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TAX REFORM, INVESTMENT,
AND THE VALUE OF THE FIRM

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ABSTRACT

The taxation of corporate assets is well understood to influence investment and firm valuation. This paper explores the consequences of postwar U.S. tax changes in a dynamic model which incorporates costs of adjustment and investor expectations of future tax reforms and macroeconomic variability. When viewed in a dynamic context, the tax code can have very different incentives than those implied by the usual static analysis. Simulation results suggest that investment is sensitive to future tax changes and business-cycle movements. The paper also illustrates the implications of this analysis for the design of tax reforms.

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Introduction

Since the work of Hall and Jorgenson (1967), there has been considerable empirical analysis of the effects of taxation on investment behavior. The literature concentrates on several issues. Initially, it emphasized the pattern and strength of the investment response to changes in the "user cost of capital" induced by changes in taxation (Hall and Jorgenson 1971, Eisner and Nadiri 1968, Bischoff 1971, Clark 1979). In this work, investment was typically divided into two classes, structures and equipment.

More recently, several studies have emphasized the effects of particular tax provisions on the incentives to invest in different types of assets, calculating "effective tax rates" based on the user cost of capital for several classes of assets at a more disaggregated level (Auerbach and Jorgenson 1980, Jorgenson and Sullivan 1981, Hulten and Robertson 1982, Gravelle 1981, Auerbach 1983, King and Fullerton 1984). These studies focused on the "long run" effects of different tax systems. They did not explore how short-run investment behavior might be influenced by anticipted changes in the tax code or costs of adjusting capital stocks to the higher or lower levels optimal under new tax policy regimes.

Though such analysis is extremely helpful in understanding the overall incentive effects of very complicated tax systems, the emphasis on steady state behavior may be misleading in a world where the tax law changes as frequently as it does. A review of recent U.S. legislative history illustrates this point.

The year 1981 saw the "tax cut to end all tax cuts," the Economic

Recovery Tax Act, which substantially reduced both corporate and individual income tax collections and contained provisions scheduled for introduction as late as 1986. One year later, Congress raised taxes, undoing some of the provisions already in operation and cancelling others yet to become effective. This happened again in 1984. Now, in 1985, there is serious discussion of a number of a number of tax proposals that again would markedly change the environment faced by taxpayers. A bet against change would appear to face long odds.[1]

In attempting to understand the likely effects of policy changes, there is little justification for ignoring this record, or for assuming that investors will. Indeed, the problem of "dynamic inconsistency", in which government will have the incentive in the future to adopt different tax policies than those promised today, was first discussed using the investment tax credit as an example (Kydland and Prescott 1977). Unanticipated changes in the investment tax credit provide an efficient "bang for the buck" in terms of increased investment per dollar of lost tax revenue, because old capital is excluded from benefitting from the tax reduction. This may also be viewed as a capital levy on existing assets, since their quasirents will be driven down by increases in new investment (Auerbach and Kotlikoff 1983). Yet anticipated changes in the investment tax credit would obviously have very different effects.

The purpose of this paper is to bring to the literature on the effects of tax policies on investment incentives an explicit treatment of short run transition behavior, taking full account of the provisions of the tax law and allowing for varying degrees of foresight on the part of investors and costs of adjustment to increasing the capital stock. Though these questions have been studied using the q model of investment (beginning with Summers 1981), the emphasis in such work has been on estimation of adjustment costs and the prediction of the behavior of investment to one-time shocks to investment incentives. Closest in spirit to the our analysis is the work of Abel (1982), who showed how temporary and anticpated changes in tax provisions would affect current investment and the value of "marginal q" (the net cost of new capital goods) in the q model. One may view the present paper as an empirical application of his analysis to the postwar U.S. experience and the current tax reform debate.

Among the questions we seek to answer below are:

- What effects, taken together, have all the postwar changes in investment incentives had on investment?
- What effects should different historical policy changes have had on the market value of corporations?
- Because of the structure of adjustment costs and differences in the durability of different types of capital, how does the pattern of investment incentives across asset types differ between the long and short runs?
- What would be the impact of tax reform proposals of the kind currently being discussed on investment and

securities values? How would various phase-in plans for these proposals alter their impacts?

- How important are expectations about future tax changes when there are substantial costs to adjusting the capital stock?

The paper is organized as follows. In the next section, we describe the model. Following this is a discussion of how the model's parameters are chosen, and the simulation technique used to solve for the paths of investment and market values over time. We then proceed to analyze the questions just raised, looking first at historical investment behavior and then at the current situation.

Modelling Investment Behavior

The model of investment used in this paper assumes that there are two types of fixed investment (structures and equipment) and costs to adjusting the capital stock that may be separate or mutual and may differ between structures and equipment. It is, in other words, a q investment model with two types of capital. We choose this level of aggregation to allow comparability with previous work, and because the greatest variation in tax treatment has historically been between these two broad classes of assets.

Consistent with the data, ours is a discrete time model with one year intervals. Each capital good is assumed to decay exponentially, and the representative, competitive firm produces its output using labor and the two types of capital subject to a constant returns to scale, Cobb-Douglas production function, with α_1 and α_2 representing the gross shares (including depreciation) of the equipment and structures, respectively, in production. The adjustment cost function is assumed to have the following form[2]:

$$(1) \qquad A(I_t) = \tfrac{1}{2}[\beta_0(I_t/K_{t-1})^2K_{t-1} + \beta_1(I_{1t}/K_{1t-1})^2K_{1t-1} + \beta_2(I_{2t}/K_{2t-1})^2K_{2t-1}]$$

where I_{it} and K_{it} are net investment and capital of type i in year t, I_t and K_t are sums over both types of investment and capital, and β_0, β_1 and β_2 are adjustment cost terms reflecting joint costs and costs specific to the two types of capital, respectively.

Given the homogeneity of the production function and adjustment cost function with respect to the scale of the firm, the value of the firm will be proportional to the size of its capital stock and the behavior of all firms can be represented by a single, aggregate representative firm.

The quadratic adjustment cost function in (1) is a two-capital-good version of the one used by Summers (1981) in his empirical analysis. It also differs in two other respects. First, it is based on net, rather than gross investment. Second, there is no constant subtracted from the ratio I/K in each quadratic term. However, one may equivalently view the current model as being based on gross investment, with a constant equal to the rate, δ, of economic depreciation being subtracted. Either way, the notion is that minimum average adjustment costs (in this case, zero) occur when net investment is zero. This makes sense if one views the costs as general ones involving changing the scale of operations rather than bolting down the new machines. Summers's preferred estimate of the constant term (.088) is quite consistent with this interpretation.

We ignore changes in relative prices between capital goods and output and between different types of capital, and assume that all new investment goods have a real price of unity in every year. The adjustment costs are assumed to be "internal", in that they relate not to an upward sloping supply schedule for capital goods but the costs of absorption at the firm level. This is consistent with the observation that historical fluctuations in capital goods prices are relatively minor compared to estimated costs of adjustment.

The firm's optimization problem consists of choosing equipment, structures and labor at each time t, taking account of current and (to the extent of the assumed planning horizon) future economic conditions. There is no risk from the firm's point of view; whatever it expects about the future (right or wrong) is expected with certainty. If we let the production function in the three factor inputs be F(•), then the firm seeks to maximize its value at time t, equal to the discounted value of its real, after-tax cash flows:

$$(2) \qquad V_t = \sum_{s=t}^{\infty} (1+r)^{-(s+1-t)} \{ (1-\tau_{s+1})(F(K_{1s},K_{2s},N_s) - w_s N_s) + (1+r)(1-\tau_s)A(I_s) + (1+r) \sum_{i=1}^{2} [-(1-k_{is})G_{is} + \tau_s \sum_{x=-\infty}^{s} ((1+r)/(1+r+\pi))^{(s-x)} D_i(s,x) G_{ix}] \}$$

where N_s is the labor input in period s, r is the real, after-tax required return, w_s is the real wage rate paid at the end of year s, $D_i(s,x)$ is the depreciation allowance at the beginning of year s for assets of type i purchased at the beginning of year x, k_{it} is the investment tax credit received on investment of type i at the beginning of year t, c is the rate of inflation, δ_i is the rate at which capital of type i depreciates, G_{it} is gross investment of type i at the beginning of year t, and τ_t is the tax rate at the beginning of year t.[3] Depreciation allowances decay at the inflation rate because they are not indexed.

