THE EFFECTS OF TAX PARAMETERS ON THE INVESTMENT EQUATIONS IN MACROECONOMIC ECONOMETRIC MODELS

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1. Introduction

Large scale econometric models have been used to predict effects on investment of changes in tax parameters such as depreciation charges, investment tax credits and business income tax rates. While ultimate results depend upon full model specifications, involving the influence of tax changes on aggregate demand, prices and interest rates, critical points of departure are the investment equations themselves. We offer here a study of the specifications, estimated parameters and substantive implications of the existing investment equations and possible alternatives in six models of the U.S. economy: BEA, Chase, DRI, Michigan, MPS, and Wharton. An analysis of full model simulations will appear in a subsequent paper.

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*/ Graduate Research Associate and William R. Kenan Professor of Economics, respectively, at Northwestern University. An almost identical, earlier version of this paper was presented to the Fourth World Congress of the Econometric Society in Aix-en-Provence, France, August 28, 1980. It embodies much of the "Phase I" and "Phase II" reports of Chirinko and Eisner (1980) for the U.S. Department of Treasury. It has been made possible by the collaboration and assistance of responsible officers and staff associated with the models under consideration -- BEA, Chase, DRI, Michigan, MPS and Wharton -- and personnel of the Office of Tax Analysis of the Treasury. The authors are particularly grateful to Allen Sinai for his careful reading of the manuscript. They alone, however, are of course solely responsible for its contents. Fuller documentation and details are to be found in the Phase I and Phase II reports to the Treasury. The analysis of full model simulations is to be found in the Phase III report, dated August 21, 1980, "The Effects of Tax Policies on Investment in Macroeconometric Models: Full Model Simulations," or OTA Paper 46.

2. A General View of Investment Functions

Investment equations in the models under consideration have a substantial family resemblance. With varying degrees of aggregation and parametric specifications, they generally view investment as a distributed lag response or adjustment of capital to desired or equilibrium levels. These in turn relate to expected demand on output, taken explicitly or implicitly as a function of capital and labor inputs, and the relative prices of output and capital or of capital and labor.

The "rental" price or user cost of capital is in principle the rate of economic depreciation, the opportunity cost in terms of foregone net earnings, and the capital loss (or minus the capital gain) associated with changing prices. These costs are defined as pure decimals which are then applied to the price of capital goods. A general formulation, which the various model equations only more or less approximate, 1/ would be:

$$(1) \quad c = \frac{q\left[(1-uv)\rho - (1-u\omega)\frac{\dot{q}}{q} + \delta\right]\left[1-k-uz\right]}{1-u}$$

where

c = the rental price of capital

q = the supply price of capital goods

u = the rate of business income taxation

v = the proportion of the opportunity cost of capital (such as interest, dividends and foregone earnings) which is tax deductible

ρ = the opportunity cost of capital, presumably an appropriately weighted average of nominal interest rates and rates of return on equity expected by firms

ω = the proportion of capital gains and losses effectively taxed

$\frac{\dot{q}}{q}$ = the expected rate of change of prices of capital goods

δ = the rate of economic depreciation

k = the effective rate of the investment tax credit and

z = the original present value of the tax depreciation expected from a dollar of investment.

1/ Cf. Jorgenson (1963) and Hall and Jorgenson (1967).

The investment equations in most of the models include a term such as c but with a number of potentially significant variations, which we will note. For one thing, allowance is made in different ways, if at all, for v, the proportion of the opportunity cost of capital which is tax deductible. Second, not all of the models allow for expected capital gains or price inflation and none recognizes the peculiar tax treatment of capital gains. Third, the rate of economic depreciation is in some instances variable but more usually held constant, at values which differ somewhat from model to model. Fourth, the investment tax credit in equipment equations is variously taken at its nominal rate and the lesser effective rate which reflects, of course, limitations on its availability in all or in part. Fifth, the determination of z, the original present value of the tax depreciation from a dollar of investment, is variously defined. It should depend upon the rate of discount, the length of life of capital for tax purposes, and the method of depreciation (straight-line, declining balance at 200 percent or 150 percent of straight-line rates, and sum-of-years-digits, as well indeed as special provisions for first year allowances). In practice, length of life is sometimes taken to vary by discrete jumps suggested by shifts to guidelines and later to ADR (Asset Depreciation Range) without attention to actual changes in lives over the years. Shifts in methods of depreciation are not always accounted for. Rates of discount as well as the extent of their variation differ among models. In one case (Michigan) z does not enter explicitly at all; rather a tax depreciation rate is used.

In the great bulk of the investment equations, there is no separate estimate of the roles of the rate of business taxation, the investment tax credit, or tax depreciation (however measured). Rather, parameters are estimated for a variable like c, the rental price of capital, or more generally, a variable in which c is a component.

Considerations of cost minimization and profit maximization with output exogenous suggest that desired capital stock will be a function of relative prices and output. (This formulation would not apply to a firm operating under perfect competition with no perceived limit to effective demand for product. For then relative prices would be exogenous but output would be endogenous.) We may thus write

$$(2)\quad K^* = f(P,c,Y),$$

where P = the price of output
c = the rental price or user cost of capital
Y = output.

Alternatively, we may substitute w, a measure of the cost of labor, for P. The assumption of a Cobb-Douglas production function, among other things, was offered by Jorgenson as the justification for a particular description of the desired stock of capital as

$$(3) \quad K^* = \beta^{(\frac{P}{c})} Y.$$

The assumption of the more general CES production function, with the constraints neither of unitary elasticity of substitution nor constant returns to scale, would then fit the more general description of the desired stock of capital:

$$(4) \quad K^* = \beta^{(\frac{P}{c})^{\sigma}} Y^r$$

where σ is the elasticity of demand for capital with respect to the relative price of output and r is the elasticity of demand for capital with respect to output. (This last elasticity will be more than, equal to or less than unity as the returns to scale are decreasing, constant, or increasing.)

The desired capital stock does not of course in itself tell us anything about investment, which is the rate of replacement of existing capital stock plus the rate of net additions. The rate of replacement may well be a variable depending upon financial considerations and a general set of expectations. The rate of net additions to capital will in principle depend upon costs of adjustment, which will in turn relate to costs of acquiring information necessary to decisions, costs of planning and again financial considerations.

All this leads us to a formulation of investment as a distributed lag function of past changes in desired capital stock plus replacement of some of the existing capital. Here, however, two underlying theoretical points should be noted. First, the speed of adjustment of capital to changes in its desired or equilibrium value may not be independent of the causes and the magnitudes of the changes. If, for example, an increase in the demand for output generates an increase in the demand for capital, investment may be expected to be undertaken with all due speed as expectations become sufficiently firm with regard to the permanence of the increased demand. If the increased demand for capital is due, however, to a fall in its relative price due to let us say a reduction in the rate of interest, thus generating a demand for more durable and hence more substantial and expensive capital, the rate of investment will be slowed by the availability of existing capacity sufficient for current production. These considerations underlie the "putty-clay" model. A demand for additional housing services will bring on investment in housing as rapidly as cost considerations permit. A lower rate of interest, causing substantial investment in more durable brick houses to replace less durable houses of wood or straw, would cause the rate of investment to increase only as existing houses of wood and straw wear out and are replaced.

This suggests that investment equations should in principle involve separate distributed lag responses to changes in relative prices and to changes in output and should also admit the possibility that the lags are not fixed and may further vary with other economic parameters. We note that our more general expression for the desired stock of capital, (4), may be written in a logarithmic transformation as

$$(5)\quad \ln K^* = \ln \beta + \sigma \ln \frac{P}{c} + r \ln Y.$$

The ratio of net investment to existing capital stock is then approximately equal to the change in the logarithm of capital which may in turn be written as distributed lag functions of changes in the determinants of desired capital as in

$$(6)\quad \frac{I_N}{K_{-1}} \simeq \Delta \ln K = \sigma[\gamma 1(L)\Delta \ln \frac{P}{c}] + r[\gamma_2(L)\Delta \ln Y]$$

where $\gamma_1(L)$ and $\gamma_2(L)$ are lag operators which indeed should be functions of such variables as the rate of interest and the cost of capital.

Finally, since investment equals net investment plus replacement, we may write

$$(7)\quad I = I_N + R = I_N + \delta K_{-1},$$

where δ may vary over time.

The investment equations in the models under consideration most often ignore the possibility that the lag distributions may vary over time and change, in particular, as a consequence of changes in other variables. They also ignore in varying degrees the putty-clay hypothesis, either assuming a putty-putty model whereby changes in relative prices can result in a speedy replacement of all of the existing capital stock or assuming that the speed of response of investment to changes in relative prices and output is the same.

3. Tax Parameters and Plan of Analysis

To the extent that there is no differentiation of lag responses and to the extent that tax parameters do not enter independently we can anticipate, in general, certain peculiar results in investment equations. First, the response to changes in the rate of business taxation, u, or the rate of the investment tax credit, k, or changes in the parameters determining z, the value of tax depreciation, will depend upon the estimated parameters of c, the entire rental price or user cost of capital, of P/c or w/c, the relative prices of output or labor and capital, or of the product of P/c and Y. Further, the response to tax parameters will depend in a number of the models on assumed values of σ , the elasticity of substitution, or of the demand for capital with respect to the relative prices of output and capital.

Indeed, what the investment equations of the various models have to say about the effects of tax incentives for investment, and what the models have in fact reported for these effects, stem very largely from the way the rental price of capital enters the investment equations. To the extent that a high value of σ is assumed or estimated, changes in tax parameters will appear to have large effects. To the extent that estimated lag functions appear shorter or faster because the estimated speed of response to changes in c, or P/c, or P/c and Y combined are faster, the effects of changes in tax parameters will appear to be more speedy. Conversely, of course, if the speed of reaction to the lagged variables is estimated as less, the implied or reported speed of reaction to changes in tax parameters will be less.

