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THE COST OF HOLDING INVENTORIES, AND THE DEMAND FOR LABOR AND CAPITAL UNDER CORPORATE TAXATION: ANOTHER LOOK

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Abstract

The paper suggests two different candidates for neutral tax treatment of inventories. The Canadian and the Scandinavian inventory deductions are then interpreted as representative examples of these two approaches. While the former is viewed as an interest-subsidy in the framework of a profit tax, the latter represents an interest-free loan in the spirit of a partial cash flow tax. The puzzling appearance of unclaimed tax allowances is rationalized in terms of a binding dividend constraint.

I Introduction

In their 1982 article, Boadway, Bruce and Mintz (BBM hereafter) reported theoretical results on the effects of inflation and taxation on firms' decisions concerning production and the average level of inventory holdings. Moreover, they discussed the possibilities of designing neutral tax treatment of inventory capital in the presence of inflation in the spirit of the Canadian inventory deduction. What we plan to do in the current paper is to reconsider the desired tax treatment of inventories in order to clarify the basic issues. Consequently, we are not only able to produce some new insight but also to derive results some of which are at odds with those obtained by BBM.

We propose that there are two quite distinct problems in tax treatment of inventories, both of which may give rise to undesirable allocational distortions. The first is the question of how to value the material inputs used in production when calculating the corporate tax liability. We think that this valuation problem is very elegantly dealt with by the BBM model in terms of the competing FIFO and LIFO approaches. But apart from the valuation distortions due to inflation, there is another fundamental problem in any corporate tax system: how ought one define the proper deductions before the corporate tax is levied? It is clear that to arrive at a measure of economic profit all relevant costs ought to be deductible. This is, we think, where some new problems arise in the tax treatment of inventories. Though the Canadian inventory deduction was designed to eliminate the apparent disincentives for firms to carry inventories when FIFO is used, we suggest in the current paper that the Canadian deduction is a proper candidate for the inventory deduction even with no inflation. This is because, if chosen appropriately, it eliminates the tax distortions both on inventory holdings and on the demand for labor and capital services caused otherwise by the current tax treatment of inventories. Second, we show that under inflationary conditions it really is no substitute for LIFO but that together with LIFO is helps to eliminate both the inflation and tax distortions.

Intuitively, our argument can be put forward as follows. There is always a delay between the initial acquisition of material inputs like raw materials or intermediate inputs and their use in the production process and the sale of final output. Although this delay may not be very long for some goods or for some industries due to rapid turnover, for others it may be quite substantial. Then acquiring productive inputs not only gives rise to the initial outlays and the costs of storage but it also represents an opportunity cost for the funds of firms. For allocational neutrality of the corporate tax, this opportunity cost ought to be made fully tax-deductible.

While the BBM discussion revolves around finding a unique fraction of the FIFO value of inventory which would eliminate both the inflation and tax distortions, our model suggests that it is necessary to deal with these problems separately. Thus, while we unambiguously favour the LIFO approach, we are able to derive the condition under which the Canadian deduction eliminates the tax distortions even when one does not remove the deductibility of the nominal cost of borrowing (as suggested by the BBM model), which is currently part of all existing corporate tax systems we are aware of.

As BBM suggest, a corporate tax based on a firm's cash flow instead of profits is the ideal approach to eliminate both the tax and the inflationary distortions provided the cost of borrowing is left undeductible. But this is not a feasible approach if one cannot treat the other types of capital investment accordingly. What we suggest is that given the deductibility of the cost of borrowing there is another method to eliminate the tax distortions and, interestingly, this is what we label, a bit vaguely, as the Scandinavian inventory deduction (prevalent in Sweden and Finland). To adjust the corporate tax liability for the opportunity cost of funds, this method allows for a partial, immediate write-off of inventory outlays. Hence, while the Canadian method amounts to designing a proper income tax, the Scandinavian approach treats inventories according to the principles of a modified cash flow tax.

The above conclusions will be derived in subsequent sections of the current paper in a value-maximization model of a firm using optimal control techniques.

II The Model

This section introduces a model of a firm which is very much like the BBM firm apart from some minor differences. Like the BBM model, this approach abstracts from price or technological uncertainty.