We use the convention that year t investment occurs at the beginning of the period, while quasirents occur at the end, with period t investment yielding its first return at the end of the same period. We also assume that adjustment costs are immediately expensed, as would be the case for internal adjustment costs that require extra factors or reduce productivity. Gross and net investment of type i are related by the identity:

$$G_{it} = I_{it} + \delta_i K_{it-1} \tag{3}$$

For labor, the optimal condition derived by differentiating (2) with respect to N calls for the firm to set the marginal product of labor equal to the real wage. As usual in models of this sort with constant returns to scale, the labor demand equation is omitted from explicit analysis. For each type of capital good i, it is most convenient to derive the first order condition with respect to gross investment at each date t, G_{it}. Assuming, for the moment, an infinite horizon and perfect foresight, this yields:

$$(4) \qquad \rho_{it} = [(1+r)/(1-\tau_{t+1})] \; [q_{it}-k_{it}-\sum_{s=t}^{\infty}(1+r+\pi)^{-(s-t)}\tau_s D_i(s-t)$$

$$- \sum_{s=t+1}^{\infty}(1-\delta_i)^{(s-t)}(1+r)^{-(s-t+1)}(1-\tau_{s+1})\rho_{is}]$$

where (using 1 and 3):

$$\begin{aligned}(5) \qquad \rho_{it} &= dF_t/dK_{it} - dA_{t+1}/dK_{it} \\ &= dF_t/dK_{it} + \tfrac{1}{2}\beta_0[(I_{t+1}/K_t)^2 + 2\delta_i(I_{t+1}/K_y)] \\ &\qquad + \tfrac{1}{2}\beta_0[(I_{it+1}/K_{it})^2 + 2\delta_i(I_{it+1}/K_{it})]\end{aligned}$$

is the "total" marginal product of capital at the end of period t, taking account of reduced concurrent costs of adjustment, and q_{it} is the marginal cost of a unit of capital, less tax savings associated with costs of adjustment:

$$(6) \qquad q_{it} = 1 + (1-\tau_t)[\beta_0(I_t/K_{t-1}) + \beta_i(I_{it}/K_{it-1})]$$

Equation (5) reminds the reader that there are two components to the firm's marginal value of an additional piece of capital this year: the marginal product of capital (dF_{t+1}/dK_{it}) and the reduction in next year's adjustment costs (dA_{t1}/dK_{it}). Expression (4) says that firms should invest in capital of type i at date t until its marginal product, after tax, equals its after tax cost (multiplied by (1+r) because costs are borne at the beginning of the period) less the present value of investment credits, depreciation allowances and future quasirents. Thus, the expression is the result of the optimal backward solution for firm behavior. When expectations are static, as is commonly assumed, (4) reduces to the standard user cost of capital formula:

(7) $$\rho_{it} = q'_{it}(r+\delta_i)(1-k_{it}-\tau_t z_{it})/(1-\tau_t)$$

where z_{it} equals the present value of depreciation allowances $D_i(s,t)$ and

(8) $$q'_{it} = (q_{it}-k_{it}-\tau_t z_{it})/(1-k_{it}-\tau_t z_{it})$$

is a tax-adjusted price of new capital goods that we will interpret below.

Because of the assumption that production is governed by a Cobb-Douglas production function, the direct marginal product of capital of type i in period t is:

(9) $$F_{it} = a_t N_t^{(1-\alpha_1-\alpha_2)} \alpha_i K_{it}^{-(1-\alpha_i)} K_{jt}^{\alpha_j} \qquad j=3-i$$

where a_t is the production function constant. Thus, given the optimal choice of labor input, expressions (4) and (5) for i and j give us two equations in the capital stocks K_{1t} and K_{2t}. Without adjustment costs, this would permit a closed form, backward solution for these capital stocks in each period.[4] However, since q_t depends on lagged capital stocks, this solution method is no longer possible, and we must resort to simulation analysis.

Parameterization

Three types of parameters appear in the model just described, relating to production (a, α_1, α_2, δ_1, δ_2, β_0, β_1, and β_2) taxation (τ, k_1, k_2, $D_1(\cdot)$ and $D_2(\cdot)$) and financial markets (r and π). For π, we use the realized values of the GNP deflator (year on year), while τ is set equal to the statutory corporate tax rate that prevailed for the majority of the year.[5] In order to calculate the production paramaters α and δ and the tax terms k and D(•), it is necessary to aggregate data on thirty-four classes of assets for which we have data (twenty equipment and fourteen structures) into corresponding values for aggregate equipment and structures. This turns out to be a very complex problem.

What we seek are parameters for aggregate capital goods that, by some measure, accurately reflect those of their components. One criterion that seems reasonable is to require that, for a particular tax system, both net and gross rates of return to capital before tax be the same for the aggregate assets as for the sums of their components. A particular motivation for using this approach is that it results in the effective tax rate, as usually measured, being invariant to the aggregation procedure.

To see what weights this criterion dictates, consider first the special case in which adjustment costs are zero and expectations are myopic. Let Ω_{ij} be the fraction of capital stock j of the total in its class i (equipment or structures) at a particular date. (We suppress the time subscript but emphasize that these capital stock weights are not time invariant.) The gross before tax return to capital of type i is then:

$$\rho_i = \sum_j \Omega_{ij}\rho_j = \sum_j \Omega_{ij}(r+\delta_j)\ (1-k_j-\tau z_j)/(1-\tau) \tag{10}$$

where δ_j, k_j and z_j correspond to asset j. The net return is:

$$r_i^n = \rho_i - \sum_j \Omega_j\delta_j \tag{11}$$

Thus, the criterion would be satisfied by weighting the indvidual values of δ by capital stock weights Ω and the tax parameters k and z by $\Omega(r+\delta)$; the tax parameters of short-lived assets should be more heavily weighted. This is an important choice, since the values of $k+\tau z$ generally increase monotonically with δ.[6]

Since capital stock weights change over time, this formula would require recomputation every year. However, this presents an index number problem, and it is unclear that we should prefer a measure with varying weights. Even after this issue is resolved, one must deal with the problem of adjustment costs and varying values of asset-specific q's, about which there is little information. Finally, there is the problem of expectations. When the marginal product of capital is dictated by expression (4), there are no simple weights (that we can think of!) that satisfy the criterion. One would generally have to determine the weights simultaneously with the solution for the marginal product itself, which would make the problem intractible.

In light of the situation, we choose to weight δ by j and tax parameters by $\Omega(r+\delta)$, using fixed values for r and the capital stock weights Ω over time. The capital stock weights used are for the year 1977, as described in Auerbach (1983). The rates of economic depreciation come from calculations by Hulten and Wykoff (1981). The fixed value used for r is .04.

Once values of δ_1 and δ_2 are known, it is possible to estimate the capital share parameters α_1 and α_2 from production and capital stock data. We begin by calculating the net-of-depreciation, before-tax return to capital in the corporate sector in 1977 by dividing the difference between value added and labor compensation in the corporate sector, taken from the 1977 Census of Manufactures, by the total corporate capital stock, equal to equipment and structures plus inventories and land. We then assume that all forms of capital earned this before-tax rate of return, R_g.[7] Next, we assume that the Cobb-Douglas production function specified above refers to gross output net of returns to inventories and land,[8] calculated as follows:

$$(12) \qquad G = Y + \delta_1 K_1 + \delta_2 K_2 - R_g(K_3+K_4)$$

where Y is value added and K_3 and K_4 are stocks of inventories and land.

Once we have obtained this value of G, we note that, since output is observed net of adjustment costs, the production function F(•) must satisfy:

$$(13) \qquad F(K_1,K_2,N) = G + A(I)$$

Finally, we define the net return to capital of type i (i=1,2) in the current period as being the derivative of G with respect to K_i, holding constant the capital stock <u>growth rates</u> (I_1/K_1), (I_2/K_2) and (I/K), less depreciation δ_i.[9] This yields (using 1 and 9):

$$(14) \qquad R_g = \alpha_i F/K_i - \tfrac{1}{2}\beta_0(I/K)^2 - \tfrac{1}{2}\beta_i(I_i/K_i)^2 - \delta_i \qquad i=1,2$$

which can immediately be solved for α_i.[10]

The resulting parameter values are:

$\alpha_1 = .167$

$\alpha_2 = .171$

$\delta_1 = .137$

$\delta_2 = .033$

with the estimated value of R_g equal to 10.4%. This estimate of the marginal product of capital (which is used in the current version of the paper only in the calculation of α_1 and α_2)[11] is consistent with previous findings. In interpreting the sizes of the two share coefficients, it should be remembered that these are shares in gross output, less estimated returns to land and inventories. Relative to usual calculations of the capital share of net output, the first of these factors (the use of gross output) would lead to a larger total share (since depreciation is included in both numerator and denominator) while the second (excluding part of the capital stock) would lead to a smaller total share (since returns to excluded capital are subtracted from both numerator and denominator.)

Finally, the production function constant a is obtained by dividing $F(\cdot)$ by the product of its component factors raised to the power of their respective factor shares. We then assume that the labor input, in efficiency units, grows at a constant rate of 3% over the entire sample period.[12] This imparts a trend rate of growth to the steady state of the model, and is set slightly below the historical capital stock growth rate of about 4% because part of that growth may be attributable to the historical decline in effective tax rates on investment.