With all of these caveats and before we proceed to reporting upon our analysis and estimations of specific models, we may note finally what may be expected from changes in the tax parameters designated in equation (1). First, if estimated parameters indicate that the partial derivative of investment with respect to c, the rental price of capital, has its expected negative sign, an increase in the investment tax credit will have to increase investment since the derivative of c with respect to k, the effective rate of the investment tax credit, is obviously negative. How much investment will be increased will depend upon the specification or estimate of σ . How fast it will increase will depend upon the distributed lag function relating to c.

Second, acceleration or other methods of increasing tax depreciation which raise the value of z will have to increase investment and, again, at speeds determined by the distributed lag function on c.

Third, effects of changes in the rate of direct taxation, u, are complicated and ambiguous. Results are affected by assumptions as to what happens to rates of return before and after taxes. Further, the higher the values of k and z and the higher the rate of expected capital gains, the less will decreases in u tend to decrease the value of c. With current high rates of inflation it is indeed possible, on a priori grounds, that decreases in u, the general marginal rate of business taxation, may raise c, the rental price of capital, and thus at least in this regard, tend to reduce investment. 1/

Our general strategy in analyzing the investment equations of the various models is as follows:

A. We shall point out how the tax parameters enter in each set of equations.

B. We shall note the direct effects of tax parameters on business investment indicated by the investment equations as currently specified and estimated. This will be accomplished, as far as feasible, by setting for the entire period, alternatively, the investment tax credit, the lives underlying tax depreciation, 2/ and the rate of business taxation at the values assumed in the last quarter of 1953. We shall then note the differences in the predicted values for investment brought on by these changes. This, of course is only a very partial exercise. It assumes that other economic variables within the investment equations and feedback from the rest of the system are unaffected.

C. We shall then relax assumptions, altering specifications where appropriate, to better ascertain what the underlying economic data can tell us about the effects of

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1/ Effects of other tax parameters, not considered in this paper, are also determined by the parameters and lag functions for c. Thus, a higher value of v, which could be obtained by making dividends tax deductible to business would lower the value of c and, if the partial derivative of investment with respect to c has the expected negative sign, will raise investment. The effect of changes in the rate of taxation of capital gains, or its rate of inclusion in taxable business income, ω , is somewhat tricky. Where capital gains are positive, lowering the rate of inclusion in taxable income will lower the cost of capital and hence presumably increase investment. Where capital gains are negative, that is, where there are capital losses, however, if such losses can be deducted from taxable income, lowering the proportion of losses which can be deducted will raise the cost of capital and hence lower investment.

2/ Furthermore, tax depreciation is calculated using the straight-line method.

tax parameters on investment without possible biases imposed by *a priori* hypotheses. This will generally involve several sorts of respecification and reestimation. First, where the elasticities of the response of desired capital or investment to changes in the cost of capital have been preset or constrained, we shall reestimate them freely. Second, where response of desired capital or investment to changes in the rental price of capital has been tied in part or in whole to a measure of the cost of capital based upon earnings-price ratios, or dividend-price ratios, we shall reestimate with a cost of capital based on the rate of interest. A low earnings-price ratio on equity may be associated with higher investment not because it reflects a lower cost of capital but rather because it reflects, in stock prices, high expected future earnings. The equity cost of capital to the firm is, after all, the ratio of expected future earnings to current stock prices.

D. We shall estimate the effects on investment of changes in tax parameters as shown by our reestimated equations.

4. Tax Parameters in the Structures of the Investment Equations

In an effort to facilitate grasping the essential ingredients of the investment equations we have, with some violence to rigor and detail, set forth equations of each of the models in fairly similar notations in Tables 1 through 6. Examination of these may be supplemented by consultation with the glossary of text variables presented in the Appendix. [1]

BEA

Turning first to the BEA model, we note that the tax parameters enter directly only in the definition of c, the rental price or user cost of capital, which in turn enters into the equilibrium or desired capital-output ratio, $(P/c)^{\sigma}$. The value of σ is estimated at .74 in the equipment equation but only .36 in the structures equation. The effects for equipment of changes in tax parameters can then be seen *a priori* as moderate, at least as against a possible assumed value of $\sigma = 1$. The effects of tax parameters on structures will be small.

The estimated values of σ reflect, among other things, the definition of ρ, the opportunity cost of capital. It attempts to adjust for expectations of inflation by an

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[1] Detailed documentation of the six investment sectors is available in Chirinko and Eisner (1980), Phase I, Appendix A.

adaptive function of current and past price changes and also includes as a component a dividend-price ratio. This last, in particular, may bias upward the estimates of σ. Sluggish movement in dividends in response to changes in expected earnings will contribute to a bias in the same direction but significantly larger than that noted above with regard to earnings-price ratios.

The role of the investment tax credit is somewhat muted by recognition of the fact that its effective rate was less than the nominal, statutory rate. The investment tax credit is scaled down by application of a constant factor of proportionality equal to .737379.

The role of tax depreciation is also somewhat muted in the BEA model by calculating z, the present value of the tax depreciation from a dollar of investent, on the basis of its straight-line formulation.

Chase

The Chase model is distinguished by an equation for new orders which feeds into the equipment equation. The new orders equation permits independent estimation of the tax parameters, u, k and z, with which we are concerned. In both the equipment and structures equations, the tax parameters enter again in c, the rental price of capital. In both equations the opportunity cost of capital, ρ, is based upon averages of interest rates and earnings-price ratios with the latter more heavily weighted in the equipment equation. Estimates of the elasticity of response with respect to the rental price of capital are not constrained, however, and are not assumed constant.

Economic depreciation is taken as a constant, at a rate of .181 for equipment and .095 for structures. In BEA it was apparently .38 for equipment and .16 for structures. The present value of tax depreciation is a function of the kind of depreciation -- straight-line, sum-of-years digits or double-declining balance -- with the length of life varying. The equipment tax credit, k, enters at its nominal statutory rate.

The Standard and Poor's index of 500 stocks enters independently in the structures equation. Thus, it possibly dilutes the effect of the earnings-price ratio.

DRI

The DRI model enters the expression PY/c as a single set of lagged terms in both the equipment and structures equations. Thus elasticities of response are constrained to be identical for prices of output, 1/ rates of output and the rental cost of capital variable. If accelerator and replacement effects dominate and the long-run elasticities of demand for capital with respect to output are unity, this will have the effect of biasing to unity the estimated elasticities of demand for capital with respect to its rental price.

A second major, strategic element in the DRI model is the debt service variable, DS, which is the ratio of interest obligations to gross cash flow, where the latter equals depreciation plus profits after taxes plus inventory valuation adjustment minus dividends. One may expect negative coefficients to the debt service variable not merely (if at all) because of liquidity constraints but also because investment will tend to be high in cyclical booms when profits are high. Variation in gross cash flow will be dominated by variations in profits after taxes, quite aside from variations in tax parameters. The DRI model will, however, imply that changes in tax parameters will have the same association with investment as the perhaps spurious association of profits and investment. If no feedback is allowed in terms of lower prices or pass-through of changes in taxes affecting profits before tax, the effects of changes in tax parameters will be particularly exaggerated.

The opportunity cost of capital, ρ , is an average of interest and equity costs, weighted by the proportions of each in business financing. The equity costs consist of a dividend-price ratio plus an estimate of the expected rate of growth of earnings per share.

The rate of economic depreciation is taken from BEA series on depreciation and capital stocks and hence varies through time. The present value of the tax depreciation from a dollar of investment, z, takes into account straight-line and sum-of-years digits depreciation.

The DRI model may be expected to indicate particularly large impacts of changes in tax parameters because in three key areas the tax parameters are constrained to enter with coefficients equal to that of other variables expected to have a close association with investment: output, profits after taxes, and dividend-price ratios.

1/ Defined as final sales less government purchases and imputed housing services, with an adjustment for pollution-abatement equipment spending.

Michigan

The Michigan model divides equipment investment into three categories: production, agriculture, and other. It is unique in having the lagged value of structures enter the equation for production investment in equipment. It also contains in the "other" equipment equation a variable measuring the difference between long-term and short-term interest rates, presumably embodying the effects of expected changes in long rates.

Tax depreciation is taken in the Michigan model as a rate which varies periodically, apparently with changes in allowable lives. The present value of the tax depreciation for a dollar of investment is not calculated.

In the structures equation the rental price of capital is taken simply as the price of structures times .06, presumably economic depreciation, plus the rate of interest. Hence no tax parameters enter. In the equipment equations, tax parameters enter through the assumed rate of tax depreciation and the assumed nominal rate of investment tax credit, k. Economic depreciation is taken at a constant rate of one-sixth in the equipment equations.

The Michigan model uses interest rates minus a price change expectations term as its measure of the opportunity cost of capital.

The rental price of capital variable enters as a ratio of labor costs in the equipment equations and as a ratio of prices in the structures equation. In none of the equations is its coefficient otherwise constrained.

The Michigan equations hence offer less *a priori* support for the role of tax parameters. They do not enter at all in the structures equations. In the equipment equations they are constrained to have effects similar to those of other components of the rental price of capital.

MPS

The MPS investment equations rest heavily on a third equation for orders for equipment. This in turn involves distributed lag functions of output and changes in output, each multiplied by $(P/c)^{\sigma}$. The value of σ is constrained at unity in the equation for orders for equipment, from which actual investment expenditures follow fairly directly. This constrains the rental price of capital to have whatever effect on investment in equipment is indicated by the coefficients of the combined terms $(P/c)\Delta Y$ and $(P/c)Y$, reflecting accelerator and replacement investment. The value of σ , taken identically equal to unity, is apparently derived from a search procedure indicating this to be appropriate for a particular form of the equation estimated. In the structures equation, however, an estimated value of σ equal to .18629 was used, thus implying a much lesser role in structures for the rental price of capital and any tax parameters entering into it.

