used covered the period 1955–81, and this determined our own sample period. A brief summary of how the data on V, A, z, al, and K were constructed in their study follows.

The data on nominal investment are taken from the Economic Planning Agency's "Gross Capital Stock of Private Firms" (various years). Although the data include the noncorporate sector, the numbers are very close to the nominal investment series calculated from the financial statements data except that the latter show erratic movements for the first few years of the sample period. The data on the capital stock was taken from the 1970 National Wealth Survey (Economic Planning Agency 1974). Since this survey is only conducted every five years, the "Gross Capital Stock" data are used for interpolation. Using the nominal investment series from the financial statements data and the investment goods price index (see below), we generated a capital stock series by a perpetual inventory method with the rate of depreciation of 8.99%.[7] It turned out that this capital stock series is very close to the EPA capital stock series.

The market value of equity is calculated under the assumption that the ratio of the market value to the book value for all corporations in manufacturing is the same as that for all corporations in manufacturing traded on the Tokyo Stock Exchange. In calculating the market value of equity, the average of daily stock prices over the fiscal year is used. The market value of long-term debt is obtained by dividing the interest payments by a long-term interest rate. The market value of short-term debt is assumed to be the same as the book value. The value of the firm is the sum of the market value of equity and debt. However, the stock market valuation of a firm includes the value of land and inventories, which must be subtracted from the value of equity plus debt to arrive at the financial valuation of the capital stock. A perpetual inventory method is used to calculate the value of land. The price index for land is the "Residential Land Price Index" constructed by the Japan Research Institute of Real Estate (*Nihon Fudosan Kenkyu-Jo*) (various years). The change in the book value of land is assumed to be equal to the change in the market value of land. The market value of land in the base year (1955) is assumed to be equal to the assessment used by the Ministry of Local Administration for the purpose of levying property taxes. The value of inventories is assumed to be equal to the book value because the majority of corporations employ the average method for inventory valuation.

To calculate A and z, the data on the depreciation formula $D(x,t)$ are necessary. The asset life for tax purposes is assumed to be 34 years for buildings, 28 years for structures, and 10 years for equipment in 1970. These figures are taken from the National Wealth Survey. The calculation incorporates the major reductions, in asset lifetimes, reductions made for tax purposes, that occurred in 1951, 1961, 1964, and 1969. The special depreciation permitted by the Special Taxation Measures Law is incorporated into the depreciation formula as follows. The fraction of special depreciation in fiscal year t, $SP(t)$, is defined as the ratio of the amount of special depreciation in the Financial Statements data to nominal investment. If $d(x,t)$ is the depreciation formula implied by a given asset lifetime for a given depreciation method, the depreciation formula $D(x,t)$ adjusted for special depreciation is:

$$D(x,t) = [1-SP(t)]d(x,t) + SP(t) \quad \text{for } t = 0,$$

and

$$D(x,t) = [1-SP(t)]d(x,t) \quad \text{for } t > 0.$$

The implicit assumption here is that the ratio of special depreciation, SP, is the same for all asset types. The yield on the Japan Telegraph and Telephone Company's bond is used as the discount rate. Other information necessary for calculating A and z is: (1) the share of respective depreciation methods and (2) the breakdown of nominal investment into the three asset types (buildings, structures, and equipment). The data on the share of respective depreciation methods are taken from the financial statements of corporations traded on the Tokyo Stock Exchange. Since virtually all corporations employ either the straight-line method (about 20%) or the declining-balance method (80%), only the two depreciation methods are considered. This share is assumed to be the same for all asset types. The data on the breakdown of nominal investment are not available on a yearly basis. The breakdown for 1975 (calendar year) is obtained from the capital formation matrix in the *1975 Input-Output Table* (General Management Agency 1979). The breakdown for all years is assumed to be the same as that in 1975.

Our construction of the investment goods price index, a, is as follows. From the capital formation matrix in the *1975 Input-Output Table*, we can obtain the breakdown of nominal investment by industry source. We use this breakdown as a weight to calculate the price index as a weighted average of the relevant components of the wholesale price index. We use the overall wholesale price index for the output price index, p.