The only parameters that remain to be chosen are the adjustment costs terms β_0, β_1 and β_2, which are quite crucial to our analysis. Previous studies have inferred these parameters from regressions of investment on "tax-adjusted q". The authors of these studies have derived "tax-adjusted q" by correcting the ratio of the market value of the firm to its capital stock (presumed to be average q) for tax factors such as the investment tax credit, accelerated depreciation and the deductibility of adjustment costs that would cause marginal and average q to differ. In one case (Abel and Blanchard 1984), average q is explicity estimated from projected future profits and interest rates. A regression of I on adjusted q can then be interpreted as estimating the inverted marginal cost function.

In a model with one capital stock, the coefficient on adjusted q would be an estimate of $1/\beta$, the inverted marginal adjustment cost. Although such regressions cannot be done if there is more than one capital stock, one can still interpret the coefficient as the inverse of the sum of marginal adjustment costs associated with investment of type i, or $[\beta_0+\beta_i]^{-1}$ in the current model.

Empirical investigations have found this coefficient to be quite small. Using annual data, Summers (1981) chose a "preferred" value of .031 from his many regressions, implying a value of the marginal adjustment cost β of 32.2, while Poterba and Summers (1983) found slightly lower values of $1/\beta$ using British data. Using quarterly U.S. data, Abel and Blanchard (1984) found values of $1/\beta$ of between 0 and .015.

However, for many reasons usually pointed out by authors of the previous studies themselves, these coefficients (which are not always even statistically significant) may be prone to serious downward bias because of an inexact measure of q being used.[13]

Estimated speeds of adjustment based on such high adjustment costs appear to be unreasonably slow, given previous work on investment behavior.

For example, Summers (1981) finds that half of the long run increase in investment that occurs in response to an unanticipated increase in the investment tax credit is achieved after approximately eight years. The same pattern of adjustment occurs in response to an immediate cut in the corporate tax rate. Previous studies based on the neoclassical model (modified to allow slower responses to changes in the cost of capital than to changes in output) found the same percentage of the long run adjustment to be reached in about eight quarters or less (Bischoff 1971, Clark 1979). Similar response patterns have been obtained from a comparison of different full model simulations (Chirinko and Eisner 1983).

While we are quite uncertain what the "true" value of β is, it seems appropriate to use one that provides more reasonable speeds of adjustment. Some experimentation suggests an overall value of $\beta = 12$, which we arbitrarily divide equally between own and common adjustment costs. That is, we assume that $\beta_0 = \beta_1 = \beta_2 = 6$. In future work, we hope to obtain our own empirical estimates of these parameters.

Solution of the Model

In the presence of adjustment costs, the model as specified can only be solved numerically. There exist different techniques to obtain such solutions. The one used here is based on the approach first taken in a q model by Auerbach and Kotlikoff (1983). The actual algorithm used depends on the policy experiment considered.

All simulations begin with the assumption that, prior to 1954, the economy was in a steady state: that economic conditions had been stable for sufficiently long that the stocks of both kinds of capital had completely adjusted, and no change in these conditions was anticipated. Though this is undoubtedly inaccurate, some such assumption is required to fix the inital values of capital stocks in a way that is consistent with the assumed production technology.

This solution for the steady state in 1953 does not depend on any future variables. Indeed, when expectations are assumed to be completely myopic throughout, the model can then be solved forward without iteration, with each year's solution beginning with K_{t-1} and solving for K_t. At the other extreme is the assumption of perfect foresight. By this, we mean that all tax and inflation rates are correctly anticipated until the present.[14] It is hard to implement this assumption for future dates, so we make assumptions about the values of these variables and suppose that firms' expectations match them. We then solve the model into the 21st century to guarantee convergence to a new steady state.

Our method begins with a path of initial guesses for the capital stocks of each type in each year. Then, a version of expression (4), with the guess of K_{t-1} held constant at time t, is solved backward for a new vector of capital stocks. These are used to update the previous guesses, and the procedure is repeated until convergence is reached.

In cases in which we wish to assume that expectations are forward looking until some particular date of a change in regime, we solve the model in the manner just described but stipulate that people assume that the tax parameters prevailing in the year before the regime shift will remain unchanged forever. This simulation generates capital stocks for the year before the regime shift. Next, we take these capital stocks and use them as the initial ones for a second simulation that begins in that year and continues into the future. For example, if one wished to assume that from 1954 through 1961 no investment tax credit was anticipated, but that after its introduction in 1962 no further mistakes were made, one would follow the procedure just described using 1962 as the year of the regime shift. This approach is very useful in analyzing current policy alternatives since, whatever is anticipated, the current capital stocks are certainly fixed and cannot change if a policy shift is announced.

Measuring the Effects of Policies

Once the solution paths are obtained for the two capital stocks, we calculate three variables of interest. One is the average q of the representative firm, its value relative to the replacement cost of its capital stock. This starts with the marginal q obtained directly from the adjustment cost function, and then takes account of the variety of tax provisions that make old and new capital differ in value. The second is the effective tax rate, which summarizes the incentive to invest in a particular asset in a given year. The third is the net investment flows of equipment and structures which the simulation generates.

Estimating Average q

It is this variable that tells us what the overall impact of a tax change will be on market value. Generally, there will be two effects. To the extent that the incentive to invest increases, marginal q, defined to be the basic price of a unit of capital capital plus the derivative of the adjustment cost function with respect to investment, will rise. In the absence of taxes, the homogeneity of production and adjustment cost functions would imply that this would also be the firm's value per unit of capital.

But to the extent that the new incentive magnifies the distinction between new and old capital, the difference between marginal q and average q will also rise. The net effect on average q can be either positive or negative for expansionary or contractionary policies. Holding marginal q constant, an increase in average q may be viewed as a lump sum transfer to the owners of corporate capital.

The formula for average q is based on an arbitrage condition between old and new capital. Since new capital goods must generate after-tax cash flows equal to marginal q, it follows that:

$$(15) \qquad \underline{q}_{it} = \tau_t[\beta_0(I_t/K_{t-1}) + \beta_i(I_{it}/K_{it-1})] + PV_{it} + k_{it} + \sum_{s=t}^{\infty} \tau_s D_i(s,t)$$

where $\underline{q}_{it}$ is marginal q and PV_{it} is the present value of the after-tax quasirents accruing to an new asset purchased for one dollar at date t. Since capital purchased at t'<t has a present value of quasirents of $(1-\delta i)^{t-t'} PV_{it}$, it follows that its value at date t, per efficiency unit of capital, is:

$$(16) \qquad \underline{q}_{it,t'} = PV_{it} + [\sum_{s=t}^{\infty} \tau_s D_i(s,t')]/(1-\delta_i)^{t-t'}$$

Solution of (15) for PV_{it} and substitution of this expression into (16) gives a solution for the value of capital of type i and cohort t' at time t, in terms of q_{it}. From (1) and the definition of marginal q, we also have:

$$(17) \qquad q_{it} = 1 + \beta_0(I_t/K_t) + \beta_i(I_{it}/K_{it})$$

Combining (16) and (17) to get each cohort's value, we then aggregate these values of average q over all vintages and both types of capital to obtain an overall value for the firm at date t.

Note that this expression for average q is consistent with the assumption of perfect foresight. When myopic expectations are assumed, we change (15) and (16) correspondingly.

Calculating Effective Tax Rates

In models based on myopic expectations, it is common to define the effective tax rate to be the percentage difference between the net (of depreciation) marginal products of capital before and after taxes. Given a fixed after-tax return, this calculation also tells us what the before tax, or social return to capital must be for the firm to earn zero profits. Unless the economy actually is in a steady state, however, this will be correct only in the year the calculation is made. Hence, the effective tax rate as commonly used measures the required before-tax return to capital in the same year, assuming myopia.

When firms are not myopic, the formula for the user cost of capital is different, but we can still answer the same question, viz., what rate of return on capital must the firm earn in the current year, taking account of future changes in taxes, inflation and the firm's marginal product of capital? As before, this will tell us what the firm's rate of return on investment must be, before taxes, in the current year. Dropping subsrcripts, the effective tax rate is defined to be:

$$(18) \qquad \theta = [(\rho/q - \delta) - r]/(\rho/q - \delta)$$

where ρ is the marginal product of capital defined in (5).

It is not clear which value of q should be used in (18). The most obvious candidate is marginal q, as defined in expression (17). However, use of this value has the effect of incorporating the tax deduction for adjustment costs in the effective tax rate. This is perfectly acceptable; it reflects the fact that part of the cost of investment is expensed. However, it makes more difficult a comparison with previous results, since even when there is economic depreciation of direct capital costs, the effective tax rate will be less than τ. By using the tax adjusted value, q', defined in (8),[15] one "undoes" the differential tax treatment of adjustment costs, and obtains the usual results for expensing, economic depreciation, and other special cases. Hence, for the sake of comparability with other studies in which adjustment costs were ignored, we take this latter approach.