The value of the tax depreciation from a dollar of investment, z, takes into account the varying proportions of depreciation by straight-line and accelerated methods. The investment tax credit is taken at its "effective rate."

In the forms specified, tax parameters can be expected to have a large role in the MPS equipment equations because of the constraint that σ equals unity. It will have a much lesser role in the structures equation because of the relatively low estimated value of σ.

Wharton

The Wharton investment sector involves equations for eight separate industry groups, each estimating the sum of equipment and structures investment. Aggregate investment is then allocated as between equipment and structures.

The nonagricultural industry investment equations are functions of current output, the one-quarter and two-quarter ahead investment anticipations and, in some cases, the current capital stock. The cost of capital affects investment by its impact on the investment anticipations variables. These are generally functions of output, the price of industry output relative to the cost of capital, and, in some cases, the capital stock. The length of the lags for these explanatory variables varies by sector. No cost of capital term enters the equation for regulated transportation.

The industry costs of capital are based on effective industry income tax rates and the statutory rate of the investment tax credit. The value of z is calculated on the assumption that all tax depreciation was sum-of-the-years-digits using industry tax lives.

The lack of constraint on the coefficients of the rental price of capital, where it does appear, implies relatively little presumption in favor of a major role for tax parameters in the Wharton investment equations.

5. Tax Scenarios: Estimates of Direct Effects of Tax Parameters

One measure of the relative direct effects of tax parameters in the different models may be derived by setting the three tax parameters with which we have been concerned at their essentially "pre-incentive" values of 1953 and noting the differences in investment indicated by the investment equations. Such a measure is of course very partial, abstracting from feedback effects on the variables in the investment equations. It hence does not offer a reliable measure of the total effects of the tax parameters on investment. It should, nevertheless, give us a good preliminary indication of the sensitivity to tax parameters of the investment equations currently specified and used in the models. We do not have such estimates for Wharton. The contrasts among the five other models -- BEA, Chase, DRI, Michigan, and MPS -- as shown in Table 7, are striking.

What we have done first is to set the investment tax credit at a rate of zero. Second, we have put the investment tax credit back at whatever values it entered the equations and set the tax depreciation variable at a value which assumes continuance of straight-line depreciation at the tax lives used or specified in 1953. (In the Michigan model the tax depreciation rate was held at the constant value of .08 for agriculture and .05 for "production" and "other.") Third, we left the investment tax credit and tax depreciation variables at whatever values they entered the equations but set the corporate profits tax rate at the value of .52 which existed in 1953. All comparisons were made for the fourth quarter of 1977 for which we had data for all of the models.

Setting the investment tax credit equal to zero but taking all other variables entering the investment equations as unaltered, the predicted values of investment in equipment showed a hugh range of results. The low, for Michigan, was a reduction of investment by $1.4 billion. Chase indicated a reduction of $4.3 billion. BEA came in with a reduction of $7.3 billion and MPS and DRI, as we might have anticipated from the specification of the investment equations, indicate a reduction in investment of $10.9 billion and $12.9 billion, respectively.

On accelerated depreciation Chase is low with an effect of $5.2 billion, with Michigan and BEA not far behind with estimated effects of $5.8 and $6.3 billion, respectively. MPS and DRI are again high with investment losses of $14.7 and $16.5 billion, respectively.

The corporate profits tax rate, as we have pointed out, does not enter as unambiguously in the rental price of capital and consequent impact on investment and here the differences across the models, while still relatively great, are not quite as large. In fact, the results for Michigan indicate that, by holding the corporate profits tax rate equal to its value in the last quarter of 1953, investment expenditures on equipment would have been higher by $.94 billion as compared to the baseline values. All of the other models record declines in investment. Chase indicates an effect of $1.4 billion, but this time BEA ranks ahead of MPS, $2.5 billion against $1.8 billion, respectively. Again, DRI shows the strongest effects with an estimated decline of $5.7 billion.

Tax parameters do not enter the Michigan structures equation. As for the other four models, DRI is much higher, both on accelerated depreciation and on the corporate profits tax rate, owing to the constaint that movements in the cost of capital or output impact on investment through the same set of distributed lag coefficients. The disparities among the remaining models are relatively small, presumably because of the lower estimated value of σ in the MPS structures equation.

It is of course important to be aware that Table 7 offers no comparison of the relative effects of variation of different tax parameters, even the direct partial effects in the investment equations. To measure these we would, at the least, have to compare changes in tax parameters that involve equal losses of tax revenues, in fact, equal present values of losses in tax revenues, since the time pattern of changes in tax revenues will be different for the investment tax credit, tax depreciation, and the corporate profits tax rate.

6. Estimated Equations

Differences in results among the models have been related generally to explicit or implicit differences in the more or less constrained values of σ, the elasticity of capital with respect to its rental price.

The investment tax parameters were most frequently imbedded in variables measuring that rental price of capital. Specifications of the components of the rental-price-of-capital variables as well as constraints imposed upon their relations with other variables were of major importance.

We focused our attention, in reestimating the model investment equations, on the coefficients of the rental-price-of-capital variables and on the specifications which affected them. In our new equations we have loosened the constraints on variables embodying tax effects and compared estimates of the original model equations (or our representations of them, sometimes trivially different) and our new equations. We then proceeded to comparable simulations of the old and new equations with specified alterations of the investment tax credit, the tax lives of depreciable assets, and the general rate of corporate taxation. We thus were able to verify the apparent implications of the various estimated parameters of the originally specified equations and our new equations and to quantify the results.

A major focus of our revised equations has been the isolation, as far as possible, of variables presumed to embody the effects of tax parameters. This suggested that in a number of the models, we revise the definition of ρ, the cost of capital, which is a key, variable component in the rental price of capital into which the tax parameters enter. In particular, we excluded from the ratio of profits after taxes to stock prices or the ratio of dividends to stock prices. For high current ratios of profits after taxes to stock prices may relate less to the current cost of capital than to the state of the business cycle and the relation between current profits and expected future profits, which latter may play a major role in the value of stock prices. High current profits may, in fact, stimulate investment through their liquidity effects and lower the effective cost of capital.

A low ratio of profits after taxes to stock prices may, however, reflect high expected future profits which would be positively related to investment and yet not be indicative of a low equity cost of raising capital. This is true, a fortiori, with regard to the ratio of dividends to stock prices. The negative relation between investment and this presumed component of the cost of capital may rather reflect a positive relation between current investment and the expected future returns on this investment which will also be positively related to current stock prices. If we are to measure the effects of tax parameters on investment in terms of their contribution to the rental price of capital we must avoid tainting our measure of the rental price of capital with spurious measures of ρ, its cost of capital component.

A further major revision we have undertaken relates most importantly to the DRI model, where the effects of changes in relative prices and of output have been constrained to be equal in the combined variable, pY/c, where Y is a measure of output, p measures the price of output and c denotes the rental price of capital. Our major new equations for DRI involve estimates of the separate effects of changes in p/c and changes in Y. Our hypothesis is that, since a strong positive relation between capital and output is well established, estimating the effects of changes in c, whether brought about by changes in tax parameters or changes in other components, will be exaggerated by estimates of a coefficient of pY/c. We might note as a corollary that, if the coefficient of p/c is really lower than that of Y, estimating a coefficeint for the combined variable may well lead to understatement of the effect of Y. Analogous issues of perhaps lesser substance occur with regard to constraints which impose similar consequences from changes in the relative price of capital goods and output or wages and of changes in relative prices due to other changes in the components of c. We have explored this with an additional set of equations in the Michigan model.

The structures of the investment equations under consideration are set forth in fairly similar notations, along with estimated parameters and associated statistics in Tables 1 through 6 (with a glossary of variables in Appendix A). We explain them briefly below.

BEA

Critical elements in the BEA model investment equations were the definition of the rental price of capital, c, the associated estimates of the elasticity of capital with respect to the rental price, σ, and the putty-putty form of the structures equation. In this equation, the entire capital stock, not merely net investment and replacement, was specified to change its magnitude with changes in the relative values of the implicit price deflator of GNP and the rental price of investment in structures.

We have undertaken two changes in specifications of the BEA equations. First, we have altered the definition of ρ, the cost of capital entering the rental price, c. The BEA model defines ρ as a weighted average of an expected interest rate term extrapolated from the past change in the rate of interest and current and past levels, and a dividend-stock price ratio. Interest costs are apparently partially adjusted for their tax-deductible component. We have defined a new ρ', modifying the definition of ρ by excluding the dividend-stock price ratio and blowing up the resultant ρ' so that its mean is equal to that of ρ.

Second, we have added a new structures equation with a putty-clay specification, as indicated in Table 1.

Changing the definition of had only a modest effect in the equipment equation. Our estimated value of σ changed from .74 to .65, suggesting a slightly lower effect for investment tax parameters than in the original equation.

In the structures equation, our new definition of ρ resulted in lowering the estimate of σ from .36 to .27 in the original putty-putty specification. It should be noted that the standard error of the regression based on the ρ' specification was somewhat larger than that with the ρ specification, however.

The putty-clay specification yields higher estimates of σ, both the ρ and ρ' versions, but again a lower estimate of in the ρ' equation. We may anticipate though that the higher values of σ in a putty-clay specification will not translate themselves into higher short-term effects of tax parameters on investment.

Chase

In the Chase model direct effects of investment tax parameters are measured in an equation for new orders in all manufacturing. Here the values of the corporate tax rate, u, of the investment tax credit, k, and of the present value of tax depreciation from a dollar of investment in equipment, z_E, divided by 1-u, all enter linearly. The new orders variable in turn enters the equipment investment equation but the tax parameters enter this equation again as components of c_E, the rental price of equipment. The structures equation does not contain the new orders variable so that the only effects of the tax parameters there are as components of c_S, the rental price of investment in structures.