Consider a firm which operates in competitive markets. Denote its output-input bundle as $x(t) = (y(t),-l(t),-g(t),-k(t),-u(t))$ and assume that its production technology is given by the functions

$$(2.1)\quad y(t) = \min\{\frac{1}{\alpha} z(t), \frac{1}{\beta} u(t)\} \qquad \alpha > 0,\ \beta > 0$$

$$(2.2)\quad z(t) = f(l(t), g(t), k(t)).$$

(2.1) states that the rate of output y(t) is produced by using material inputs u(t) and a combination of other inputs z(t) in fixed proportions such that α and β are strictly positive and constant. In (2.2) it is assumed that the firm utilizes a given time-invariant technology to combine other productive inputs like labor services l(t) and capital services g(t). Apart from these traditional inputs, the stock of inventories k(t) is included in the z(t) function to allow for the possibility that holding positive amounts of inventories conveys some contribution to the production process. z(t) is assumed to be strictly increasing, concave and twice differentiable in l and g, i.e. f_l, $f_g > 0$, f_{ll}, $f_{gg} < 0$ while with respect to k it is assumed that $f_k \geq 0$, $f_{kk} \leq 0$.[1)] It is assumed that the constraints (2.1) and (2.2) are part of the technologically feasible set $F(t) \subset R^5$, i.e. $x(t) \in F(t)$. The non-negative spot prices corresponding to y(t), l(t) and g(t) are given by p(t), w(t) and r(t). Hence, the firm is assumed to hire capital services at the market rental r(t). Let q(t) stand for the market price of currently acquired material inputs, denoted by j(t). This will be differentiated from the valuation of the current flow of material inputs from the stock of inventories to the production process as determined by the tax authorities and denoted here by q*(t).

It makes economic sense to assume that new equity issues are ruled out as a source of financing for new material inputs and that the share that is not financed by borrowing (= dB/dt) will be covered by internal funds derived from current profits. Hence, one has the identity

$$(2.3)\quad P_u(t) + dB/dt = q(t)j(t)$$

with P_u denoting undistributed profits. Total profits currently generated, including those distributed as dividends, P_d, after subtracting the corporation tax liability L(t) are given by

$$(2.4) \quad P_d(t) + P_u(t) = p(t)y(t) - w(t)l(t) - r(t)g(t) - c(k(t)) - iB(t) - L(t)$$

where strictly convex costs of holding inventories c(k) have been introduced with $c_k > 0$, $c_{kk} > 0$. i stands for the interest on debt.

We want to abstract from the well-known agency problem by assuming that the firm is owned by individuals who at the same time run the firm as managers. Given their after-tax opportunity cost, say $(1-\tau_i)\rho_o$, and assuming that they are risk-neutral, one can write the non-arbitrage condition for their asset portfolio as

$$(2.5) \quad (1-m)P_d(t) + (1-s)dV/dt = (1-\tau_i)\rho_o V(t).$$

V(t) stands for the market valuation of their ownership claims on the current firm, m represents the tax rate on dividend income and s is the effective tax rate on capital gains. There are many solutions to (2.5), but it is rational to choose employment, inventory, and dividend policies which maximize the current valuation V obtained from (2.5) as

$$(2.6) \quad V(t_o) = \int_{t_o}^{\infty} \theta P_d(t)\exp(-\rho(t-t_o))dt$$

where $\theta = (1-m)/(1-s)$ is King's (1974a) tax discrimination variable. The discount rate used in evaluation of the dividend stream is given by $\rho = (1-\tau_i)\rho_o/(1-s)$.

As it has been well-known since King (1974b), the tax system gives rise to a number of arbitrage opportunities for participants in the financial markets. For the current problem the determination of the financial structure of the firm is not a matter of secondary importance. Interest deductibility creates well-known incentives to substitute debt for other forms of financing. But there are reasons why one does not observe full-debt firms. For example, though firms have prenegotiated credit arrangements with banks or with the firms which supply their material inputs, there are quantitative limits for indebtedness. The reasons for these limits in terms of informational asymmetries have become more understandable only recently due to Stiglitz and Weiss (1981). Hence, based on this view and the empirical observations which support the importance of internal funds in the financing of business expenditure, we are ready to borrow the BBM formulation of the determinate debt-equity ratio, i.e. $B(t) = bq(t)k(t)$ where $b > 0$. Actually, the exogeneity of the debt-equity ratio is not crucial for our argument as long as the case of full debt finance (at the margin) is ruled out.

By definition, the rate of change of the stock of inventories is given by

(2.7) $$dk/dt = j(t) - u(t) = j(t) - (\frac{\beta}{\alpha})f(l,g,k).$$

Hence, the rate of change of debt can be written as

(2.8) $$dB/dt = b(dq/dt)k + bq(t)(j(t) - u(t)).$$

Moving on to the corporate tax liability, we argue that the tax laws in most countries do not allow for adequate deduction of inventory expenses.