Our estimates of u, v, S, and R come from the tax data. The corporate tax rate u is the ratio of national and local corporate taxes to taxable income. The enterprise tax rate v is the ratio of enterprise tax to taxable income. Information on S is obtained directly from the tax data.[8] The measurement of R (tax-free reserves) is more problematic. As of 1981 there are 28 tax-free reserves listed in the Corporate Tax Law and the Special Taxation Measures Law. Since, in some cases, corporations accumulate reserves beyond the maximum amount specified by the tax law without any further tax benefits, the figures given for reserves in the financial statements data are not useful. Furthermore, the financial statements data do not report tax-free reserves separately; some of the figures for tax-free reserves are merged with special depreciation and other reserves that are not tax-free. However the tax data contain figures for six major tax-free reserves beginning in 1963. These are (1) the reserve for bad debts, (2) the bonus reserve, (3) the reserve for retirement allowances, (4) the reserve for price fluctuations, (5) the overseas market development reserve for small- and medium-sized enterprises, and (6) the reserve for overseas investment losses. The amount credited to these reserves (except to the last two, which are minor relative to the rest) must be added back in full in the following accounting year, as assumed in our theoretical model. For lack of alternative data sources, we use the total of these six tax-free reserves for R.

The data thus obtained that are necessary to calculate tax-adjusted Q are assembled in table 10.1. The data for 1955 (fiscal year) are not available because the calculation of Q requires data for the preceding year. Table 10.2 contains the tax-adjusted Q. Since no data are available for R (tax-free reserves) before 1962, our calculation assumes that the ratio of R to aK (the reproduction cost of capital) prior to 1963 is the same as the ratio for 1963. As we can see by comparing the Q series in table 10.2 with the data on the market value of equity in table 10.1, stock prices are the main source of variation in Q.

A basic assumption underlining the formula (29) is that R, the amount deductible from corporate income, is proportional to the capital stock (see eq. [23]).[9] In order to ascertain the validity of this assumption, we examined the financial statements of individual manufacturing firms that are publicly traded. We obtained the relevant data from the *NEEDS Company Data* compiled by the *Nihon Keizai Shimbun* (Japan Economics Daily). From data on accounting depreciation and the book value of depreciable assets, the market value of the reproduction cost of capital, aK, is constructed by a perpetual inventory method for about 620 firms for the fiscal years 1965–81. Although this data set consists mainly of individual financial statements, there is an item that reports the maximum amount to be credited to the reserve for retirement allowances from 1976 on. This amount is regressed on the capital stock for each year. Table 10.3 reports the regression results. Although the intercept term is significant, the capital stock coefficient is very close to that obtained in the regression without the intercept. This finding supports our proportionality assumption about reserves.

The investment-capital ratio and tax-adjusted Q are plotted against time in

Table 10.1 **Components of the Tax-Adjusted Q**

Year	Equity	Debt	Value	Capital	Investment	Reserve	p_{INVEST}	p_{OUTPUT}	u	v	τ	z
1956	1,041	1,423	332	2,198	535	N.A.	.631	.581	.401	.120	.469	.530
1957	1,553	2,125	602	2,784	867	N.A.	.651	.579	.400	.121	.469	.477
1958	1,912	2,532	1,189	3,370	912	N.A.	.613	.546	.372	.118	.442	.495
1959	2,692	2,502	1,536	3,956	1,158	N.A.	.625	.559	.392	.114	.458	.498
1960	5,019	3,132	3,379	4,542	1,942	N.A.	.626	.560	.400	.115	.466	.495
1961	6,603	3,886	4,431	5,754	2,338	N.A.	.638	.567	.386	.113	.453	.483
1962	7,263	4,220	4,554	6,967	2,486	N.A.	.625	.557	.368	.113	.437	.465
1963	6,459	5,651	3,705	8,179	2,641	462	.622	.569	.368	.111	.435	.543
1964	6,348	6,654	3,309	9,392	2,842	561	.622	.569	.363	.112	.430	.543
1965	6,350	7,899	3,630	10,605	2,453	629	.623	.575	.349	.108	.415	.569
1966	8,591	9,503	6,130	12,615	2,870	738	.648	.591	.344	.111	.413	.604
1967	10,099	10,969	6,625	14,625	4,210	914	.659	.599	.342	.112	.411	.593
1968	13,149	13,007	8,811	16,635	5,372	1,118	.664	.603	.340	.113	.410	.579
1969	24,022	15,622	17,948	18,645	6,948	1,602	.683	.623	.344	.113	.414	.574
1970	21,408	18,781	13,853	20,655	7,923	2,062	.696	.637	.356	.113	.425	.565
1971	21,783	23,562	15,570	26,649	6,823	2,223	.686	.632	.349	.109	.416	.593
1972	21,126	29,373	15,950	32,642	7,315	2,540	.720	.652	.362	.109	.427	.620
1973	27,238	31,780	13,136	38,636	8,754	3,090	.877	.800	.379	.113	.445	.576
1974	28,133	33,858	6,265	44,630	9,739	4,058	1.018	.988	.396	.120	.466	.507
1975	38,763	46,364	27,562	50,624	8,890	4.458	.997	1.007	.379	.111	.445	.542
1976	48,535	48,433	35,830	55,502	9,055	4,834	1.032	1.062	.411	.117	.477	.556
1977	45,151	53,055	34,115	60,379	8,916	5,811	1.048	1.066	.413	.120	.480	.591
1978	50,800	58,059	42,809	65,257	8,276	5,680	1.063	1.041	.413	.116	.477	.611
1979	54,740	57,103	36,869	70,135	10,827	6,098	1.150	1.175	.414	.116	.478	.582
1980	60,394	53,820	28,405	75,013	13,316	6,593	1.210	1.331	.422	.116	.486	.549
1981	83,012	63,191	51,437	79,891	14,321	6,780	1.195	1.350	.429	.115	.492	.563