Simulation Results

This section presents the results of simulations, chosen to provide answers to some of the questions raised in the introduction. We begin by comparing the historical measures of average q and investment that would have prevailed with and without adjustment costs. Because of the erratic behavior that would occur under perfect foresight in the absence of adjustment costs, we perform this comparison under the assumption of myopic expectations. By construction, effective tax rates for the two simulations will be identical, since all differences will be absorbed in q', the tax-adjusted cost of capital goods that is used in expression (18).[16] The main point is to illustrate the smoothing of investment and the impact that movements in marginal q have on average q when adjustment costs are present. Both simulations are performed for the period 1953-1990, with the assumption made that the Bradley-Gephardt "Fair Tax" plan is implemented in 1985. This plan would lower the corporate tax rate to 30%, repeal the investment tax credit and provide declining balance depreciation allowances designed to have a present value of near that of economic depreciation at rates of inflation like those recently experienced in the U.S.[17]

Table 1a presents effective tax rates for these two simulations. For each year, there are two numbers: the effective tax rates for equipment and structures, respectively. These results are quite consistent with those of the previous literature.[17]

Beginning from effective tax rates in 1953 well above the statutory rate of 52% for equipment, and somewhat lower for structures, rates move lower with the tax changes introduced in 1954, and again in 1962 with the introduction of the investment tax credit. Tax rates on equipment go down again in 1972 with the reintroduction of the investment tax credit and the introduction of the Asset Depreciation Range (ADR) System. By 1980, higher rates of inflation have pushed effective tax rates back up again, particularly on equipment. The introduction of ACRS in 1981 brought effective tax rates on equipment essentially to zero, also lowering tax rates on structures to an postwar low. Reduced inflation in 1982 brought tax rates down still further.[19] Rates went up in 1983 on equipment and 1984 on structures because of the 1982 and 1984 tax acts, which introduced a fifty percent basis adjustment for the investment tax credit and an eighteen year (instead of fifteen year) tax life for structures, respectively.

A switch to Bradley-Gephardt in 1985 would substantially increase the effective tax rate on equipment, leaving both effective tax rates near the statutory rate of .30. The constancy of effective tax rates reflects the assumption of constant future real interest rates and inflation.

Table 1b displays values for average q, or $\underline{q}$, for the simulation without adjustment costs, for structures, equipment, and in the aggregate, based on estimated capital stock composition and tax treatment in each year. Since there are no adjustment costs in this case, marginal q is identically equal to one, so movements in average q are entirely due to changes in the relative tax treatment of new and old capital.

These values of average q have also declined over the years as the distinction made by the tax system between old and new capital has widened. Under a system of economic depreciation, average q would equal marginal q net of the tax deduction of adjustment costs, as defined in (6) (averaged over the two types of capital). With no adjustment costs this value is, of course, one. The estimated time series given in Table 1b suggest that average q was actually above one in 1953. After the acceleration of depreciation allowances in 1954, and throughout the 1950s and until 1962, average q was approximately equal to one. However, since then q has been lower, reaching a low of .80 in 1981 and staying near this value since.[20] A switch to Bradley-Gephardt in 1985 would return average q back to a value of approximately one, as depreciation allowances are decelerated and the investment tax credit removed, thereby removing the tax distinction between old and new capital.

The net investment rates for equipment, structures and in the aggregate under the no-adjustment-cost simulation are displayed in Table 1c, expressed as a percentage of the respective capital stocks. These numbers are quite unrealistic, as one would expect them to be. But if one wants to allow for a sluggish adjustment of investment, this must be carried through consistenly to other calculations, such as for average q.

With adjustment costs present, the nature of the results for investment and average q change quite dramatically. Because marginal adjustment costs are high when investment demand is strong, firms seek to smooth their investment. At the same time, the value of average q diverges from one not only because of the distinction between new and old capital but also because of the presence of marginal adjustment costs. Given the value of the sum of β_0 and β_i for i=1,2 and the statutory tax rate of about .5, this increases the value of average q by about 6 times the growth rate of capital, or .18 in the long run. In the short run, average q is determined both by the distinction between new and old capital (the difference between average q and marginal q) and the value of marginal q itself. A change in the incentive to invest will typically affect both of these terms, sometimes in different directions.

These results can be seen immediately from the time series displayed in Table 2b. The aggregate value of average q starts out at 1.23, indicating a very small aggregate difference in the tax treatment of new and old capital. For equipment, depreciation slower than economic depreciation leads to a premium in the value of old capital goods. The value of average q falls very little in 1981, from 1.09 to 1.08, as the increase in marginal q associated with more investment nearly outweighs the effect of the levy on old capital. A similar effect is present for the period 1971-72, when the reinstitution of the investment tax credit and the introduction of the Asset Depreciation Range for equipment incresed the incentive to invest. Without costs of adjustment, aggregate average q drops from .94 to .88. With costs of adjustment, it does not drop at all.

The sharp increase in average q that occurs in 1985 is due to the decreases distinction between old and new capital introduced by Bradley-Gephardt. In the short run, this effect dominates the decline in marginal q associated with a reduced incentive to invest in equipment.

Table 2c presents the net investment figures produced by the simulations. The impact of adjustment costs is clear. Though investment still increases in years of increased investment incentives, such as 1962, 1972 and 1981, these increases are of the order of magnitude of 0.5 percent to 1.1 percent of the aggregate capital stock. Such changes are well within the range of historical fluctuations in investment, representing a swing of perhaps 2 percent of output. The proposed switch to Bradley-Gephardt in 1985 would reduce investment by about .4 percent of the capital stock, although a decline of about .1 percent would occur even without any such change, as net investment slowly approaches its assumed steady state value of 3.0 percent of the capital stock.

Tables 3a, b and c present the results of a simulation of behavior over the same period under the assumption that there is perfect foresight as well as adjustment costs to investment. We assume that, prior to 1984, expectations about what would happen in years 1954-1984 were correct. It is obviously impossible to simulate perfect foresight about the years 1985 and beyond, so we assume that firms expected 1984 to be characteristic of all subsequent years. We also provide information in the table for the years 1985-1990 under the assumption that the Bradley-Gephardt plan is introduced unexpectedly in 1985 and that there is perfect foresight about the future impact of this policy, once introduced.

A major effect, seen in Table 3a, is the increase in effective tax rates that occurs in years before increases in investment incentives that do not benefit old capital but reduce its marginal product. This is evident in 1961, 1971 and 1980, when the effective tax rates on both structures and equipment rise from the previous year's values, in contrast to declines for each year that were seen for the myopic case.

One can also see differences in the pattern of investment over time, compared to the case of myopia (with adjustment costs), although there does not appear to be any noticeable increase in the volatility of the series, as one might have expected. Under perfect foresight, aggregate net investment varies between 3.1 percent of the capital stock in 1971 and 4.8 percent in 1962, 1981 and 1982. Under myopic expectations, the range is from 2.8 percent in 1970 to 4.6 percent in 1982 and 1983.

In general, it is difficult to compare the investment series in Tables 2c and 3c for any particular year, since the entire time path of investment and expectations is different under the two assumptions. For example, investment in equipment increases from 3.5 percent to 3.9 percent during 1980-81 under myopic expectations and from 4.1 percent to 4.4 percent under perfect foresight. One cannot say that the effect of expectations is to reduce the effect of the 1981 incentives, however, since there is a natural tendancy for investment to decline over time toward the steady state value of 3.0 percent, at a faster rate for higher levels of investment.

The different assumption about expectations has a relatively insignificant impact on average q. This is because, with statutory tax rates changing little over time, the only real differences in the formula come from the use of different nominal interest rates to discount depreciation allowances and the use of different future marginal products of capital to calculate the present value of after-tax quasirents, PV.

One of the criticisms of schemes like the Bradley-Gephardt plan and other proposals to lower statutory tax rates is that they provide transfers to old capital and reduce the incentive to invest. This outcome is evident in Table 3, as well as in the earlier tables. But supporters argue that such plans encompassing low statutory rates and economic depreciation allowances are desirable for other reasons.[21] Hence, it would be useful to know whether this characteristic of reducing average tax rates while increasing marginal ones can be influenced by a phasing in of one of the new plans.

This possibility is examined in our simulation presented in Table 4. We assume the same path for the years 1953-84 as is presented in Table 3, and that in 1985 a phase-in plan for Bradley-Gephardt is announced and implemented with perfect foresight beginning in 1985. The phase-in calls for the immediate removal of the investment tax credit and ACRS depreciation, but only a gradual reduction in corporate tax rates, to 42% in 1986, 38% in 1987, 34% in 1988 and 30% in 1989. This policy would, obviously, involve a smaller revenue loss than one with an immediate reduction in the corporate tax rate to 30%, as was simulated in Table 3.