The rental price in both cases includes the cost of capital, ρ. For equipment this is an average of the interest rate on newly issued Aa utility bonds and the ratio of profits after taxes in billions of dollars to the Standard and Poors index of 500 common stocks. The value of ρ is calculated from a similar average in the case of structures, but with a lesser weight for PRAT/SP, the ratio of profits to the stock price index. The structures equation also enters a set of lagged stock price indices as a separate variable.

Our estimates of the equation involving ρ', in which the stock price index and profits after taxes are taken out of the c/p variable and enter separately, indicate a striking reduction in the absolute value of the coefficient of c/p, from 61.4 to 30.3, as shown in Table 2. While leaving intact the estimated effects of tax parameters in the curiously specified equation for new orders, the reduction in the coefficient of c/p as we move from the ρ equation to the ρ' equation suggests that an "untainted" estimate of the coefficient of the rental price of capital will indicate lesser effects of tax parameters on investment in equipment.

In the structures equation, the coefficient of c/p is again reduced in absolute size, from 85.6 to 66.5 as we move from the ρ equation to the ρ' equation. This reduction is less in absolute magnitude and still less relatively than the corresponding reduction in the case of equipment. The structures equation, one may note, has a significantly positive coefficient for the stock price index but a relatively small and insignificant coefficient for the PRAT/SP variable.

DRI

Tax parameters enter the DRI investment equations through c in the pY/c variable and in the debt service variable, DS. The specification is implicitly putty-putty with direct adjustment of equipment investment to a change in rental price completed over a total of nine quarters. Any reasonably substantial coefficients of the pY/c variables will hence imply a substantial effect on investment.

The debt service variable, defined as the ratio of interest payments to gross cash flow, may also have a substantial effect because cyclical increases in profits, closely related to cash flow, are likely to be positively associated with cyclical movements in investment. Since cyclical movements of interest payments are much less, we may expect a considerable negative relation between investment and the debt service variable, reflecting essentially the positive relation between investment and profits. This positive relation of investment to profits will come through all the more greatly if the role of output is misspecified. The merging of Y in a combined pY/c variable may then have the effect of lowering the constrained coefficient of Y even as it raises the constrained coefficient of p/c and raises the absolute value of the coefficient of the debt service variable.

The DRI model uses for ρ a weighted average of interest costs and the sum of the dividend stock price ratio and a measure of the expected rate of growth of earnings. To the extent that the measure of expected earnings growth captures the earnings-dilution cost of selling new equity as perceived by firms, the DRI measure of ρ may be robust against the criticisms we have advanced earlier. To the likely extent that it is an inadequate measure of these costs in terms of expected future earnings, the DRI measure of ρ may also be defective as an indicator of the cost of capital.

We have thus undertaken two kinds of revisions in the DRI equations, both separately and in combination. First, we have split the pY/c variables into their separate relative price and output components, p/c and Y, or more precisely, $(p/c)\overline{Y}$ and $Y\overline{(p/c)}$. Second, we have redefined ρ' as the DRI measure of the interest rate, blown up to have the same mean as the originally defined ρ. (Thus $\rho' = i\,\overline{\rho}/\overline{i}$.) We are hence able to offer four sets of estimates: 1) the original DRI equations, with the combined pY/c variable and the original ρ and hence the original c; 2) equations with the original ρ but with $(p/c)Y$ and $Y\overline{(p/c)}$ entered as separate sets of variables; 3) the original DRI specification but with ρ' substituted for ρ; 4) equations with ρ' substituted for ρ and with $(p/c)\overline{Y}$ and $Y\overline{(p/c)}$ substituted for pY/c.

The results for equipment appear very much in line with our hypotheses. Splitting the pY/c variable lowers the constrained coefficient of .0135 to .0056 for p/c and raises the coefficient to .0213 for Y. Further, the absolute size of the coefficient of the debt service variable was reduced from 48.2 to 25.2. The splitting of the pY/c variable thus points to a reduction in the implicit effects of all tax parameters in the order of more than 50 percent in the DRI equipment equation.

Substituting ρ' for ρ in itself reduces the estimated coefficient of pY/c and the absolute value of the coefficient of the debt service variable. The combined effect of both alterations, substituting ρ' for ρ and splitting the pY/c variable, is most dramatic. The coefficient of the separate p/c variable is reduced to .0035, little more than one quarter of its constrained value in the original DRI equation and the absolute size of the coefficient of the debt service variable is reduced to 14.2, again less than 30 percent of its amount in the original DRI equation. [1]

The DRI equations for structures, however, reveal no such dramatic differences. This may relate to the generally poor fit of the DRI structures equations. The sum of the coefficients of pY/c was not significantly greater than zero in the original DRI equation and neither the corresponding pY/c sum nor the sums of coefficients of the separate p/c and Y variables were significantly different from zero in our equations. In our revision incorporating both ρ' and the separate p/c and Y variables, the absolute size of the highly significant debt service variable was somewhat reduced, from 45.9 in the original DRI structures equation to 38.3. Our revisions have not, however, made very much difference in the structures equations.

Michigan

The Michigan model, it may be recalled, generates the smallest effects of tax parameters on investment. Indeed, there is no direct scope for them at all in the structures equation.

We have used the Michigan model to examine a further split of the relative price variable in which tax parameters affecting investment are usually imbedded. What we have done is to break out of the relative price of capital and labor term, c/w, the price of capital goods and the wage rate. This leaves as the residual variation in the rental price of capital, c, the interest rate in the structures equation and

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[1] An "F" test reveals that the improvement in fit resulting from the separation of p/c from Y in the ρ' equation for equipment is clearly significant; $F(2,76) = 4.83$, which is just about at the .99 probability level. The "F" statistic for the ρ equation was 2.74, corresponding to a probability level of .93.

in equipment, in addition, a price change term and the tax factors of depreciation, the corporate tax rate and the investment tax credit.

Results were mixed in the three equipment equations -- production, agriculture and other -- and in structures. In "production" investment, which had a mean value of almost $15 billion, the split lowered the absolute value of the coefficient of the rental price of capital component including the interest rate and tax parameters. In the small agricultural component (mean investment about $4 billion) the absolute value of the coefficient of the rental price of capital residual variable was raised considerably and the relative price term showed a significant "wrong" positive sign. (This may have related to interaction with the variable measuring relative price changes of farm and nonfarm products.)

In the equation for "other" equipment investment, the mean value of which was $43.5 billion, the split brought little change in the coefficient of the rental price of capital variable. In structures, this split did cut the coefficient of the residual rental price of capital variable roughly in half in absolute value and also showed a very substantial and significant negative coefficient of the new variable measuring the relative price of capital goods and wages. This may suggest a better formulation of the structures equation but is not directly relevant to our current work since tax parameters do not enter here.

MPS

In the MPS equations we have reestimated both equipment and structures equations with focus on the values of σ , the elasticity of demand for capital with respect to the relative price of output and capital. In the MPS model equation for orders for equipment σ is specified as having a value of unity. When we reestimate this equation with the MPS specification of ρ and no constant term, we do indeed get a maximum likelihood estimate of σ of 1.03. When we estimate σ without constraining the constant term to be zero, however, we find that the constant is signficantly negative, the estimated value of σ falls to .70 and the accelerator coefficients generally rise.

Variance in ρ in the MPS equations relates chiefly to variance in the dividend-stock price ratio and to interaction of the corporate tax rate and the proportion of capital costs which is tax-deductible. There is general allowance for an interest rate component but the current MPS model equations constrained its coefficient to be zero.

In accordance with our general approach we have defined ρ' so that the interest rate is included and the dividend-stock price ratio is excluded. Estimates of the equipment equation with ρ' substituted for ρ yield considerably smaller estimates of the value of σ . In the equation with no constant term, as specified in the MPS model, our estimated value of σ falls from 1.03 to .71. In the much better fitting model with the constant term the estimated value of σ in the ρ' equations falls from .71 to .19. This last value of σ would suggest a vastly smaller role for tax parameters in affecting investment in equipment.

In the MPS structures equation, the value of σ provided in the model is .18629, thus implying only modest effect of tax parameters on investment in structures. Our own estimate of the structures equation as originally specified including the MPS definition of ρ yields a value of σ of .22. The dramatic differences seen in equipment do not appear in our different equations in structures. The equation using ρ with a constant term here gives a value of σ of .29, that using ρ' yields a value of σ of .16, and that using ρ' with a constant term gives a value of σ of .27.

Wharton

In the Wharton model, our only modification to the original equations is to alter the definition of ρ. The opportunity cost of capital is defined as a fixed-weighted average of an estimate of the real rate of interest and the dividend-stock price ratio. As argued above, this latter term may be a poor proxy for the true equity costs that the firm faces, and we have reestimated the Wharton equations with ρ', equal to the real rate of interest scaled appropriately to insure that the means of ρ and ρ' are equal.

The number of equations that were reestimated with the new definition of the cost of capital is rather voluminous and, in Table 6, we present a representative set of equations for durable manufacturing. In both the one- and two-quarter ahead anticipations equations, the sums of estimated coefficients are significantly lower for the relative price term, and somewhat lower for the output term. This pattern holds for the majority of the reestimated equations, although in some cases the sums of coefficients increase relative to the original estimates. Given the interrelationships that exist in the investment sector of each industry, it is somewhat difficult to determine from an examination of the coefficients the responsiveness of aggregate investment to changes in parameters. The simulation results presented in Table 13 provide a convenient means by which to assess the differences between the original and modified equations.