The proper deduction depends on whether the aim is to have a tax based on cash flow or on profit. Let us assume throughout that the interest on debt is tax-deductible and that use of material inputs u(t) is deductible and valued at q*(t). In addition, let us introduce an undetermined deduction, say D(t), to derive analytically the conditions it has to satisfy for neutrality. Hence, the corporation tax liability reads as

$$(2.9)\quad L(t) = \tau\,[p(t)(\tfrac{1}{\alpha})z(t) - w(t)l(t) - r(t)g(t) - c(k(t)) - iB(t) - q^*(t)u(t) - D(t)]$$

where $\tau > 0$ stands for the corporate tax rate. Note that we have explicitely assumed deductibility of the rental cost of capital. We hasten to borrow the ingenious idea of the endogenous, average holding period for inventories, $T(t) = k(t)/u(t)$, from the BBM model to define the alternative valuations of material inputs under inflation as

$$(2.10)\quad q^*(t) = \begin{cases} q(t-T) & \text{under FIFO} \\ q(t) & \text{under LIFO.} \end{cases}$$

Similarly, we assume the case of steady, fully anticipated inflation given by

$$(2.11)\quad \frac{1}{p}\frac{dp}{dt} = \frac{1}{w}\frac{dw}{dt} = \frac{1}{r}\frac{dr}{dt} = \pi,\quad \frac{1}{q}\frac{dq}{dt} = \gamma,\quad \pi \gtreqless \gamma.$$

One can now write the expression for the distributed profits as

$$(2.12)\quad P_d = (1-\tau)[p(\tfrac{1}{\alpha})f(l,g,k) - wl - rg - c(k) - ibqk] - qj + b\gamma qk + bq[j - (\tfrac{\beta}{\alpha})f(l,g,k)] + \tau q^*(\tfrac{\beta}{\alpha})f(l,g,k) + \tau D.$$

The Hamiltonian function (in current values) is given by

$$(2.13)\quad H = P_d + \lambda\,[j - (\tfrac{\beta}{\alpha})f(l,g,k)]$$

where $\lambda = \lambda(t)$ is the costate variable associated with equation (2.7). There are three control variables (l,g,j) and one state variable (k) in the maximization problem.

III Optimal policy

Any candidate for the optimal control has to satisfy, in addition to (2.7) and the initial condition for k(t), the following set of necessary conditions

$$(3.1)\quad (1-\tau)[p(\tfrac{1}{\alpha})f_l - w] - bq(\tfrac{\beta}{\alpha})f_l + \delta\tau q^*T(\tfrac{\beta\gamma}{\alpha})f_l + \tau q^*(\tfrac{\beta}{\alpha})f_l + \tau D_l - \lambda(\tfrac{\beta}{\alpha})f_l = 0$$

$$(3.2)\quad (1-\tau)[p(\tfrac{1}{\alpha})f_g - r] - bq(\tfrac{\beta}{\alpha})f_g + \delta\tau q^*T(\tfrac{\beta\gamma}{\alpha})f_g + \tau q^*(\tfrac{\beta}{\alpha})f_g + \tau D_g - \lambda(\tfrac{\beta}{\alpha})f_g = 0$$

$$(3.3)\quad \lambda = (1-b)q - \tau D_j$$

$$(3.4)\quad (1-\tau)[p(\tfrac{1}{\alpha})f_k - c_k - ibq] + b\gamma q - bq(\tfrac{\beta}{\alpha})f_k - \delta\tau q^*\gamma + \tau q^*(\tfrac{\beta}{\alpha})f_k + \tau D_k - \lambda(\tfrac{\beta}{\alpha})f_k = p\lambda - (d\lambda/dt).$$

Here the following notation has been used

$$\delta = \begin{cases} 1 & \text{for FIFO} \\ 0 & \text{for LIFO.} \end{cases}$$

It makes economic sense to consider only the case with $\lambda(t) \geq 0$ for all t. Moreover, one pressumes that the maximized Hamiltonian is concave in k.[2)] Finally, (3.3) implies

$$(3.5)\quad \lim_{t\to\infty} \lambda(t)e^{-\rho(t-t_0)} = \lim_{t\to\infty} e^{-\rho(t-t_0)}(q(t)(1-b) - \tau D_j).$$

Hence, the tax system can be structured in the way that a transversality condition holds by adjusting D_j in face of a trend in q(t). Alternatively, if D_j is kept equal to zero, the transversality condition holds for the inflation rates $\leq \rho$. Given these conditions, (3.1)-(3.4) can also be regarded as sufficient for optimality.