The results in Table 4 show that the increase in average q is about the same as without the phase-in. This masks two offsetting effects, however. First, the incentive to invest is increased by the phase-in. Second, the windfalls received by owners of existing assets are reduced. As can be seen from a comparison of the investment figures in Tables 3c and 4, the gradual reduction in the corporate tax rate leads to an acceleration of investment, with more investment in both structures and equipment in each of the years between 1985 and 1988, and less thereafter.

These higher rates of investment are associated with the desire by firms to invest while their depreciation allowances (which still have an accelerated pattern relative to economic depreciation) have greater value in generating tax deductions, as discussed by Abel (1982). Thus, this phase-in leads to a situation where investment actually rises in the aggregate in 1985 with the enactment of Bradley-Gephardt, while at the same time reducing the extent of its windfall to old capital.

To compare the effects of these different tax plans, net investment figures are much more helpful than effective tax rates, as measured for the perfect foresight case. With the phase-in, effective tax rates are actually higher in 1985 (compare Tables 3a and 4), but this simply reflects the fact that investment is higher in 1985 and expected to decline faster under the phase-in. This means larger anticipated capital losses as marginal q declines, necessitating a somewhat higher current marginal product to compensate investors.

Naturally, this beneficial effect depends on the tax change being unanticipated. To the extent that firms in earlier years might have expected such discriminatory treatment of their assets, their investment levels would have been lower than indicated by the simulations.

The simulation results presented so far are based, of course, on highly stylized assumptions about the production technology, the pattern of true economic depreciation, aggregation over firms and assets, methods of financing marginal investments, and other variables. Since this model was designed to capture the effects of historical tax changes on firm valuation and investment incentives, we examined the sensitivity of our results to different specifications of the historical pattern of required returns and marginal products of capital.

Tables 5 and 6a present simulation results for a perfect foresight scenario (with adjustment costs) in which firms' required rate of return corresponds to the risk-adjusted after-tax real rate on 4- to 6-month commercial paper which prevailed in the year of investment. This series on adjusted interest rates was calculated by (19):

$$r_a = 0.06 + (1-\tau)PR - INFL \qquad (19)$$

where r_a is the adjusted rate, PR is the nominal (annualized) return on 4- to 6-month paper, and INFL is the contemporaneous inflation rate (which firms know exactly since the simulations assume perfect foresight). The after-tax risk premium in (19) is 6%, which roughly corresponds to the historical difference between after-tax risk-free interest rates and after-tax profit rates.

While for reasons mentioned earlier it can be misleading to compare two investment series year-for-year, a comparison of Tables 3 and 6a reveals some important trends. The simulation which uses adjusted commercial paper rates shows investment through 1975 which has a similar pattern but is generally higher than investment in the constant interest rate simulation. As interest rates rise in the mid-1970's the capital stock adjusts and investment rates are lower than in the constant-rate simulation. One example of this adjustment is the slackening of investment in structures in 1976, which contrasts with the acceleration of structures investment for that year in the constant-rate simulation.

A more striking difference comes in the switch-over to Bradley-Gephardt in 1985. Table 6a reveals equipment investment to fall dramatically in response to the removal of some of its tax preferences in 1985, a result which is more pronounced than the investment drop in the constant-rate simulation. The difference reflects the post-1970's long-term adjustment of the capital stock to lower levels and the consequences of unfavorable tax changes on top of this adjustment. For structures, investment recovers slightly in 1985, while still reflecting that the stock of structures is too high for a sustained 3% growth rate. This contrasts with the seemingly small effect of Bradley-Gephardt on structures investment in the constant-rate case.

Average q in the first column of Table 5 moves in a fashion similar to average q in Table 3, with the exception that higher investment keeps average q above the constant-rate average q through 1975 by its effect on marginal q. In general, interest rate changes will have three effects on average q (relative to constant-rate calculations): one, through changes in contemporaneous investment and marginal q, another through changes in the nominal discount rate if old capital is locked into depreciation patterns which are accelerated to a different degree (for the remaining basis) than that currently in use, and a third through changes in investment patterns which affect the depreciation pattern composition of old capital.

Since postwar tax reforms have generally increased the acceleration of depreciation allowances each time, one expects that higher interest rates will usually produce lower values of average q through all of these effects. Table 5 reflects the consequences of rising interest rates in the late 1970's and 1980's, as average q falls below one in 1980 and continues to fall steadily until the introduction of Bradley-Gephardt in 1985. The 1985 tax reform has similar effects on the value of old capital in the variable-interest rate case and in the constant-rate case. For equipment, this result is the product of the sharp deceleration of depreciation deductions which just balances the effect of investment disincentives on marginal q. For structures, the 1985 investment incentives raise marginal q slightly, while the depressing effects of higher interest rates on average q are less important than for equipment since a smaller fraction of the structures capital stock was put in place with the accelerated post-1981 depreciation schedules.

Tables 5 and 6b report the results of simulations in which the required rate of return was held constant (at 0.04) but the marginal product of capital varied cyclically around its long-run growth path. These simulations assume that firms have perfect foresight and that adjustment costs are present.

In order to obtain a historical series of marginal products consistent with the production function technology specified earlier, we used data on after-tax corporate rates of return from Feldstein, *et*. *al*. (1983). Assuming capital market equilibrium and constant returns technology, this rate of return will be equal to the marginal gross return to capital, R_g in (14). Note that this methodology implicitly assumes that yearly variation in the return to capital is attributable to shocks to the production function and not to changes in the capital/labor ratio. As before, we assume for the purpose of calculating production function coefficients that net investment is 3% each year. Then, using (9) and (14), the technical and labor-related component of the production function can be computed:

$$(20) \qquad a_t N_t^{(1-\alpha_1-\alpha_2)} = \frac{(C + R_g^t)}{D} K_t^{(1-\alpha_1-\alpha_2)}$$

where the left side of (20) is the value to be calculated, and C is a constant equal to:

$$(21) \qquad C = \tfrac{1}{2}(0.03)^2(\beta_0+\beta_1 s_1+\beta_2 s_2) + \delta_1 s_1 + \delta_2 s_2$$

where s_i is the share of capital of type i in the capital stock ($s_1 + s_2 \equiv 1$).

Since (20) is a relationship which holds for all years, it must hold for 1977, the year from which values are calibrated. Marginal products of capital for all other years were calculated using α_1 and α_2 to solve for $a_t N_t^{(1-\alpha_1-\alpha_2)}$ relative to its value in 1977:[21]

$$(22) \qquad \frac{a_t N_t^{(1-\alpha_1-\alpha_2)}}{a_t N_t^{(1-\alpha_1-\alpha_2)}} = \frac{C + R_g^t}{C + R_g^{77}} \cdot \left[1.03^{(t-77)}\right]^{(1-\alpha_1-\alpha_2)}$$

The investment pattern shown in Table 6b is slightly lower but closely resembles that of Table 3 until the late 1960's. Starting then, investment falls from its levels in the benchmark run, while maintaining analogous year-to-year movements. No doubt these results in Table 6b reflect the declining rate of return to capital, the economic malaise captured here as marginal products which fall from trend values. Equipment investment declines sharply in response to the unexpected tax regime change in 1985, while investment in structures rises slightly. Both of these results are quite similar to those found in Table 3.

Average q in the second column of Table 5 tracks the values of average q in Table 3, with the exception that it falls more quickly starting in the late

1960's. Average q makes a recovery in 1985, though not to as high a level as in the runs reported in Table 3. Naturally, these results are the products of the investment decline brought about by lower marginal products. Lower marginal q's generate lower average q's during the period 1967-1984, and the lower average q's in 1985 (especially for structures) reflect that a smaller fraction of the capital stock in place in that year was depreciated using the most accelerated methods.

Tables 5 and 6c presents results for the simulations in which both interest rates and marginal products were permitted to vary in the manner described above. Not surprisingly, these results resemble a combination of those in Tables 6a, 6b, and the first two columns of Table 5. Investment in both equipment and structures declines starting in the late 1960's, and is somewhat more volatile throughout the period than was the case in earlier runs. High interest rates and declining marginal products deliver a combined hammer blow to investment (especially in structures) at the end of the 1970's, an effect much stronger than in any of the other runs. When Bradley-Gephardt is introduced in 1985, equipment investment again declines dramatically and structures investment stays quite low while recovering somewhat.

Average q's in the third column of Table 6 follow patterns similar to those of the first two columns, with declining q's in the late 1960's following those of column two and leading those of column one by a few years. By the mid-1970's, however, the investment disaster produces low marginal q's which drive average q below the values in other columns and below one in 1977. Average q continues to fall until 1985, when its recovery is on the same order of magnitude as recoveries in other runs.