We may indicate in general that, particularly where the original models suggested major effects of tax parameters on investment, our revised equations, free of what have seemed to us to be critical constraints generating the results, have produced parameter estimates suggesting considerably lesser effects of tax variables on investment. That story can be developed much more clearly and precisely in simulations of paths of investment with varying values of the key tax parameters of the investment tax credit, tax depreciation and the corporate income tax rate. It is to these simulations that we shall now turn.

7. Simulations

We report on four basic sets of simulations, similar as far as possible for each of the six models. The first is a long-run simulation in which the relevant tax parameters are held at their fourth quarter, 1953 levels. This means setting the investment tax credit at zero, the corporate tax rate, effective or statutory as defined in the models, at its 1953-IV rate, and applying tax depreciation by the straight-line method at the length of lives assumed by the models to exist in the fourth quarter of 1953.

Second, we have alternatively changed the investment tax credit, the corporate tax rate and the tax depreciation lives in the first quarter of 1973 and followed the resultant path of investment for generally a five-year period through the fourth quarter of 1977. For the investment tax credit, we have doubled the rate for equipment beginning in the first quarter of 1973 and have introduced a credit for structures at 10 percent (an effective rate of 8.1 percent in the DRI model and 8.5 percent in the MPS model). We have set the corporate tax rate at 90 percent of its historical rate beginning in the first quarter of 1973. And we have set the tax lives for depreciable assets at 50 percent of their historical rates beginning in the first quarter of 1973.

We have then mapped baseline paths for investment in equipment and structures for the original model equations (or our approximate rendition of them) and noted the effects upon investment indicated by each of the specified sets of changes in tax parameters. Next, we have constructed similar baseline paths for each of our modified equations and noted the indicated effects on investment of the changes in tax parameters in these equations. Thus we are able to note not only how the original model equations indicate changes in tax parameters will affect investment but also how the indicated effects are dependent upon model specification and how they change with the new, less constrained and, in our view, better specified equations which we have estimated.

To simplify the presentation, we shall offer in our tables and concentrate in our discussion on the results for the fourth quarter of 1977, in billions of 1972 dollars and as a percent of baseline.

To anticipate in summary fashion, the simulations offered generally, and particularly in the results for equipment, a striking confirmation of the hypotheses we have expressed and of the implications of the estimated equations indicated above.

BEA

The BEA equipment equations, it will be recalled, were only moderately modified by our respecification of ρ as ρ'. The rather substantial effects of tax parameters on investment indicated in the BEA model are hence only moderately reduced with our new specification. With none of the "investment incentives" introduced since 1953, the BEA equipment equation indicates that investment in equipment would have been some $15.6 billion in 1972 dollars less in the fourth quarter of 1977, some 17 percent of the baseline. Our revised ρ' equation lowers that effect only to $14 billion, or 15.1 percent of the baseline.

Making the equipment tax credit twice its historical value beginning in 1973 would have increased equipment investment by $9 billion or 9.8 percent of baseline according to the original BEA equation. According to our ρ' equation it would have increased equipment spending by $8 billion or 8.6 percent of baseline. This latter figure, we may point out, indicates that the bang for the buck is not expectionally promising. Since a doubling of the investment tax credit meant an increase from 10 percent to 20 percent beginning in 1975, the additional loss of tax revenue equal to 10 percent of equipment spending would have increased that spending by less than 10 percent. Our single equation simulations suggest that we could have gotten more added investment by paying for the equipment and giving it to business free than by the device of a "tax incentive" to induce them to buy it on their own.

The relative magnitude of effects shown in the original and modified equation are similar for reductions in the corporate tax rate and in the lives for tax depreciation, as may be seen in Table 8. The ρ' equations show modestly smaller effects on investment.

The BEA structures equation, with its distinctly smaller value of σ, shows markedly smaller effects of changes in tax parameters. Using the original BEA putty-putty model, the introduction of a 10 percent investment tax credit for structures would have increased structures investment by only

3.48 percent of baseline by the fourth quarter of 1977. Our modified ρ' equation reduces that effect to 2.64 percent of baseline.

The putty-clay specification which we have introduced generates higher estimates of σ, as might be expected, and hence greater long-run and also greater medium-run effects on structures investment. By the fourth quarter of 1977, the increases in structures investment was some 30 to 40 percent greater in the putty-clay equations than in the putty-putty equations. The putty-putty result for a 10 percent investment tax credit in structures was +$1.13 billion in our ρ'equation for 1977-IV as against $1.49 billion in the putty-clay ρ' equation. 1/ But in the putty-putty equation the indicated added investment in structures had reached a peak of about $2.30 billion as early as the third and fourth quarters of 1974 and the amount of added investment then began to decline. In the putty-clay model the amount of additional structures investment rose throughout the five-year period but was apparently pretty much at its equilibrium level by the fourth quarter of 1977.

Both the putty-putty model for structures investment and the results flowing from it are really implausible. The putty-clay models indicate that a reduction in tax revenues equal to 10 percent of structures investment would tend to increase that investment by some two-thirds of the lost tax revenues according to the ρ equation and some one-half of the tax revenues according to the ρ' equation. All of these estimates, we must remind ourselves, are based only upon the single investment equations without feedback from the rest of the model. Higher interest rates resulting from higher investment demand, for example, would tend to reduce the effects of these tax incentives. Effects from changes in aggregate demand would depend, of course, upon what assumptions are made about other offsetting taxes as well as whether the economy is or is not at or near full employment.

Chase

The original Chase equations do not indicate as large effects of tax parameters on equipment investment. The simulations with our revised ρ' equations reduce those estimated effects further. Thus, the long-run no tax incentive simulation indicates that equipment investment would be less by $11.7 billion in 1977-IV, or 12.8 percent of baseline. Our ρ' equation reduces this estimated effect to $8.2 billion or 8.9 percent of baseline. The effects of

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1/ The BEA model is specified so that a 10 percent statutory investment tax credit is transformed into a 7.37 percent effective rate.

doubling the investment tax credit were only 4.6 percent of baseline, less than half of that indicated in the BEA equations. Our ρ' equation reduced the effects substantially further to just over 3 percent of baseline. Thus a dollar of lost tax revenues from an increase in the investment tax credit would generate not much more than 30 cents in additional equipment investment, again without feedback from the rest of the model.

The effects in structures were considerably less in the original Chase equation, the 10 percent investment credit, for example, raising structures investment by only 3.37 percent of baseline. Our ρ' equations here made very little difference, as shown in Table 9B and as might have been anticipated from Table 2B, which reported the estimated equation.

The Chase equations were estimated without the Cochrane-Orcutt autocorrelation correction. When we introduced the correction the results were about the same in equipment but changed somewhat in structures. Here we find simulation of the original Chase equation estimated with the autocorrelation correction yielding a somewhat higher structures effect, 6.38 percent of baseline for a 10 percent investment tax credit and similarly greater figures for changes in other tax parameters. Simulation of our ρ' equation, as in equipment, yields a lesser effect, however, only 4.9 percent of baseline.

DRI

The DRI simulations offer the most dramatic confirmation of sensitivity of predicted results to equation specification and estimation. The original DRI model equation, with ρ containing its dividend-stock price component and with the combined pY/c variable, indicates that the setting of all tax parameters at the levels that existed in 1953-IV would have resulted in $36.8 billion 1972 dollars less equipment investment in 1977-IV, some 40 percent of baseline. 1/ Simulation of the equation estimated with separate p/c and Y variables cut this effect by fully three-quarters, to $8.5

1/ The debt service variable in the DRI model makes it extremely difficult to simulate effects of changes in depreciation lives. The algorithm which DRI may have used in such simulations not proving available, we constructed our own. For computational convenience, we used constant tax lives for equipment and structures in performing the simulations which begain in 1954. The reported results in 1977-IV would have been changed slightly if historic tax lives had been used.

billion, only 9.3 percent of baseline. The ρ' equation with separate p/c and Y reduced this smaller simulated effect by half again, to $4.5 billion, or 4.9 percent of baseline.

The original DRI model equations generate, along with MPS, the largest effects of tax incentives on equipment investment. The doubling of the investment tax credit for equipment beginning in 1973-I results in an increase in equipment spending of $13.1 billion 1972 dollars in 1977-IV, or 14 percent of baseline, according to our simulation. Splitting the pY/c variable again results in a hugh decrease in the simulated effect, to $3.7 billion or 4.04 percent of baseline. Simulation of the ρ' equations makes a lesser difference but again reduces the predicted effects, to $2.81 billion in the equation with separate p/c and Y variables, or 3.05 percent of baseline. Thus, from a simulated effect of $1.42 of added equipment spending for each dollar of tax revenues lost through the investment tax credit indicated by the original DRI equation, we move to an indicated effect of only $0.31 of added equipment investment for each dollar of revenues lost from the investment tax credit when we worked with our modified ρ' equation with separate p/c and Y.

Similarly contrasting effects are to be found with the acceleration of depreciation and reduction in the corporate tax rate, although in the ρ' equations the net effect on investment of a corporate tax reduction is slightly negative. The result stems from the greater effect of the lower u in raising the after-tax cost of capital when that is made to depend wholely on deductible interest payments. In the original formulation the adjusted dividend-stock price ratio component was presumably unaffected by changes in the corporate tax rate.

The halving of depreciation lives raised 1977-IV equipment investment by $8.0 billion 1972 dollars in the original DRI model equation, or 8.69 percent of baseline. The simulation with the p/c and Y split reduced the accelerated depreciation effect to $2.4 billion, or 2.60 percent of baseline. And the split with the ρ' equation lowered that predicted effect still further, to $1.3 billion, 1.37 percent of baseline or less than one-sixth of the effect shown in the original DRI equation.