Totally differentiate (3.3) to obtain $(d\lambda/dt) = (1-b)dq/dt - \tau dD_j/dt$. Then after some trivial manipulations, the first-order conditions can be rewritten as follows.

$$(3.6)\quad (1-\tau)[p(\tfrac{1}{\alpha})f_1-w] - q(\tfrac{\beta}{\alpha})f_1[1 - \tau\tfrac{q^*}{q}] + \delta\tau q^*T(\tfrac{\beta\gamma}{\alpha})f_1 + \tau[D_1 + D_j(\tfrac{\beta}{\alpha})f_1] = 0$$

$$(3.7)\quad (1-\tau)[p(\tfrac{1}{\alpha})f_g-r] - q(\tfrac{\beta}{\alpha})f_g[1 - \tau\tfrac{q^*}{q}] + \delta\tau q^*T(\tfrac{\beta\gamma}{\alpha})f_g + \tau[D_g + D_j(\tfrac{\beta}{\alpha})f_g] = 0$$

$$(3.8)\quad [p(\tfrac{1}{\alpha}) - q(\tfrac{\beta}{\alpha})\tfrac{1-\tau q^*/q}{1-\tau}]f_k + \tfrac{\tau}{1-\tau}[D_k + D_j(\tfrac{\beta}{\alpha})f_k - \delta\gamma q^* + q\gamma - dD_j/dt]$$

$$= c_k + ibq + \rho q(1-b)\left[\frac{1-\tau D_j/q(1-b)}{1-\tau}\right] - q\gamma$$

These equations determine the demand for labor and capital services together with optimal inventory holdings. They look complicated, but this is only because of the effects of the corporate tax system. Their interpretation is very straightforward. Here we plan to prove the following propositions.

Proposition 1. Under FIFO, it is not possible to specify an inventory deduction which would eliminate all the allocational distortions in the demand for labor, demand for capital, and the desired inventory holdings caused by the corporation tax.

The validity of this proposition is immediately clear from the conditions (3.6)-(3.8); for any $q^* \neq q$ and $T > 0$, there is no way to choose D_1, D_j, D_g, D_k and dD_j/dt such that τ could be eliminated from these equations. Comparing (3.6) and (3.7) under no tax to the case with the corporation tax and FIFO (but without any special inventory deduction), one finds that f_1 and f_g are larger in the latter case if $(q^*/q)(1+T\gamma)<1$. Since this always holds, one can conclude that FIFO not only affects the inventory decision but also reduces the demand for labor and the demand for capital. The effects of FIFO on inventory holdings are a bit complicated in (3.8). But this is simply because here the FIFO principle interacts with the incomplete deductibility of the cost of financial capital. Rising prices create an additional incentive for inventory holdings regardless of the fact that the nominal appreciation will be taxed under FIFO. This part of the marginal return is given by the term $[\tau/(1-\tau)](q - q^*\delta)\gamma$ on the left-hand side of (3.8). As we will see, the principle of taxing the nominal appreciation is sound only if the true cost of inventory capital is fully deductible. Assuming that this is not the case, one can see from (3.8) rewritten (with the simplifying assumption $f_k = 0$) as

$$\frac{\tau}{1-\tau}(q - q^*)\gamma = c_k(k) + ibq + \rho q(1-b)\,\frac{1}{1-\tau} - q\gamma$$

that, under the given tax system, inventory holdings may be smaller or larger than in the absence of taxes. The outcome depends on the expected rate of inflation and on the dependence of the nominal costs of financing, i and ρ, on the expected rate of inflation.

Proposition 2. While the LIFO principle is necessary for elimination of the inflationary distortions, it is not sufficient for the elimination of the tax distortions.

Set $q^* = q$ and $\delta = 0$ in (3.6)-(3.8) to see that actually LIFO eliminates (even with no special inventory deduction) all the distortions caused by inflation.[3)] Then the value of the marginal product of these inputs hired net of the accompanying increase in the costs of additional material inputs required corresponds to the marginal cost, i,e,

$$p(\frac{1}{\alpha})f_1 - q(\frac{\beta}{\alpha})f_1 = w$$

$$p(\frac{1}{\alpha})f_g - q(\frac{\beta}{\alpha})f_g = r.$$

But (3.8) reduces to

$$p(\frac{1}{\alpha})f_k - q(\frac{\beta}{\alpha})f_k = q[\frac{c_k(k)}{q} + ib + \rho(1-b)/(1-\tau) - \gamma/(1-\tau)].$$

The right-hand side, the real cost of inventory capital, shows that even with LIFO, ceteris paribus, the corporation tax interacts with inventory holdings unless an additional inventory deduction is introduced. We now prove that there exist two different inventory deductions which satisfy the requirement of tax neutrality.