Note: Equity = market value of equity; Debt = market value of debt; Value = denominator in (24) of text; Capital = nominal reproduction cost of capital; Investment = nominal investment; Reserve = tax-free reserves (all figures given are in billions of yen). p_{INVEST} = price index of investment goods (normalized to one for the 1975 calendar year); p_{OUTPUT} = price index of outputs; u = national and local corporate tax rate; v = enterprise tax rate; τ = "effective" tax rate defined by (28); z = present value of depreciation allowances defined by (26).

Table 10.2 Investment and Tax-Adjusted *Q*

Year	I/K	Q
1956	.244	−1.129
1957	.311	−.980
1958	.271	−.598
1959	.293	−.460
1960	.427	1.110
1961	.406	1.061
1962	.357	.437
1963	.323	−.184
1964	.303	−.501
1965	.231	−.590
1966	.227	−.228
1967	.288	−.224
1968	.323	.037
1969	.373	1.445
1970	.384	.623
1971	.256	.060
1972	.224	−.204
1973	.227	−.600
1974	.218	−1.128
1975	.176	−.176
1976	.163	.068
1977	.148	−.101
1978	.127	.084
1979	.154	−.188
1980	.178	−.483
1981	.179	.108

Table 10.3 Regression of the Retirement Reserve on the Capital Stock

			With Intercept			Without Intercept
Fiscal Year	Sample Size	Mean of Capital Stock	Constant	Capital Stock	R^2	Capital Stock
1976	626	20,826	759	.062	.69	.064
			(5.5)	(37.8)		(39.6)
1977	626	21,892	1,062	.055	.59	.057
			(5.9)	(29.8)		(31.2)
1978	620	22,362	1,146	.058	.60	.061
			(5.9)	(30.1)		(31.5)
1979	618	23,688	1,165	.058	.62	.061
			(6.0)	(31.5)		(32.9)
1980	616	25,096	1,181	.062	.64	.065
			(5.9)	(33.1)		(34.6)
1981	613	25,247	998	.067	.67	.070
			(5.2)	(35.3)		(37.0)

Note: The dependent variable is the maximum allowable limit on the amount deductible from corporate income as credits to the Reserve for Retirement Allowances. Numbers in parentheses are the *t*-values.

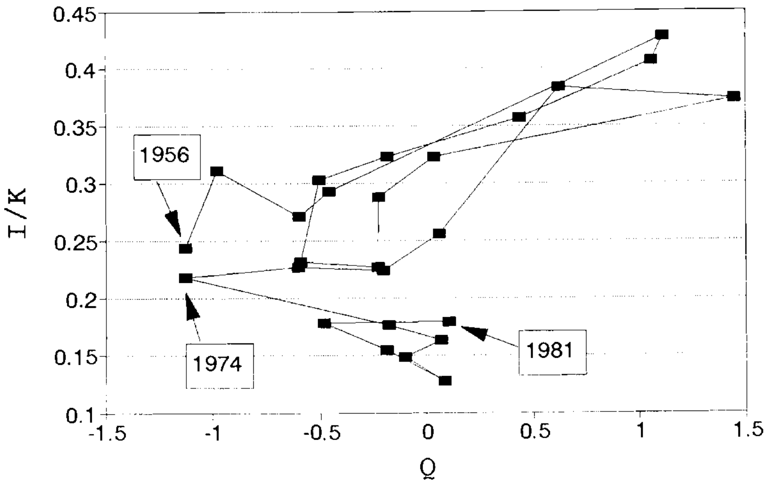

Fig. 10.1 Plot of I/K against Q: 1956–81

figure 10.1. The two major peaks in investment that occurred in 1960 and 1970, and the sharp trough in 1965, correspond almost exactly to the path of the Q series. This results in a strong positive correlation, until 1974, between I/K and Q. It is thus tempting to fit a regression of I/K on Q to estimate the Q-based investment equation as in expression (25) (with w^*/p dropped under the separability assumption $F[K,L,I] = G[K,L] - C[I,K]$). This gives, for sample period 1956–74,