In comparing results from different foresight and business cycle specifications, it is reasonable to contrast simulated investment and average q to values which prevailed over this period. Table 7 presents net corporate investment, expressed as a fraction of the capital stock, in equipment and structures for the period 1953-1984. These investment rates are not derived from the published BEA net investment series; they are calculated by applying the BEA gross investment data and Hulten-Wykoff depreciation rates to form a perpetual inventory of corporate capital assuming the published 1925 net capital stock to be accurate. The investment series produced by this method are then measured consistently with net investment calculations from the simulation runs.

Table 7 illustrates several sharp features of the postwar investment experience. Equipment investment strongly accelerates in the mid-1960's, presumably in response to the introduction of the investment tax credit and repeal of the Long amendment. Both equipment and structures appear to be affected by business cycle downturns in 1970-1971 and 1975-1976. Structures never recover from the latter shock, with the tax code and high interest rates combining to prevent net investment in every year of the post-1975 period from equalling any of its previous values.

These features of the historical investment pattern seem to be best captured by the perfect foresight simulations with varying interest rates. Investment in the simulation with myopic expectations and no adjustment costs (Table 1c) responds too quickly to tax changes, producing anomalous results such as negative equipment investment in 1966, the historical peak. Even when adjustment costs are added to the myopic run (Table 2c), the model fails to replicate the equipment investment boom in the 1960's and the decline of structures investment in the 1970's. The perfect foresight simulation which ignores business-cycle effects (Table 3c) also fails to capture the magnitude of these swings; in fact, this run shows structures investment to accelerate in 1981. The perfect foresight simulation with variable marginal products but a constant interest rate (Table 6b) produces results similarly at odds with investment data.

Tables 6a and 6c, which report simulations in which firms have perfect foresight and interest rates vary, contain investment series which appear to track actual investment most closely. Equipment investment rises strongly in the mid-1960's, though not as much as in the historical data. In both simulations the late 1970's are very hard on structures investment. The results in Table 6c, which come from a simulation in which both interest rates and marginal products vary, show a very deep drop in structures investment at the end of the 1970's. The magnitude of investment swings in Table 6c makes Table 6a (perfect foresight and variable interest rates only) appear to mirror historical investment most closely. While these comparisons do not constitute a statistical test, they suggest the importance of interest rate movements to any tax-based explanation of investment behavior. It is possible that with a different specification of adjustment costs business-cycle influences on marginal products could provide useful realism as well.

Conclusions

This paper represents a first attempt to characterize investment behavior in a manner that allows one to consider the effects of different tax policy changes on the investment behavior of firms and the value of their shares. Our simulated results indicate how important the presence of adjustment costs are when one wishes to consider how an abrupt change in the economic environment will affect the firm. This is particularly true if tax changes are either announced or anticipated.

There are a number of extensions one would wish to consider before using simulations such as these for more than illustrative purposes. We hope to include in the simulations the effects of changes in personal taxes, given some assumptions about the determination of the firm's financial policy. Perhaps most important and yet most difficult is the task of obtaining better estimates of the production parameters. The adjustment cost terms, about which we have the least empirical evidence, are, unfortunately, possibly the most crucial to our results. We hope to remedy this situation. At the same time, sensitivity analysis of the simulation results would be desirable.

Notes

1. Nor is the frequency of policy changes unique to the U.S. Britain has shown an equal variability of tax provisions (as described in Poterba and Summers 1983 and King and Fullerton 1984), most recently (in 1984) scaling back provisions for the expensing of investment and lowering the corporate tax rate, as most reform proposals being discussed currently in the U.S. would.

2. For ease of notation, we write $A(\cdot)$ as a function of I_t alone rather than all its arguments.

3. The constancy of π is not assumed in our analysis, and is used here only for the sake of simplicity. Some of the later simulations examine the effect of allowing r to vary.

4. Note that net investment is simply the first difference of the capital stock.

5. This and other tax data used is described in Appendix A of Auerbach (1983).

6. We note in passing that if the rate of growth of the capital stock, say g, equals the interest rate, then this latter set of weights corresponds to using investment *flow* weights rather than capital *stock* weights.

7. This would be true only if, among other things, the effective tax rates on all forms of capital were equal, which they were not.

8. This assumption is required if we are to consider the investment decisions separately for structures and equipment.

9. This marginal product definition is required for G to be homogeneous of degree one with respect to its inputs.

10. The internal consistency of this procedure can be verified by noting that, given this solution for α_1 and α_2, $R_g(K_1 + K_2)$ equals $[(\alpha_1 + \alpha_2)F - A(I) - \delta_1K_1 - \delta_2K_2]$ which, by (12) and (13), equals $[Y - R_g(K_3 + K_4) - (1-\alpha_1-\alpha_2)F]$. Thus, the net returns to capital equal value added less the competitive return to labor.

11. In future work, we intend to examine how well simulations with time-varying parameters do in predicting observed movements in the marginal product of capital r_g.

12. Denison (1979, p. 92) finds all factors and productivity changes other than capital growth to contribute exactly 3.00% annually to the growth of U.S. nonresidential business output over the period 1948-1973. While this figure includes noncorporate businesses and would presumably be lower over the

period of the 1970's, it suggests that 3% is the most reasonable choice for the exogenous growth rate of noncapital inputs.

13. These include the presence of returns to other factors in the firm's market value, heterogeneity of the capital stock and the standard use of a tax adjustment based on myopia of expectations about future changes in the tax law. Some evidence in support of this comes from the finding by Abel and Blanchard that the coefficient of investment on adjusted q rises substantially (to between .084 and .121 for quarterly data) when the variable is purged of that part of its variation estimated to have come from fluctuations in the cost of capital (as opposed to profitability).

14. This is also trivially true of the real, required after-tax return, which in the first four simulations is set equal to a constant rate of 4%. This simplification is relaxed in the later simulations.

15. When expectations are nonmyopic, q' is defined consistently, with future changes in τ taken into account.

16. To see this, note that, except for q', the cost of capital in (7) depends on parameters exogenous to the firm.

17. See Auerbach (1984) for a further discussion of the plan. It is quite similar in character to the one introduced by the U.S. Treasury in November, 1984.

18. The main differences with calculations reported in Auerbach (1983) are the alternative method of aggregation and the use of the current value, rather than an ARIMA forecast, of the inflation rate. These variations do not have an important impact on the results.

19. The much stronger effect of changes in the inflation rate on the tax rate for equipment is due to its having a shorter lifetime than structures. See Auerbach (1979) for further discussion.

20. These results are quite similar to those presented in Auerbach (1983).

21. For example, the reduced problem of tax losses that would result from the removal of front-loading of depreciation allowances that causes a temporal mismatch between taxable cash flows and tax deductions.

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Table 1a
Effective Tax Rates: Myopic

Year	Equipment	Structures
1953	0.61	0.51
1954	0.54	0.46
1955	0.57	0.49
1956	0.60	0.51
1957	0.60	0.51
1958	0.56	0.47
1959	0.58	0.49
1960	0.56	0.47
1961	0.53	0.45
1962	0.37	0.43
1963	0.36	0.42
1964	0.26	0.41
1965	0.27	0.40
1966	0.29	0.41
1967	0.47	0.43
1968	0.36	0.47
1969	0.44	0.49
1970	0.56	0.50
1971	0.53	0.47
1972	0.08	0.43
1973	0.17	0.45
1974	0.30	0.48
1975	0.31	0.48
1976	0.13	0.41
1977	0.16	0.42
1978	0.23	0.44
1979	0.27	0.44
1980	0.26	0.43
1981	0.02	0.35
1982	-0.19	0.30
1983	-0.14	0.26
1984	-0.14	0.29
1985	0.27	0.28
1986	0.27	0.28
1987	0.27	0.28
1988	0.27	0.28
1989	0.27	0.28
1990	0.27	0.28

Table 1b
Average q: Myopic (No Adjustment Costs)

Year	Equipment	Structures	Total
1953	1.18	1.00	1.05
1954	1.15	0.95	1.01
1955	1.14	0.96	1.02
1956	1.14	0.97	1.02
1957	1.14	0.97	1.02
1958	1.13	0.96	1.01
1959	1.12	0.97	1.01
1960	1.11	0.96	1.00
1961	1.10	0.96	1.00
1962	1.00	0.92	0.94
1963	0.99	0.92	0.94
1964	0.96	0.92	0.93
1965	0.99	0.92	0.93
1966	0.94	0.92	0.93
1967	0.98	0.92	0.95
1968	0.91	0.91	0.91
1969	0.91	0.91	0.91
1970	0.96	0.94	0.94
1971	0.95	0.93	0.94
1972	0.84	0.91	0.88
1973	0.86	0.92	0.90
1974	0.85	0.92	0.90
1975	0.83	0.92	0.89
1976	0.81	0.88	0.85
1977	0.82	0.89	0.86
1978	0.81	0.89	0.86
1979	0.81	0.89	0.86
1980	0.81	0.89	0.87
1981	0.76	0.82	0.81
1982	0.77	0.83	0.81
1983	0.77	0.83	0.81
1984	0.76	0.85	0.82
1985	0.91	0.96	0.95
1986	0.87	0.95	0.94
1987	0.86	0.96	0.93
1988	0.85	0.95	0.92
1989	0.86	0.95	0.92
1990	0.87	0.95	0.92