Modification of the structures equation in the DRI model does not bring similar changes. As suggested earlier in our discussion of those equations, perhaps because structures spending is not that closely related to output over the preceding nine quarters, the coefficients of the pY/c variables in the original DRI structures equation were not high (nor were they statistically significant). Reestimated equations did not therefore have much scope for reduced estimates and, indeed, the free p/c coefficient was slightly higher. Our structures simulation in fact showed somewhat greater additions to investment resulting from increasing or introducing the investment tax credit. As in equipment, the ρ' specification suggested sharply lesser effects of reducing the corporate tax rate than the original DRI ρ equation.

Michigan

We have done no simulations with the Michigan structures equations because they contain no tax parameters. Taxes indeed have mixed effects in the Michigan equipment equations.

Tax depreciation is defined as a rate rather than, as in the other models, in terms of length of life and method of depreciation which feed into the present value term, z. In our Michigan depreciation simulations, therefore, we have doubled tax depreciation rates rather than halving lives. The particular form of the rental price of capital variable in the Michigan model, we may also note, is such that the partial derivative of rental price with respect to the rate of corporate taxation is negative unless (as was true according to the rates assumed in the Michigan model before 1962) the rate of tax depreciation plus the rate of price inflation was far less than the assumed rate of economic depreciation of one-sixth.

In all three of the equipment sectors, the Michigan simulations indicated only very small effects of the investment tax credit. In no case did doubling it in 1973 and thereafter raise equipment spending by more than 2.78 percent of baseline.

The corporate tax rate did in fact manifest a "perverse" effect. Lowering it to 90 percent of its historical rate from 1973 on actually reduced equipment investment in most instances.

Doubling the tax depreciation rate turned out, however, to have a very large effect. This would appear to be a consequence of the very large assumed tax depreciation rates of some 21 percent and 36 percent in recent years.

Our alternate c' equations, splitting relative price effects from the rental price variable, did not indicate consistent differences in simulated results, in some sectors for some parameter changes suggesting lesser effects on investment and in some cases greater effects.

MPS

The MPS simulations for equipment show extreme sensitivity to equation specification. Simulation of the original MPS equation with no constant term, and with our estimated σ of 1.03 substituted for the specified σ of unity, indicates very large effects of tax parameters on investment. Setting all tax parameters at 1953-IV levels leads to a predicted decline of equipment investment of over $25 billion by the fourth quarter of 1977, or 30.3 percent below baseline. When the equation including a constant term is used for simulation, that reduction is lessened to 23.3 percent. The ρ' equation without a constant term generates a predicted drop of 19.7 percent below baseline while the ρ' equation with a constant term indicates a drop of only 6.81 percent, less than one-quarter of that suggeeted by the investment in equipment equation specified in the MPS model.

The other equipment simulations bring similarly constrasting results. Thus, the original ρ equation indicates that doubling the equipment tax credit beginning in 1973-I would cause an increase in equipment investment of $12.7 billion 1972 dollars, 15.12 percent of the baseline. The MPS orders for equipment equation with a constant term, however, generates a simulated reduction of only 10.68 percent of baseline. The ρ' equation, in which the interest rate is substituted for the dividend-stock price ratio, suggests an increase of only 8.28 percent of baseline. And the ρ' equation with a constant term knocks the added equipment investment down to 2.78 percent of baseline, only 18.4 percent of the effects indicated in the originally specified MPS model. Roughly similar, contrasting results are found with changes in the corporate tax rate and in the lives of assets used in depreciation for tax purposes.

The results of structure simulations are, as anticipated, not nearly as dramatic. Indeed here, since the introduction of a constant term somewhat raises the low estimates of σ, the simulated results suggest correspondingly somewhat greater effects on investment. Substituting the interest rate for the dividend-stock price ratio in the definition of ρ, however, does generally lower the predicted effects of tax parameters, particularly when the structures equation is estimated, as in the MPS model, without a constant term. In none of the structures equations, it may be noted, does increased investment come close to equaling the loss in tax revenues resulting from the tax incentives. This can be seen clearly again in the case of introduction of an investment tax credit of 10 percent beginning in the first quarter of 1973. In that simulation, resultant investment by the fourth quarter of 1977 increases over a range of from 3.93 percent of baseline to 7.40 percent of baseline, thus generating from 39 cents to 74 cents of added investment for each dollar of lost tax revenue. Of course, as in all of these simulations, the results relate only to the investment equations, without feedback from the rest of the model.

Wharton

The Wharton model calculates total aggregate investment expenditure and then divides the estimate between aggregate equipment and structures. Thus, the effects of alterations in tax parameters will tend to have symmetric effects on spending for equipment and structures. An increase of 10 percent in the investment tax credit rate for structures and a doubling of the rate for equipment beginning in 1973-I leads to an approximately 4.91 percent increase in nonresidential investment in the original Wharton equations and a 2.95 percent increase in our modified set. In performing this simulation, we assumed that these increases in investment tax credit rates were such that the relative price between equipment and structures was not affected. [1]

A 10 percent cut in the corporate income tax rate had little effect on either set of estimates, with total investment approximately .53 percent and .19 percent higher than the baseline values in the original and modified equations, respectively. This low response is due to the recognition of the tax deductability of interest payments in the Wharton rental price of capital. Under sufficiently high rates of inflation (as exist currently), this term and the value of tax depreciation can actually increase the rental price of capital in the face of cuts in the corporate income tax rate.

8. Summary and Conclusion

Investment equations in the six models under consideration, BEA, Chase, DRI, Michigan, MPS and Wharton, differ in specification, estimated parameters and results. The results in the equipment equations have differed sharply, primarily as a result of differences in the implicit or explicit values of σ , the elasticity of investment with respect to the rental price of capital. Where there were high values of σ , whether due to a constraint tying the rental price of capital to output, as in DRI, constrained homogeniety (no constant term) in MPS, or use of the ratio of earnings or of dividends to stock prices as a component of the cost of capital (BEA, Chase, DRI, MPS, and Wharton), even with a growth-in-earnings term, the impact of tax parameters on investment was high. Where σ did not have a high value, the impact was low.

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[1] We also assumed that the discrepencies between the National Income and BEA Survey data remained at their historic values.

The differences across models are striking. As shown in Table 14, our simulations of the original equipment investment equations indicate that doubling the equipment tax credit beginning in 1973 generated a range of effects on equipment investment by the fourth quarter of 1977 from a low of $1.4 billion 1972 dollars for Michigan to a high of $13.1 billion for DRI, with MPS not far behind. The BEA simulation indicated a high-middle estimate of $9 billion while Chase and Wharton came in fairly low at $4.3 and $5.1 billion, respectively. The mean figure from the six simulations was $7.6 billion, some 8.3 percent of actual equipment investment in 1977-IV.

Our preferred revised equations, eliminating the dividend-stock price ratio from the cost of capital variable, splitting output and the rental price of capital into separate variables in DRI and removing the homogeneity constraint in MPS, bring drastic reductions in the effects of tax parameters in the original models. The Chase, DRI and MPS results of doubling the investment tax credit for equipment are knocked down to the range of $2.7 to $2.8 billion. The BEA estimates remain relatively high, due apparently to the persistently high estimate of σ, .65 in our revised equation. All in all, simulations of our revised equations yield a mean increase in equipment investment of $3.5 billion, down to 3.8 percent of actual equipment investment, and only 46.3 percent of the mean figure derived from simulation of the original equations.

Investment classified in the models as structures amounted to less than half of that in the equipment category and was generally much less responsive to tax parameters in simulations of the original model equations. There were no tax parameters in the Michigan structures equation, hence changing tax parameters could have no effect on structures investment there. Over the other models, the range of effects from instituting a 10 percent credit for investment in structures varied considerably less then effects from the analogous doubling of the investment tax credit for equipment. Aside from Michigan, the range of predicted added investment in the original equations extended from $1.4 billion for Chase and BEA, to $2.4 billion for MPS and a high of $2.8 billion for DRI. The mean for all five models was $1.7 billion, only 4.3 percent of actual structures investment.

In the case of structures investment, however, with the original equations containing explicit values of σ of .18629 and .36 and implicit values also generally low, as indicated by coefficients of rental price of capital variables, our revised equations offered results which were not substantially different from those of the original model equations. The mean of predicted increases in structures investment derived from our revised equations was identical to that for the original equations, calculated to the first decimal.

Thus, the effects on total business fixed investment of essentially adding 10 percentage points of investment credit in both equipment and structures ranged, with the original model equations, from a low of $1.4 billion in the Michigan model to a high of $15.8 billion in the DRI model, a difference of over 1,000 percent. The mean of the disparate estimates came to $9.3 billion, or 7.07 percent of the actual investment figure of $131.7 billion. Because of our distinctly lower simulated results in equipment, our revised equations yielded, along with a smaller spread, a considerably lower mean of $5.2 billion, or 3.98 percent of total investment. In either set of equations, but of course a fortiori in the revised set, it may be noted that a 10 percent increase in the tax credit brought considerably less than 10 percent in added investment. The mean results from the original model equations suggest that each dollar of tax loss would result in about 71 cents of added investment. The revised equations offer a comparable figure of only 40 cents.

All this, it must be recalled again, includes only the direct effects of changing tax parameters in the investment equations themselves. Full model simulations can alter these results, depending in each case on the extent and manner of feedback from other equations in the system. 1/

1/ Some of that story, again, is to be found in Chirinko and Eisner (1980), Phase III or OTA Paper 46 .