$$I/K = \underset{(0.009)}{0.31} + \underset{(0.013)}{0.071}\, Q, \quad \text{SER} = 0.040,\ R^2 = 0.65,\ \text{D-W} = 1.27,$$

where the numbers in parentheses are standard errors, SER is the standard error of the regression, and D-W is the Durbin-Watson statistic. The Q coefficient of 0.071 is, however, biased because Q is an endogenous variable. A larger value of the error term in the investment-Q equation raises investment and hence aggregate demand. It is conceivable that stock prices move up reflecting a boom brought about by the increase in aggregate demand. If this is the case, the ordinary least squares (OLS) estimate of the Q coefficient is biased upward. The same reasoning implies that the correlation between I/K and Q is also consistent with many other theories of investment as long as there is a general equilibrium link between aggregate demand and stock prices. To correct for the simultaneity bias, we use the tax variables u, v, and z in table 10.1 as instruments. The two-stage least squares (2SLS) estimate of the same equation, still for sample period 1956–74, is slightly different:

$$I/K = \underset{(0.010)}{0.31} + \underset{(0.025)}{0.062}\,Q, \quad SER = 0.41.$$

This positive association between I/K and Q that remains after the simultaneity bias is removed is certainly consistent with the Q theory.

However, the positive association ceases to hold after 1974. In fact, when the sample period includes the years following 1974, the 2SLS estimate of the Q coefficient is no longer significant at the 5% level. In other words, by historical standards, Q has been too high. Three explanations come to mind for the puzzling behavior of Q after 1974. First, another variable may exist that we failed to take into account in our method. Second, the denominator of Q may have been mismeasured, or third, the numerator may have been mismeasured. The first explanation notes that the relationship between I/K and Q as given in expression (25) involves real factor prices w^*/p, whose components include energy prices. Energy inputs are needed to install new machines within the firm. As energy prices increase, installation activity is depressed, and the I/K–Q relation shifts downward.

The second explanation relies on the heterogeneity of capital. If there is limited ex post substitutability between energy and capital, the financial markets will heavily discount energy inefficient machines when energy prices increase, while our calculation of the capital stock gave the same weight to both energy efficient and energy inefficient machines of the same age. However, if this explanation is correct, Q should have been undervalued in recent years, which has not been the case. The third explanation is that stock prices, which are the main source of the variability in the numerator, contain a bubble that somehow started around 1974 and is responsible for the overvaluation of stocks in subsequent years. Although it appears plausible, this third explanation begs the question of why managers have not taken advantage of the bubble and issued large amounts of new shares to finance investment and pay off debts.

10.5 Conclusion: Taxes and Corporate Investment

Finding a significant relationship between two *ratios* at the aggregate level has been notoriously difficult. The positive relationship between the investment-capital ratio and Q documented in this paper should therefore be taken seriously. According to the Q theory, this relationship is structural in that it is determined by the shape of the adjustment cost function, which is invariant to policy parameters or expectations about future economic variables. Thus we can use this structural investment-Q relationship to evaluate the role of corporate taxes for investment. In order to do this we have to distinguish between the direct and indirect effects of taxes on Q. The direct effect is precisely modeled here: equation (29) indicates exactly how Q should be adjusted for taxes. From table 10.1 we can see that this direct effect accounts for a very small fraction of variations in Q that are dominated by changes in stock prices. The indirect effect operates through the value of the firm, which is not modeled here. However, again from table 10.1, we can immediately see that the tax parameters (u, v, τ, z) have very little to do with changes in the value of the firm. It must be some other factor, such as future profitability, that has been a major determinant of the value of the firm. We conclude that the role played by taxes has been minor for investment in postwar Japan.