Table 1c
Investment: Myopic (No Adjustment Costs)

Year	Equipment	Structures	Total
1953	0.030	0.030	0.030
1954	0.130	0.145	0.141
1955	-0.011	-0.014	-0.013
1956	-0.011	-0.012	-0.011
1957	0.022	0.023	0.023
1958	0.101	0.104	0.103
1959	0.002	0.000	0.001
1960	0.062	0.065	0.064
1961	0.065	0.069	0.067
1962	0.178	0.095	0.122
1963	0.043	0.046	0.045
1964	0.111	0.082	0.092
1965	0.023	0.033	0.030
1966	-0.004	-0.006	-0.006
1967	-0.088	-0.011	-0.037
1968	0.062	-0.050	-0.014
1969	0.007	0.007	0.007
1970	-0.058	0.024	-0.005
1971	0.056	0.063	0.061
1972	0.338	0.160	0.218
1973	-0.011	-0.011	-0.011
1974	-0.035	-0.030	-0.032
1975	0.021	0.022	0.022
1976	0.143	0.173	0.162
1977	0.015	0.014	0.014
1978	-0.006	-0.005	-0.005
1979	0.028	0.043	0.038
1980	0.018	0.019	0.019
1981	0.158	0.181	0.173
1982	0.010	0.110	0.106
1983	0.014	0.049	0.037
1984	0.024	-0.002	0.006
1985	-0.097	0.022	-0.018
1986	0.030	0.030	0.030
1987	0.030	0.030	0.030
1988	0.030	0.030	0.030
1989	0.030	0.030	0.030
1990	0.030	0.030	0.030

Table 2b
Average q: Myopic (With Adjustment Costs)

Year	Equipment	Structures	Total
1953	1.35	1.17	1.23
1954	1.36	1.17	1.23
1955	1.34	1.16	1.21
1956	1.32	1.14	1.19
1957	1.31	1.14	1.19
1958	1.33	1.16	1.21
1959	1.31	1.15	1.20
1960	1.31	1.16	1.20
1961	1.31	1.17	1.21
1962	1.26	1.14	1.18
1963	1.25	1.15	1.18
1964	1.25	1.17	1.20
1965	1.24	1.18	1.20
1966	1.21	1.17	1.18
1967	1.20	1.17	1.17
1968	1.13	1.08	1.09
1969	1.11	1.07	1.08
1970	1.13	1.12	1.12
1971	1.14	1.14	1.14
1972	1.13	1.14	1.14
1973	1.11	1.13	1.12
1974	1.08	1.11	1.10
1975	1.06	1.11	1.09
1976	1.07	1.13	1.11
1977	1.06	1.12	1.10
1978	1.04	1.11	1.08
1979	1.05	1.13	1.10
1980	1.04	1.12	1.09
1981	1.03	1.11	1.08
1982	1.04	1.12	1.09
1983	1.03	1.13	1.10
1984	1.02	1.12	1.09
1985	1.18	1.33	1.28
1986	1.17	1.31	1.27
1987	1.16	1.30	1.26
1988	1.15	1.29	1.25
1989	1.15	1.28	1.24
1990	1.16	1.27	1.24

Table 2c
Investment: Myopic (With Adjustment Costs)

Year	Equipment	Structures	Total
1953	0.030	0.030	0.030
1954	0.035	0.039	0.038
1955	0.033	0.034	0.034
1956	0.030	0.031	0.030
1957	0.030	0.030	0.030
1958	0.034	0.036	0.035
1959	0.032	0.033	0.033
1960	0.034	0.035	0.035
1961	0.035	0.038	0.037
1962	0.048	0.039	0.042
1963	0.047	0.040	0.042
1964	0.051	0.042	0.045
1965	0.048	0.042	0.044
1966	0.045	0.038	0.040
1967	0.031	0.038	0.036
1968	0.042	0.026	0.031
1969	0.039	0.025	0.030
1970	0.026	0.029	0.028
1971	0.027	0.032	0.030
1972	0.051	0.035	0.041
1973	0.047	0.032	0.037
1974	0.042	0.028	0.033
1975	0.040	0.028	0.033
1976	0.041	0.040	0.040
1977	0.040	0.038	0.039
1978	0.038	0.035	0.036
1979	0.036	0.036	0.036
1980	0.035	0.035	0.035
1981	0.039	0.045	0.043
1982	0.041	0.049	0.046
1983	0.039	0.051	0.046
1984	0.040	0.046	0.044
1985	0.026	0.048	0.040
1986	0.028	0.045	0.039
1987	0.029	0.044	0.039
1988	0.030	0.042	0.038
1989	0.031	0.040	0.037
1990	0.032	0.039	0.037

Table 3a
Effective Tax Rates: Perfect Foresight

Year	Equipment	Structures
1953	0.61	0.54
1954	0.59	0.52
1955	0.59	0.52
1956	0.59	0.52
1957	0.58	0.51
1958	0.58	0.51
1959	0.57	0.50
1960	0.57	0.50
1961	0.65	0.53
1962	0.49	0.48
1963	0.49	0.48
1964	0.41	0.47
1965	0.42	0.47
1966	0.29	0.46
1967	0.60	0.50
1968	0.46	0.48
1969	0.29	0.45
1970	0.47	0.47
1971	0.60	0.49
1972	0.33	0.47
1973	0.35	0.47
1974	0.33	0.47
1975	0.28	0.48
1976	0.26	0.45
1977	0.26	0.45
1978	0.23	0.45
1979	0.23	0.44
1980	0.30	0.49
1981	0.03	0.39
1982	-0.14	0.37
1983	0.03	0.35
1984	0.02	0.37
1985	0.21	0.36
1986	0.22	0.36
1987	0.23	0.35
1988	0.24	0.34
1989	0.25	0.34
1990	0.25	0.33

Table 3b
Average q: Perfect Foresight

Year	Equipment	Structures	Total
1953	1.33	1.18	1.23
1954	1.37	1.20	1.25
1955	1.37	1.20	1.25
1956	1.37	1.20	1.25
1957	1.37	1.20	1.25
1958	1.36	1.20	1.25
1959	1.35	1.20	1.24
1960	1.33	1.19	1.24
1961	1.32	1.19	1.23
1962	1.29	1.18	1.22
1963	1.27	1.18	1.21
1964	1.24	1.17	1.19
1965	1.21	1.16	1.18
1966	1.19	1.16	1.17
1967	1.18	1.15	1.16
1968	1.18	1.15	1.16
1969	1.17	1.15	1.15
1970	1.16	1.15	1.15
1971	1.16	1.14	1.15
1972	1.13	1.14	1.14
1973	1.12	1.13	1.13
1974	1.11	1.13	1.13
1975	1.11	1.14	1.13
1976	1.09	1.13	1.12
1977	1.08	1.13	1.11
1978	1.07	1.12	1.11
1979	1.06	1.12	1.10
1980	1.06	1.12	1.10
1981	1.05	1.12	1.09
1982	1.04	1.12	1.09
1983	1.04	1.11	1.09
1984	1.02	1.11	1.08
1985	1.14	1.29	1.24
1986	1.13	1.28	1.23
1987	1.12	1.27	1.22
1988	1.12	1.26	1.22
1989	1.12	1.26	1.21
1990	1.13	1.25	1.21

Table 3c
Investment: Perfect Foresight

Year	Equipment	Structures	Total
1953	0.030	0.030	0.030
1954	0.039	0.042	0.041
1955	0.038	0.041	0.040
1956	0.039	0.041	0.040
1957	0.039	0.041	0.040
1958	0.039	0.040	0.040
1959	0.039	0.040	0.039
1960	0.039	0.039	0.039
1961	0.038	0.038	0.038
1962	0.055	0.043	0.047
1963	0.051	0.042	0.045
1964	0.050	0.039	0.043
1965	0.044	0.037	0.039
1966	0.042	0.036	0.038
1967	0.028	0.035	0.033
1968	0.046	0.039	0.041
1969	0.045	0.039	0.041
1970	0.029	0.033	0.032
1971	0.030	0.031	0.031
1972	0.052	0.032	0.039
1973	0.049	0.032	0.038
1974	0.048	0.032	0.038
1975	0.048	0.033	0.038
1976	0.043	0.038	0.040
1977	0.043	0.038	0.040
1978	0.042	0.038	0.039
1979	0.040	0.036	0.038
1980	0.041	0.037	0.038
1981	0.044	0.049	0.047
1982	0.043	0.049	0.047
1983	0.038	0.047	0.044
1984	0.039	0.043	0.041
1985	0.022	0.043	0.036
1986	0.023	0.042	0.035
1987	0.024	0.041	0.035
1988	0.025	0.040	0.035
1989	0.026	0.039	0.035
1990	0.027	0.038	0.034