Table 1. BEA Equations, Equipment and Structures

$$E = \sum_{j=0}^{11} b_{jYE} \left(\frac{p}{c}\right)_{-j}^{\sigma_E} \left(Y - .87\ Y_{-1}\right)_{-j} + \sum_{j=0}^{8} b_{juE} \left(\frac{p}{c}\right)_{-j}^{\sigma_E} \left(\frac{Y}{UT} - Y\right)_{-j}$$

$$S = \sum_{j=0}^{15} b_{jYs}(1-.94L) \left(\frac{p}{c}\right)_{-j}^{\sigma_s} \left(\frac{Y}{UT^{.48}}\right)_{-j} + \sum_{j=0}^{15} b_{jus} \left(\frac{p}{c}\right)_{-j}^{\sigma_s} \left(\frac{Y}{UT} - Y\right)_{-j} \quad \text{(Putty-Putty)}$$

$$S = \sum_{j=0}^{15} b_{jYs} \left(\frac{p}{c}\right)_{j}^{\sigma} \left(\frac{Y}{UT^{.48}} - .94\ \frac{Y_{-1}}{UT^{.48}}\right)_{-j} + \sum_{j=0}^{15} b_{jus} \left(\frac{p}{c}\right)_{j}^{\sigma_s} \left(\frac{Y}{UT} - Y\right)_{-j} \quad \text{(Putty-Clay)}$$

(1) Variable or Statistic	(2)	(3)	(4)	(5)	(6)	(7)
	Regression Coefficients and Standard Errors					
	Equipment		Structures			
			Putty-Putty		Putty-Clay	
	ρ	ρ'	ρ	ρ'	ρ	ρ'
Constant	-	-	-	-	-	-
Σb_{jY}(ELAG1; SLAG1,P-P; SLAG1,P-C)	.3876 (.0048)	.4188 (.0050)	1.4961 (.0447)	1.2844 (.0873)	1.5091 (.0460)	1.2792 (.0537)
Σb_{ju}(ELAG2; SLAG2)	-.0326 (.0056)	-.0424 (.0057)	-.1586 (.0241)	-.1368 (.0453)	-.1009 (.0278)	-.0813 (.0317)
σ	.74	.65	.36	.27	.48	.36
Autocor.Coef.	.675	.659	.815	.945	.805	.870
R^2	.997	.997	.979	.975	.978	.976
S.E.Regression	1.0748	1.0741	.8126	.8799	.8265	.8634
DW	2.009	2.007	2.205	2.079	2.039	2.025
n	79	79	71	71	71	71
	Means and Standard Deviations					
ELAG1, SLAG1	179.103 (51.928)	168.280 (48.322)	32.642 (9.786)	37.517 (7.175)	29.319 (3.862)	34.634 (4.272)
ELAG2, SLAG2	160.069 (85.092)	151.067 (81.185)	56.850 (27.903)	64.780 (32.380)	48.225 (23.524)	57.368 (28.583)
Equip.,Struct.	60.984 (18.571)	60.984 (18.571)	38.437 (5.385)	38.437 (5.385)	38.437 (5.385)	38.437 (5.385)

Table 2. Chase Equations, Equipment and Structures

$$E = b_{0E} + b_{1E}\ (cd + cnd)_{-} + \sum_{j=0}^{9} a_{jE}\left(\frac{c_E}{p}\right)_{-j} + b_{2E}\ CRED_{-} + b_{3E}\ NOR_{-}$$

$$S = b_{0s} + b_{1s}\ (cd + cnd)_{-} + \sum_{j=0}^{9} a_{js}\left(\frac{c_s}{p}\right)_{-j} + b_{2s}\left(\frac{p}{w}\right)_{-} + b_{3s}\ un_{-} + b_{4s}\ SP_{-}$$

A. With Autocorrelation Coefficient

(1) Variable or Statistic	(2)	(3)	(4)	(5)	(6)	(7)
	Regression Coefficients and Standard Errors				Means and Standard Deviations	
	Equipment		Structures			
	ρ	ρ'	ρ	ρ'	Equipment	Structures
Constant or Investment	-17.161 (4.897)	-21.548 (2.602)	31.720 (10.578)	38.712 (10.173)	62.486 (17.822)	36.068 (6.682)
NOR_	1.290 (.116)	1.153 (.191)	- -	- -	45.680 (8.908)	
CRED_	-.912 (.433)	-.572 (.403)	- -	- -	-.0940 (.6868)	
$(cd+cnd)_{-}$	.1014 (.0155)	.0826 (.0221)	.0549 (.0268)	.0427 (.0217)	339.715 (64.696)	324.1 (71.0)
$(c/p)_{-}$	-61.381 (19.661)	-30.277 (13.953)	-85.584 (39.524)	-66.539 (29.568)	.225 (.020)[a]	.156 (.039)[b]
un_	- -	- -	-.407 (.336)	-.483 (.310)		5.318 (1.273)
$(P/w)_{-}$	-	-	-35.546 (21.612)	-54.083 (21.094)		.2697 (.0529)
SP_	- -	.0775 (.0525)	.1451 (.0327)	.1461 (.0332)		77.102 (21.944)
PRAT	- -	.0711 (.0278)	- -	- -	49.912 (22.089)	45.825 (22.208)
PRAT/SP	- -	- -	- -	-1.034 (1.607)	.574 (.199)	.572 (.183)
Autocor.Coef.	.633	.552	.823	.810		
R^2	.9965	.9970	.9875	.9875		
S.E. Regression	1.0752	1.0057	.7619	.7645		
DW	2.023	2.045	2.045	2.035		
n	75	75	90	90		

Table 2. Chase Equations, Equipment and Structures

B. Without Autocorrelation Coefficient

(1) Variable or Statistic	(2)	(3)	(4)	(5)
	Regression Coefficients and Standard Errors			
	Equipment		Structures	
	ρ	ρ'	ρ	ρ'
Constant	-14.796 (2.542)	-20.889 (1.490)	33.080 (4.912)	31.777 (6.327)
NOR_	1.167 (.0653)	1.182 (.1311)	-	-
CRED_	-1.037 (.2658)	-.5343 (.2835)	-	-
(cd+cnd)_	.1155 (.0089)	.0827 (.0165)	3.953 (1.381)	5.013 (1.605)
(c/p)_	-67.690 (10.500)	-30.110 (9.506)	-45.071 (19.505)	-44.882 (14.711)
un_	-	-	-1.119 (.1812)	-1.033 (.1767)
(P/w)_	-	-	-32.790 (9.753)	-33.847 (12.706)
SP_	-	.0538 (.0339)	.1527 (.0212)	.1438 (.0213)
PRAT	-	.0714 (.0214)	-	-
PRAT/SP	-	-	-	-2.880 (1.833)
Autocor.Coef.	-	-	-	-
R^2	.9941	.9956	.9689	.9703
S.E. Regression	1.4034	1.2305	1.2125	1.1924
DW	.7429	.8668	.4692	.4934
n	76	76	91	91

N.B. The "minus" subscript alone ("-"), here and in subsequent tables, indicates a general lag operator, of a somewhat varied but usually distributed form, as:

$$(cd + cnd) = \Sigma\gamma . \ (cd + cnd)$$

Table 3. DRI Equations

A. Equipment

$$E = b_0 + \sum_{j=3}^{9} b_j \left(\frac{pY}{c}\right)_{-j} + \sum_{j=1}^{7} d_j\, DS_{-j} + f_1\, KE_{-1} *UTP + f_2 KE_{-1} + f_3(Y' - Y) + f_4\, VNWAR$$

(1) Variable or Statistic		(2) Regression Coefficients and Standard Errors ρ	(3) ρ, p/c, Y	(4) ρ'	(5) ρ', p/c,Y	(6) Means and Standard Deviations ρ	(7) ρ'
Constant or E		-14.537 (4.130)	-38.863 (10.365)	-15.983 (5.891)	-37.538 (12.940)	63.530 (20.220)	63.530 (20.220)
pY/c	(Σb_j)	.0135 (.0038)	-	.0084 (.0040)	-	3336.7 (952.5)	4186.5 (1065.9)
$(p/c)\overline{Y}$	(Σb_{jp})	-	.0056 (.0037)	-	.0035 (.0033)	3293.9 (245.4)	4165.3 (223.3)
$Y(\overline{p/c})$	(Σb_{jY})	-	.0213 (.0091)	-	.0180 (.0066)	3293.9 (767.1)	4165.4 (970.1)
DS	(Σd_j)	-48.228 (16.473)	-25.248 (14.876)	-38.789 (18.478)	-14.162 (14.985)	.2154 (.0917)	.2154 (.0917)
KE_{-1}		-.1281 (.0698)	-.0851 (.0564)	-.1337 (.0798)	-.0784 (.0555)	329.3 (91.3)	329.3 (91.3)
KE_{-1} * UTP		.2938 (.0909)	.1503 (.0794)	.3099 (.1153)	.1231 (.0857)	273.3 (75.0)	273.3 (75.0)
Y' - Y		-.1019 (.0203)	-.0959 (.0192)	-.1148 (.0211)	-.1014 (.0180)	-60.0 (22.6)	-60.0 (22.6)
VNWAR		3.120 (.888)	2.775 (.878)	3.164 (.917)	2.752 (.886)	.0930 (.2922)	.0930 (.2922)
Autocor. Coef.		.881	.748	.911	.720		
R^2		.997	.997	.997	.997		
S.E. Regression		1.2001	1.1738	1.2447	1.1833		
DW		1.735	1.735	1.647	1.698		
n		85	85	85	85		

Table 3. DRI Equations

B. Structures

$$S = b_0 + \sum_{j=3}^{9} b_j \left(\frac{pY}{c}\right)_{-j} + \sum_{j=1}^{7} d_j \, DS_{-j} + f_1 \, KS_{-1} {*}UTP + f_2 \, KS_{-1}$$