We also note from figure 10.1 that the relationship between investment and Q was disrupted precisely when oil prices increased sharply. As argued in section 10.4, this phenomenon is consistent with the Q theory because the adjustment cost could depend on factor prices. However, breakdown of historical relationships during the two oil shocks may not be limited to just investment. Documenting and explaining the impact of the oil shocks on other key macroeconomic relationships are left for future research.

Appendix A
Derivation of the Valuation Formula (4)

Combining (1), (2a), (2b), the value of the firm is written as

$$\text{(A1)} \quad V_0 = \sum_{t=0}^{\infty} C(0, t)[(1-u_t-v_t)\Pi_t + (u_t+v_t)X_t + (u_t+v_t)S_{t-1} - a_tI_t],$$

where

$$\text{(A2)} \qquad C(s, T) = \begin{cases} 1 & \text{if } s = t \\ (1+r_s)^{-1} \ldots (1+r_{t-1})^{-1} & \text{if } s < t \end{cases}$$

$$\text{(A3)} \qquad X_t = DEP_t + (R_t - R_{t-1}).$$

With this notation, (2c) becomes

$$\text{(A4)} \qquad S_t = v_t(\Pi_t - X_t) - v_tS_{t-1},$$

which can be solved for S_{t-1} as

$$\text{(A5)} \quad S_{t-1} = v_{t-1}\sum_{i=0}^{t-1}\Psi(i, t-2)Y_i - v_{t-1}\Psi(0, t-2)S_{-1} \quad \text{for } t > 0,$$

where

$$\text{(A6)} \qquad Y_t = \Pi_t - X_t,$$

(A7)
$$\Psi(i,j) = \begin{cases} 1 & \text{if } i > j. \\ (-v_i)(-v_{i+1}) \ldots (-v_j) & \text{if } i \leq j. \end{cases}$$

Substituting (A5) into (A1) we obtain

(A8)
$$\begin{aligned} V_0 &= \sum_{t=0}^{\infty} C(0,\ t)[\Pi_t\ -\ (u_t + v_t)Y_t\ -\ a_t I_t] \\ &+ \sum_{t=1}^{\infty} C(0,\ t)[(u_t + v_t)v_{t-1} \sum_{i=0}^{t-1} \Psi(i,\ t-2)Y_i] \\ &- \sum_{t=1}^{\infty} C(0,\ t)[(u_t + v_t)v_{t-1}\Psi(0,\ t-2)]S_{-1}\ +\ (u_0 v_0)S_{-1}. \end{aligned}$$

The second summation can be rewritten as

$$\begin{aligned} &\sum_{t=1}^{\infty}\sum_{i=0}^{t-1}[C(0,\ t)\ (u_t + v_t)v_{t-1}\Psi(i,\ t-2)Y_i] \\ &= \sum_{i=1}^{\infty}\sum_{t=0}^{i-1}[C(0,\ i)(u_i + v_i)v_{i-1}\Psi(t,\ i-2)Y_t] \text{ (by interchanging } i \text{ with } t) \\ &= \sum_{t=0}^{\infty}\sum_{n=1}^{\infty}[C(0,\ t+n)(u_{t+n} + v_{t+n})v_{t+n-1}\Psi(t,\ t+n-2)Y_t] \text{ (by setting } i\ =\ n\ + \\ &= \sum_{t=0}^{\infty} C(0,\ t)[\sum_{n=1}^{\infty} C(t,\ t+n)(u_{t+n} + v_{t+n})v_t\Psi(t+1,\ t+n-1)]Y_t \\ &\qquad [\text{since } v_{t+n-1}\Psi(t,\ t+n-2)\ =\ v_t\Psi(t+1,\ t+n-1)] \\ &= \sum_{t=0}^{\infty} C(0,\ t)y_t v_t Y_t, \end{aligned}$$

where

(A9)
$$y_t\ =\ \sum_{n=1}^{\infty} C(t,\ t+n)(u_{t+n} + v_{t+n})\Psi(t+1,\ t+n-1).$$

(The "since" clause bracketed above refers only to the line preceding it.)