Propositon 3. Assume that the LIFO principle ($q^* = q$, $\delta = 0$)is applied. Then the inventory deduction (Type I) which satisfies the following conditions gives neutrality with respect to the corporation tax,

$$D_j = q(1-b)$$

$$D_l = -D_j(\frac{\beta}{\alpha})f_l$$

$$D_g = -D_j(\frac{\beta}{\alpha})f_g$$

$$D_k = -D_j(\frac{\beta}{\alpha})f_k + dD_j/dt - q\gamma.$$

By integrating, the inventory deduction of Type I can be written as[4)]

$$(3.9) \quad D = (1-b)(dq/dt)k + (1-b)qj - (1-b)q(\frac{\beta}{\alpha})f(l,g,k) - q\gamma k.$$

It is easy to arrive at this deduction by setting the last terms on the left-hand side of (3.6)-(3.8) equal to zero and by choosing D_j such that the tax distortion is eliminated from the third term on the right-hand side of (3.8).

Proposition 4. Assume that the LIFO principle is applied. Then the inventory deduction (Type II) which satisfies the following conditions gives tax neutrality with respect to the corporation tax,

$$D_j = D_l = D_g = dD_j/dt = 0$$

$$D_k = \rho(1-b)q - \gamma q.$$

By integrating, the inventory deduction of Type II can be written as

$$(3.10) \quad D = [\rho(1-b) - \gamma]qk.$$

To prove this, substitute the above conditions into (3.6)-(3.8). The cost of inventory capital has to correspond to that in a taxless economy. Hence, (3.8) implies

$$\frac{1}{1-\tau}\rho(1-b)q - \frac{\tau}{1-\tau} D_k - \frac{\tau}{1-\tau} q\gamma = \rho(1-b)q$$

which gives $D_k = \rho(1-b)q - \gamma q$.

Note that both deductions suggest that the tax authorites ought to include the nominal appreciation of inventories in the tax base. Under LIFO, this is always a necessary adjustment.

IV Discussion of the Results

The above results highlight a fact that is often neglected, namely that the tax treatment of inventories is not only relevant for the average inventory holdings by firms. We have shown that under FIFO, disincentives definitively arise also with respect to the demand for labor and capital. On the other hand, we have shown that the distortions due to inflation can be eliminated by switching to LIFO, but this does not provide a correction for the excessive pre-tax required rate of return on internal equity. One can of course raise the question whether it is more important to correct the distortions in the demand for labor and capital due to inflation and FIFO than the distorted incentives for carrying inventories. But no choice is needed because one can try to correct both distortions. And there are two different candidates.

Take first the Canadian inventory deduction. Following BBM, write it as $D_c = v_c qk$, where v_c is a parameter. This deduction satisfies the neutrality requirement (3.10) (when LIFO is used) if the tax authorities choose

(4.1) $v_c = \rho(1-b) - \gamma$.

The informational requirements for introducing this deduction are not unreasonable. The authorities need to have estimates of the nominal rate of return on undistributed profits, the debt-equity ratio and the expected inflation rate. Moreover, if the deduction is based on the FIFO value of inventories q^*k instead of the LIFO value qk, the v_c parameter ought to be adjusted as $v_c = (q/q^*)(\rho(1-b) - \gamma)$. Whether the Canadian 3 % deduction of the FIFO value is of a reasonable magnitude depends hence on the actual debt-equity ratios, which obviously may not be quite the same for all firms. Note that if $b = 1$ and the cost of borrowing is deductible, no additional deduction is needed under FIFO any more than under LIFO.

The Scandinavian tax system (Sweden, Finland) allows the firms to create an inventory undevaluation of the form $v_s q^*k$ and deduct its change from the tax base.[5)] Hence, the Scandinavian deduction is

$$(4.2) \quad D_s = \frac{d}{dt}(v_s q^*k) = v_s(dq^*/dt)k + v_s q^*(dk/dt)$$

$$= v_s(dq^*/dt)k + v_s q^*j - v_s q^*(\frac{\beta}{\alpha})f(1,g,k) .$$

If the authorities allowed in conjunction with LIFO the nominal appreciation of inventory in the tax base, the Scandinavian deduction would exactly correspond to (3.9).[6)] Hence, though (3.9) looks complicataed, it is actually very simple to administer in practice. For neutrality, the tax authorities ought to estimate the debt-equity ratio b and then choose

$$(4.3) \quad v_s = 1-b$$

as a fraction of the change in the nominal value of the annual inventory to be deducted from the tax base.[7)]

The economic interpretation of the Canadian and Scandinavian tax deductions is very straightforward. Rather than providing a correction for FIFO, the former can be viewed as an attempt to properly define the tax base for an ideal profit tax. But note that in contrast to the BBM results our model with non-zero f_k implies that the deduction of the full nominal cost of finance is not sufficient for neutrality under FIFO (see again (3.8)).