Table 4
Gradual Tax Reform: 1985
(Perfect Foresight)

Year	Equipment	Structures	Total
	Effective Tax Rates		
1984	0.02	0.37	
1985	0.24	0.40	
1986	0.22	0.37	
1987	0.21	0.35	
1988	0.20	0.33	
1989	0.23	0.33	
1990	0.24	0.32	
	Average q		
1984	1.02	1.11	1.08
1985	1.15	1.28	1.24
1986	1.13	1.27	1.22
1987	1.12	1.26	1.22
1988	1.11	1.25	1.21
1989	1.11	1.25	1.20
1990	1.12	1.24	1.20
	Investment		
1984	0.039	0.043	0.041
1985	0.033	0.053	0.046
1986	0.030	0.048	0.042
1987	0.028	0.044	0.038
1988	0.026	0.041	0.035
1989	0.024	0.038	0.033
1990	0.025	0.037	0.033

Table 5
Total Average q: Interest Rate and Marginal Product Variants
(Perfect Foresight)

Year	Interest Rate Varies	Marginal Product Varies	Interest rate and Marg. Product Vary
1953			
1954	1.29	1.24	1.28
1955	1.29	1.24	1.28
1956	1.28	1.23	1.26
1957	1.27	1.23	1.25
1958	1.25	1.23	1.24
1959	1.25	1.23	1.25
1960	1.25	1.23	1.25
1961	1.25	1.23	1.25
1962	1.25	1.22	1.26
1963	1.25	1.21	1.25
1964	1.24	1.19	1.24
1965	1.24	1.16	1.23
1966	1.24	1.14	1.21
1967	1.24	1.12	1.19
1968	1.24	1.11	1.18
1969	1.23	1.09	1.16
1970	1.23	1.08	1.15
1971	1.22	1.08	1.14
1972	1.19	1.07	1.12
1973	1.18	1.06	1.10
1974	1.17	1.06	1.09
1975	1.14	1.06	1.07
1976	1.09	1.06	1.02
1977	1.06	1.05	1.00
1978	1.04	1.05	0.97
1979	1.01	1.04	0.94
1980	0.99	1.04	0.92
1981	0.96	1.04	0.90
1982	0.94	1.05	0.89
1983	0.94	1.05	0.90
1984	0.94	1.05	0.90
1985	1.10	1.21	1.05
1986	1.10	1.20	1.06
1987	1.10	1.20	1.06
1988	1.11	1.19	1.07
1989	1.11	1.19	1.07
1990	1.12	1.19	1.08

Table 6a
Investment: Variable Interest Rates
(Perfect foresight)

Year	Equipment	Structures	Total
1953	0.030	0.030	0.030
1954	0.044	0.048	0.047
1955	0.043	0.048	0.046
1956	0.042	0.046	0.045
1957	0.041	0.043	0.042
1958	0.039	0.041	0.040
1959	0.039	0.040	0.040
1960	0.040	0.040	0.040
1961	0.041	0.041	0.041
1962	0.059	0.048	0.052
1963	0.056	0.048	0.051
1964	0.057	0.047	0.050
1965	0.052	0.046	0.048
1966	0.051	0.047	0.049
1967	0.038	0.048	0.044
1968	0.058	0.053	0.055
1969	0.055	0.052	0.053
1970	0.039	0.044	0.042
1971	0.038	0.042	0.040
1972	0.058	0.040	0.047
1973	0.055	0.039	0.045
1974	0.052	0.039	0.044
1975	0.047	0.035	0.039
1976	0.038	0.030	0.033
1977	0.034	0.027	0.030
1978	0.031	0.023	0.026
1979	0.026	0.018	0.021
1980	0.024	0.014	0.018
1981	0.025	0.023	0.024
1982	0.023	0.020	0.021
1983	0.019	0.019	0.019
1984	0.020	0.015	0.017
1985	0.008	0.022	0.016
1986	0.010	0.022	0.017
1987	0.013	0.022	0.018
1988	0.014	0.022	0.019
1989	0.016	0.022	0.020
1990	0.018	0.023	0.021

Table 6b
Investment: Variable Marginal Products
(Perfect Foresight)

Year	Equipment	Structures	Total
1953	0.030	0.030	0.030
1954	0.037	0.040	0.039
1955	0.038	0.039	0.039
1956	0.036	0.038	0.037
1957	0.036	0.038	0.037
1958	0.037	0.037	0.037
1959	0.040	0.037	0.038
1960	0.040	0.037	0.038
1961	0.041	0.036	0.037
1962	0.058	0.041	0.047
1963	0.054	0.040	0.045
1964	0.051	0.036	0.041
1965	0.043	0.033	0.036
1966	0.037	0.031	0.033
1967	0.019	0.028	0.025
1968	0.034	0.030	0.031
1969	0.030	0.029	0.029
1970	0.014	0.023	0.020
1971	0.016	0.022	0.020
1972	0.038	0.022	0.028
1973	0.035	0.021	0.026
1974	0.033	0.022	0.026
1975	0.035	0.023	0.027
1976	0.032	0.028	0.030
1977	0.031	0.028	0.029
1978	0.029	0.028	0.028
1979	0.027	0.027	0.027
1980	0.029	0.027	0.028
1981	0.034	0.039	0.037
1982	0.034	0.039	0.038
1983	0.032	0.039	0.036
1984	0.033	0.036	0.035
1985	0.016	0.038	0.030
1986	0.018	0.037	0.030
1987	0.020	0.036	0.030
1988	0.021	0.035	0.030
1989	0.023	0.035	0.030
1990	0.024	0.034	0.031

Table 6c
Investment: Variable Interest Rates and Marginal Products
(Perfect Foresight)

Year	Equipment	Structures	Total
1953	0.030	0.030	0.030
1954	0.043	0.046	0.045
1955	0.043	0.046	0.045
1956	0.039	0.043	0.042
1957	0.037	0.041	0.040
1958	0.037	0.038	0.038
1959	0.040	0.039	0.040
1960	0.041	0.039	0.039
1961	0.043	0.040	0.041
1962	0.063	0.047	0.053
1963	0.060	0.047	0.052
1964	0.058	0.045	0.050
1965	0.051	0.043	0.046
1966	0.046	0.042	0.043
1967	0.029	0.040	0.036
1968	0.045	0.044	0.044
1969	0.040	0.041	0.041
1970	0.023	0.033	0.030
1971	0.024	0.032	0.029
1972	0.044	0.030	0.035
1973	0.040	0.028	0.033
1974	0.037	0.027	0.031
1975	0.034	0.025	0.028
1976	0.027	0.021	0.023
1977	0.023	0.017	0.020
1978	0.019	0.013	0.015
1979	0.014	0.008	0.010
1980	0.012	0.005	0.008
1981	0.016	0.015	0.015
1982	0.014	0.012	0.013
1983	0.012	0.012	0.012
1984	0.015	0.009	0.011
1985	0.003	0.016	0.011
1986	0.005	0.016	0.012
1987	0.008	0.017	0.013
1988	0.010	0.017	0.015
1989	0.012	0.018	0.016
1990	0.014	0.018	0.017

Table 7
U.S. Corporate Investment, 1953-1984

Year	Equipment	Structures	Total
1953	0.051	0.037	0.042
1954	0.036	0.035	0.035
1955	0.047	0.041	0.043
1956	0.050	0.043	0.045
1957	0.049	0.039	0.043
1958	0.005	0.031	0.021
1959	0.023	0.028	0.026
1960	0.030	0.032	0.031
1961	0.020	0.032	0.028
1962	0.035	0.033	0.034
1963	0.041	0.031	0.034
1964	0.060	0.034	0.043
1965	0.081	0.044	0.057
1966	0.096	0.045	0.064
1967	0.070	0.041	0.052
1968	0.070	0.041	0.052
1969	0.073	0.041	0.054
1970	0.052	0.036	0.042
1971	0.036	0.030	0.032
1972	0.053	0.031	0.040
1973	0.076	0.034	0.051
1974	0.066	0.030	0.045
1975	0.028	0.021	0.024
1976	0.034	0.020	0.026
1977	0.054	0.018	0.034
1978	0.062	0.022	0.040
1979	0.062	0.027	0.043
1980	0.054	0.024	0.038
1981	0.052	0.023	0.036
1982	0.029	0.021	0.024
1983	0.036	0.014	0.024
1984	0.067	0.027	0.046