Using this y_t, the third summation in (A8) can be rewritten as

$$\begin{aligned} &\sum_{t=1}^{\infty} C(0,\ t)[(u_t + v_t)v_{t-1}\Psi(0,t-2)]S_{-1} \\ &= \sum_{t=1}^{\infty} C(0,\ t)[(u_t + v_t)v_0\Psi(1,\ t-1)]S_{-1} \\ &\qquad [\text{since } v_{t-1}\Psi(0,\ t-2)\ =\ v_0\Psi(1,\ t-1)] \\ &= y_0 v_0 S_{-1}. \end{aligned}$$

Thus (A8) becomes

$$V_0 = \sum_{t=0}^{\infty}[C(0, t)(\Pi_t - \tau_t Y_t) - a_t I_t] - y_0 v_0 S_{-1} + (u_0 + v_0)S_{-1}$$

(A10)
$$= \sum_{t=0}^{\infty} C(0, t)[(1-\tau_t)\Pi_t - a_t I_t] + \tau_0 S_{-1},$$

$$= \sum_{t=0}^{\infty} C(0, t)\tau_t \mathrm{DEP}_t + \sum_{t=0}^{\infty} C(0, t)\tau_t(R_t - R_{t-1}),$$

where

(A11)
$$\tau_t = u_t + v_t - y_t v_t.$$

Now, it is shown in Hayashi (1982) that the second summation in (A10), the present value of $\tau_t \mathrm{DEP}_t$, where DEP_t is defined in (3) in the text, can be decomposed as

(A12)
$$\sum_{t=0}^{\infty} C(0, t)(1 - z_t')a_t I_t + A_0',$$

where z' and A' are defined in the text (see eqq. [7] and [8]). Furthermore, it is easy to show that the last summation in (A10) becomes

(A13)
$$\sum_{t=0}^{\infty} C(0, t)\tau_t(R_t - R_{t-1}) = \sum_{t=0}^{\infty} C(0, t)[\tau_t - \tau_{t+1}/(1+r_t)]R_t - \tau_0 R_{-1}.$$

Substituting (A12) and (A13) in to (A10), we obtain the formula (4) in the text.

Appendix B
Glossary of Symbols

A = Present value of accounting depreciation on assets already in existence (see [27]);
A' = Present value of tax saving arising from accounting depreciation on assets already in existence (see [9]);
a = Price of investment goods;
$C(t,s)$ = Discounting factor as of t for income at s (see [1]);
c = Cost of capital (see [17]);
$D(x,t)$ = Depreciation formula as of t on an asset of age x;
DEP = Amount of accounting depreciation (see [3]);
F = Production function;
I = Investment;

K = Capital stock;
L = Labor input;
p = Output price;
Q = Tax-adjusted Q (see [19] and [29]);
RL = Employment-related tax-free reserves;
RK = Other tax-free reserves;
R = $RL + RK$;
r = Nominal interest rate;
S = Enterprise tax;
T = Total corporate tax (see [2a]);
u = Tax rate on corporate income excluding the enterprise tax;
v = Enterprise tax rate;
V = Market value of the firm;
w = Wage rate;
w^* = Wage rate adjusted for the employment-related tax-free reserves (see [15]);
y = Present value of tax changes per yen of the enterprise tax (see [5]);
z = Present value of accounting depreciation on one yen of new investment (see [26]);
z' = Present value of tax saving arising from accounting depreciation on one yen of new investment (see [7]);
δ = Rate of physical depreciation;
Π = Gross pretax profits;
λ = Shadow price of capital;
τ = Effective tax rate (see [6]).

Notes

1. For a good description of the Japanese corporate tax system, see *An Outline of Japanese Taxes* (various years), published by the Printing Bureau under the auspices of the Tax Bureau of the Ministry of Finance.
2. For a few tax-free reserves, the law permits corporations to spread the amount to be added back to income over several years. The tax-free reserves for which the data are available to us are the types described in the text.
3. For the reserve for retirement allowances, R is the amount that has been accumulated.
4. If static expectations about future τ are assumed and if z is the Hall and Jorgenson (1971) z, then z' reduces to τz.
5. The fact that $(1-\delta)/(1+r) \cong 1-\delta-r$ has been used.
6. Kuniaki Hata of the Tax Bureau was in charge of the calculation in this study.
7. This number is obtained as follows. From the capital formation matrix in the *1975 Input-Output Table*, we can obtain the breakdown for manufacturing as a whole of capital inputs by industry source. Take the physical depreciation rates from Hulten

and Wykoff (1981) and take a weighted average with the weights thus obtained. This yields an estimate of δ of 8.99%.

8. Only the total of the corporate enterprise tax collected from all industries is reported. The enterprise tax paid by corporations in manufacturing is obtained by multiplying this total by the manufacturing sector's share of the national corporate tax.

9. Under constant returns to scale, the wage bill is proportional to the capital stock, given factor prices. Thus the proportionality assumption (23) for *RL* implies that *RL* is proportional to the capital stock.

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