While the Canadian deduction is a step towards designing an ideal profit tax, the Scandinavian deduction points more in the direction of a cash flow tax. One can rewrite the Scandinavian deduction (under FIFO) as a whole as

$$(4.4) \quad q^*u + D_s = v_s q^*j + (1-v_s)q^*u + v_s(dq^*/dt)k$$

which suggests that the firms are entitled to an immediate write-off of traction v_s when acquiring the material inputs while they can deduct the rest (at initial prices) when the inputs are used. The deduction is adjusted for the rate of inflation. Note that in equilibrium $j = u$ so that the deduction can be simply written as $q^*u + D_s = q^*j + v_s(dq^*/dt)k$. This expression shows the analogy to the cash flow tax even more clearly. A full step towards the cash flow tax would call for abandoning the interest deductibility and allowing for $v_s = 1$.[8)]

It should be noted that, in practice, neither in the Canadian or the Scandinavian tax system is the nominal appreciation of inventories included in the tax base. But since FIFO is applied, this is almost the same thing due to the inflation gap in sales revenues and costs of production.

Put for a moment the question of inflation aside and assume that LIFO is used. Then from quite a new angle, one can compare the Canadian and the Scandinavian inventory deductions as follows. Using (3.8) rewrite the corresponding costs of inventory capital as

$$(4.5a)\quad [\cdot]f_k = c_k + \{bi + (1-b)[\frac{\rho}{1-\tau} - \frac{\tau v_c}{(1-\tau)(1-b)}]\}q - q\gamma$$

$$(4.5b)\quad [\cdot]f_k = c_k + \{bi + (1 - b - \tau v_s)\frac{\rho}{1-\tau}\}q - q\gamma .$$

Then according to (4.5a), the Canadian deduction means a direct subsidy offsetting the cost of internal funds by up to $\tau v_c/(1-\tau)(1-b)$ per unit of internal financing. Alternatively, it can be viewed as an interest subsidy. (4.5b) in turn suggests that the Scandinavian deduction can be viewed as an interest-free loan from the government, the fraction of which in the financing of a unit of inventory is given by τv_s. Then the fraction left for the internal funds in reduced to $1-b-\tau v_s$.

A question of practical interest is what happens to the inventory holdings if there is a ceteris paribus change in the corporate tax rate, in the expected rate of inflation, a change in relative prices, etc. If the Canadian and the Scandinavian deductions take the form (3.10) and (3.9), the inventory holdings are of course immune to changes in the corporate tax rates. They are not, however, insensitive to changes in the personal taxes on capital income since many of these affect ρ. In the Canadian regime, if v_c is set too low, an increase in the corporate tax rate raises the cost of holding inventories. The precise condition is

$$(4.6)\quad v_c < \rho(1-b)q/q^* - (q/q^* - 1)\gamma .$$

In the Scandinavian case, an increase in the corporate tax rate unambiguously raises the cost of inventory holdings if

(4.7) $\delta\gamma q^*/(1-\tau) > 0$

which always holds under FIFO.[9)]

The ultimate effects of acceleration of inflation are ambiguous and depend heavily upon the manner in which the nominal rates i and ρ adjust. This in turn depends on the whole "macro" system and no general conclusions can be presented. Perhaps the easiest way to see what happens when the relative price of material inputs falls measured in final goods is to divide both sides of (4.5a-b) by the price p. Under normal conditions (where c_k/p can be taken as constant and where γ is not too high relative to i and ρ) a reduction in q/p means real capital gains realizable through larger inventory holdings on the average. (Note that this effect is strengthened by the mechanism associated with the increase in the coefficient of f_k).

V The Puzzle of Unclaimed Tax Allowances

In practice, the Scandinavian case is a bit more complicated than as presented above. The tax laws actually only specify the upper limit for v_s, say $\bar{v}$, and the choice of v_s is left to the firms. Given a positive discount rate, one would predict that the firms always claim all the potential tax allowances and this is also what the traditional theory of corporate taxation assumes. However, it has recently been found that the so-called tax exhaustion phenomenon is important, for example, in the U.S.A. and in the U.K., cf. Auerbach (1984) and Edwards and Keen (1985). Unclaimed tax allowances viewed as hidden losses are partly the Scandinavian counterpart of tax exhaustion. It has been argued by Bergström and Södersten (1984) that the existence of unclaimed tax allowances makes the corporate tax system neutral with respect to marginal decisions, and the reason is very simple. Since the firms equiped with a stock of unused allowances can reduce their taxable profit derived from marginal investments down to zero, the tax system becomes irrelevant for marginal decisions.

Tax exhaustion will arise if the firms do not have sufficiently intra-marginal profits, as the U.S. or the U.K. experiences suggest. Similarly, lack of sufficient intramarginal profits may be the reason for a prolonged period of unclaimed tax allowances in a substantial fraction of the Scandinavian firms. But due to the available loss-offset provisions, it need not be. In this section we show that the puzzling phenomenon of unclaimed tax allowances may actually be explained in terms of the dividend constraint even with no tax exhaustion. While in the previous sections the firm was assumed to be free to choose its dividend policy, this section introduces the (natural) constraint that in an economy where the inventory deduction can freely be chosen by the firm within given limits ($0 \leq v_s \leq \bar{v}$), its distributed profits cannot exceed the reported profits net of corporate taxes. With some minor qualifications, this holds in the Scandinavian tax system.

The dividend constraint means that P_d in (2.12) has to satisfy

$$(5.1) \quad P_d \leq (1-\tau)[p(\frac{1}{\alpha})f(l,g,k) - wl - rg - c(k) - ibqk$$

$$- q^*(\frac{\beta}{\alpha})f(l,g,k) - D_s]$$

where D_s is given by (4.2) with the modification that this time its right-hand side has to include an additional term, $q^*k(dv_s/dt)$. This gives rise to a mixed constraint of the form

$$(5.2) \quad K(k,v_s;l,g,j,x) \geq 0$$

where v_s is now viewed as an additional state variable and $x = dv_s/dt$ is taken as a control variable. Denoting the marginal valuation of $v_s(t)$ by $\mu(t)$ and by introducing η_1, η_2 and ϕ as non-negative shadow prices, (2.13) can be transformed into a Lagrangean function

$$(5.3) \quad \mathcal{L} = H + \mu x + \eta_1 v_s + \eta_2(\bar{v} - v_s) + \phi K.$$

Though $\mathcal{L}$ is linear in x with the implication that the solution is of the bang-bang type, the equilibrium necessitates that $x = dv_s/dt = 0$.

To solve for the equilibrium value of v_s, note that (5.2) can be reduced to

$$(5.4) \quad D_s \leq qj - b\gamma qk - q^*u$$

or, equivalently

$$(5.4)' \quad v_s \leq \frac{q}{q^*}\left[\frac{j - (q^*/q)u - b\gamma k}{\gamma k}\right] = a(q^*/q).$$

These follow from applying the equilibrium properties $j(t) = u(t)$ and $D_s = v_s(dq^*/dt)k$. It is thus worth pointing out that in equilibrium with no inflation $D_s = 0$, while it is optimal for the firm to adjust D_s so as to compensate for increasing prices under positive rate of inflation. This is, however, accomplished via time-invariant v_s, the equilibrium value of which is dictated by the dividend constraint as given in (5.4)′. Suppose now that the upper limit for v_s, i.e. $\bar{v}$, has been set to a 'relatively' low level such that $\bar{v} < a(q^*/q)$. Then $v_s < a(q^*/q)$, or equivalently, $K > 0$ and $\phi = 0$. From the condition $\partial \mathcal{L}/\partial v_s = -d\mu/dt = 0$[10) it follows (for any positive rate of inflation, to make it precise) that $\eta_2 = \tau(dq^*/dt)k > 0$. Hence, the constraint $v_s \leq \bar{v}$ is binding and generates a positive shadow price, the value of which is positively related to the corporation tax rate τ. Turning to the allocative implications, one notes that the results of the previous sections apply directly. Hence, depending on the value $\bar{v}$ decided by the tax authorities, the demand for productive inputs and the inventory decisions may or may not be distorted.

In the above case, the dividend constraint (5.2) was not binding and in a sense the firm was over-taxed. Suppose now instead that $\bar{v}$ is 'relatively' high, $\bar{v} \geq a(q^*/q)$. Then the distributed profits converge to the after-tax reported profits and the constraint (5.2) becomes binding. But this implies that in (5.4)' $v_s = a(q^*/q) \leq \bar{v}$ (with the equality holding only in the just-binding case). Historically, $\bar{v}$ has been relatively high as compared to a casual estimate of the value suggested by the neutrality requirement. Hence, it seems that the puzzling observation of unclaimed inventory deductions can be explained in terms of the binding dividend constraint. The intuitive explanation is simple enough. The use of a higher value of v_s would be available for the firm. Any change in the inventory deduction, say ΔD_s, would however lead to a temporary reduction in the reported profit by the same amount, but it would reduce the tax liability, again temporarily, only by the amount $\tau\Delta D_s$. This would reduce current dividends with no compensating increase later on and hence this cannot be the optimal policy.

There is one more interesting result one obtains regarding the inventory deduction of the Scandinavian type. For any positive rate of inflation γ, the firm always chooses a positive v_s (this is because $a(q^*/q) > 0$

is equivalent to $e^{\gamma T}(1-b\gamma T) > 1$, which always holds). This result of uniqueness with respect to the optimal v_s under positive inflation can be contrasted to the case of zero inflation. Namely, in the latter case the model does not determine any unique (optimal) value for v_s. In equilibrium with no anticipated inflation the firm automatically chooses $D_s = 0$ and it is totally indifferent with regards to the value of v_s it may have adopted in the past (maybe under conditions of non-zero inflation). In this case, the dividend constraint is also automatically fulfilled (see (5.4)). Though this is a degenerate case, it is useful not to disregard it because it highlights the difference in the role of the inventory deduction and the dividend constraint in inflationary and in non-inflationary situations.

VI Final Remarks

The design of an appropriate corporate tax system with desirable properties has appeared to be a complex task, at least in the case of productive firms with different types of working and long-term capital and with different types of financing. Deficiencies and misprocedures in calculation of the corporate tax liability may lead to misleading signals in the stock market and hence inefficiences in allocation. Though most of the literature on corporate taxation has focused on designing appropriate deductions for long-term assets, this paper argues that the tax treatment of working capital including stocks of material inputs are not of secondary importance. We have dealt both with the valuation problem and the opportunity cost problem. Indeed, the latter is exacerbated by the fact that there is also usually a delay between production and sales, an aspect we did not explicitely discuss. Due to the opportunity cost problem, the firms have strong incentives to substitute trade credits, i.e. accounts payable, for internal financing. This may allow for deduction of the opportunity cost either explicitely or implicitely through the adjustment of the market price of material inputs acquired. But this would eliminate the opportunity cost problem only to the extent that the maturity structure of these credit arrangements exactly corresponds to the actual turnover of inventories and this seems very unlikely in practice.

Footnotes:

1) Nothing in our key results hinges upon the assumption that k(t) enters the function f, so those who do not like this ad hoc way of introducing productivity of inventories are free to assume that $f_k = f_{kk} = 0$. We discuss several issues both in the cases where $f_k > 0$ and $f_k = 0$. However, as it becomes clear in the next section, the assumption of non-zero f_k helps to emphasize the distinct roles played by the inflation distortions and the tax distortions.

2) This claim holds unambiguously when $f_k \equiv 0$. It does not need to hold if $f_k > 0$ but this unlikely outcome is excluded here.

3) But note that in the absence of the direct productive contribution of inventories (with $f_k = 0$) introduction of LIFO also eliminates the distortions in the demand for labor and capital services caused by the corporation tax. In (3.6) and (3.7) this result is not obtained since f_l and f_g depend on k.

4) We set the constant of integration equal to zero to avoid lump-sum subsidies.

5) The results obtained in the earlier work on the Scandinavian inventory deduction (Ylä-Liedenpohja 1979/1980 and Honkapohja - Kanniainen (1981)) are qualified in several ways in the current paper.

6) The Scandinavian deduction allows for non-zero D_j, D_l and D_g simply because any increase in the material inputs used means a corresponding increase in the use of other inputs, too.

7) Over the past years, this fraction has been 0.30-0.40 in Sweden and in Finland.

8) Note that due to the stated difference in the Canadian and the Scandinavian inventory deduction, the valuation of a marginal unit of inventory of a firm is different. Solving from (3.3), one obtains for the equilibrium values of the costate variables $\lambda_c/q = 1-b < \lambda_s/q = (1-b)(1-\tau)$.

9) The resulting adverse effects on inventory holdings are enhanced by the accompanying decrease in the coefficient of f_k on the left-hand side.

10) Intuitively, the marginal valuation of v_s, i.e. $\mu(t)$, and hence its rate of change have to be zero in the optimal program.

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