(1)		(2)	(3)	(4)	(5)	(6)	(7)
Variable or Statistic		Regression Coefficients and Standard Errors				Means and Standard Deviations	
		ρ	ρ, p/c,Y	ρ'	ρ',p/c,Y	ρ	ρ'
Constant or S		-.255 (7.128)	-29.488 (20.705)	-6.074 (12.378)	-31.229 (30.697)	37.788 (6.354)	37.788 (6.354)
pY/c	(Σb_j)	.0026 (.0017)	-	.0022 (.0017)		5276.7 (750.0)	7764.8 (831.4)
$(p/c)\overline{Y}$	(Σb_{jp})	-	.0045 (.0023)	-	.0029 (.0021)	5427.5 (784.1)	8095.4 (1544.9)
$Y(\overline{p/c})$	(Σb_{jY})	-	.0065 (.0049)	-	.0027 (.0031)	5427.5 (1264.0)	8095.4 (1885.3)
DS	(Σd_j)	-45.927 (11.745)	-49.413 (14.796)	-46.623 (12.035)	-38.321 (14.826)	.2154 (.0917)	.2154 (.0917)
KS_{-1}* UTP		.1308 (.0610)	.0948 (.0712)	.0899 (.0862)	.0771 (.0932)	352.0 (78.8)	352.0 (78.8)
KS_{-1}		-.0277 (.0490)	-.0349 (.0560)	.0125 (.0698)	.0108 (.0801)	424.0 (94.8)	424.0 (94.8)
Autocor. Coef.		.871	.873	.882	.880		
R^2		.979	.979	.978	.979		
S.E. Regression		.9576	.9575	.9589	.9696		
DW		1.917	2.021	1.873	1.951		
n		85	85	85	85		

Table 4. Michigan Equations, Equipment (Production, Agriculture and Other) and Structures

$$EX = b_{0x} + b_{1x}\,\Delta Y_{-} + b_{2x}\left(\frac{c}{w}\right)_{-} + b_{3x}\,S_{-1} + b_{4x}\,EX_{-1}$$

$$EA = b_{0a} + b_{1a}\,\Delta Y_{-} + b_{2a}Y_{-} + b_{3a}\Delta\left(\frac{c}{w}\right)_{-} + b_{4a}(\dot{P}_f - \dot{P}_{nf})_{-1} + b_{5a}\,EA_{-1}$$

$$EO = b_{0o} + b_{1o}\,Y_{-} + b_{2o}\left(\frac{c}{w}\right)_{-} + b_{3o}(i_L - i_s) + b_{4o}\text{DASTRIKE} + b_{5o}\,S_{-1} + b_{6o}\,EO_{-1}$$

$$S = b_{0s} + b_{1s}(Y_{-1} - Y_{-3}) + b_{2s}\,Y_{-} + b_{3s}\left(\frac{c}{p}\right)_{-} + b_{4s}\,S_{-1}$$

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variable	Regression Coefficients and Standard Errors							
or Statistic	EX, c	EX, c'	EA, c	EA, c'	EO, c	EO, c'	S,c	S,c'
Constant	2.132	2.938	-.359	-.084	-2.132	-4.217	1.720	.635
	(.759)	(.984)	(.239)	(.255)	(4.202)	(4.867)	(.058)	(1.065)
ΔY_{-}	.049	.054	.0143	.0179	-	-	-	-
	(.010)	(.011)	(.0055)	(.0055)				
$Y_{-1}-Y_{-3}$	-	-	-	-	-	-	.0250	.0245
							(.0052)	(.0052)
Y_{-}	-	-	.00103	.00078	.0106	.0120	.0063	.0061
			(.00046)	(.00045)	(.0053)	(.0055)	(.0030)	(.0030)
$(c/w)_{-}$	-4.866	-	-3.775	-	-9.492	-	-32.300	-
	(1.227)		(2.329)		(3.485)		(13.211)	
$c'_{-}\overline{(q/w)}_{-}$	-	-2.771	-	-12.908	-	-12.634	-	-15.158
		(2.044)		(4.341)		(5.073)		(19.273)
$(q/w)_{-}\,\bar{c}'_{-}$	-	-16.279	-	64.669	-	1.725	-	-50.072
		(9.018)		(27.963)		(13.588)		(19.654)
$\dot{P}_f - \dot{P}_{nf}$	-	-	1.666	1.316	-	-	-	-
			(.454)	(.459)				
$i_L - i_s$	-	-	-	-	1.121	1.101	-	-
					(.153)	(.155)		
DASTRIKE	-	-	-	-	.665	.679	-	-
					(.203)	(.204)		
E_{-1}	.762	.755	.818	.807	.732	.715	-	-
	(.049)	(.049)	(.067)	(.065)	(.073)	(.075)		
S_{-1}	.046	.024	-	-	.121	.161	.882	.862
	(.023)	(.028)			(.053)	(.070)	(.052)	(.054)

Table 4. (continued)

(1) Variable or Statistic	(2) EX,c	(3) EX,c'	(4) EA,c	(5) EA,c'	(6) E0,c	(7) E0,c'	(8) S,c	(9) S,c'
	Regression Coefficients and Standard Errors							
R^2	.981	.982	.965	.968	.993	.993	.987	.987
S. E. Regresion	.4100	.4079	.2158	.2073	1.0897	1.0921	.8049	.8025
DW	1.483	1.532	1.865	1.960	1.714	1.699	1.995	1.986
n	66	66	66	66	68	68	87	87
Mean and St. Dev. of Dep. Var.	14.922 (2.897)	14.922 (2.897)	4.161 (1.113)	4.161 (1.113)	43.509 (12.570)	43.509 (12.570)	35.928 (6.799)	35.928 (6.799)

Table 5. MPS Equations

A. Orders for Equipment

$$ORE = \sum_{j=1}^{8} \left(\frac{p}{c}\right)^{\sigma_E}_{-j} (b_{j\Delta Y}\, \Delta Y_{1-j} + b_{jY}\, Y_{1-j}) + \sum_{j=1}^{6} d_{jk}\, D_k + \sum_{j=1}^{6} d_{jp}\, DP$$

(1)	(2)	(3)	(4)	(5)
	Regression Coefficients and Standard Errors			
Variable or Statistic	ρ	ρ, with constant term	ρ'	ρ', with constant term
Constant or ORE	-	-7.457 (2.260)	-	-20.471 (2.984)
$\left(\frac{p}{c}\right)^{\sigma} \Delta Y_{1-j} (\Sigma b_{j\Delta Y})$	25.059 (7.766)	47.768 (12.939)	77.285 (8.442)	152.732 (25.080)
$\left(\frac{p}{c}\right)^{\sigma} Y_{1-j} (\Sigma b_{jY})$	1.7350 (.0598)	2.9832 (.1615)	2.3545 (.0721)	6.6801 (.3106)
Dk (Σd_{jk})	-26.675	-25.341	-21.129	-19.180
DP (Σd_{jp})	74.672	69.642	110.06	78.250
σ_E	1.03	.70	.71	.19
Autocor.Coef.				
R^2	.957	.958	.927	.948
S.E.Regression	4.6619	4.6072	6.0734	5.1411
DW	1.54	1.63	1.07	1.47
n	83	83	83	83
σ_E by Direct Estimation	.164	.143	.055	-.023

Means and Standard Deviations

$\left(\frac{p}{c}\right)^{\sigma} \Delta Y_{1-j}$	.2515 (.3853)	.1616 (.2498)	.1586 (.2667)	.0810 (.1306)
$\left(\frac{p}{c}\right)^{\sigma} Y_{1-j}$	30.420 (9.049)	19.778 (5.333)	20.036 (5.700)	10.195 (2.378)
Dk	.0361	.0361	.0361	.0361
DP	.0723	.0723	.0723	.0723
ORE	58.105 (20.406)	58.105 (20.406)	58.105 (20.406)	58.105 (20.406)

Table 5. MPS Equations

B. Structures

$$S = \sum_{j=1}^{17} b_{jY}\left(\frac{p}{c}\right)^{\sigma_s} Y_{-j} + b_{18}\, KS_{-1}$$

(1)	(2)	(3)	(4)	(5)
	Regression Coefficients and Standard Errors			
Variable or Statistic	ρ	ρ, with constant term	ρ'	ρ', with constant term
Constant	-	-4.676 (4.516)	- -	- 15.661 (4.911)
$(p/c)^{\sigma_s} Y_{-j}$ (Σb_{jY})	10.002 (1.839)	8.234 (1.600)	10.650 (2.174)	8.357 (1.224)
KS_{-1}	-.1778 (.0482)	-.1453 (.0409)	-.1683 (.0517)	-.1142 (.0265)
σ_s	.22	.29	.16	.27
Autocor. Coef.	.8324	.8013	.8792	.7683
R^2	.980	.980	.980	.981
S.E.Regression	.8311	.8345	.8431	.8311
D W	2.08	2.03	2.13	1.99
n	63	63	63	63
	Means and Standard Deviations			
$(p/c)^{\sigma_s} Y_{-j}$	11.6324 (1.7465)	12.9682 (1.8642)	10.5896 (1.5346)	12.5575 (1.5943)
KS_{-1}	409.935 (76.657)	409.935 (76.657)	409.935 (76.657)	409.935 (76.657)
S	38.247 (5.871)	38.247 (5.871)	38.247 (5.871)	38.247 (5.871)

Table 6. Wharton Equations, Total Investment by Sector i

$$(E+S)_i^a = b_{0,i} + b_{1,i}\,(E+S)_i^1 + b_{2,i}\,(E+S)_i^2 + b_{3,i}\,Y_i + b_{4,i}\,K_{-1,i}$$

$$(E+S)_i^1 = d_{0,i} + d_{1,i}\,(E+S)_i^2 + \sum_{j=0}^{n_1} d_{jYi}\,Y_{-j,i} + \sum_{j=0}^{n_2} d_{jKi}\,K_{-j,1} + \sum_{j=0}^{n_3} d_{jci}\left(\frac{p}{c}\right)_{-j,i}$$

$$(E+S)_i^2 = c_{0,i} + \sum_{j=0}^{m_1} c_{jYi}\,Y_{-j,i} + \sum_{j=0}^{m_2} c_{jKi}\,K_{-j,i} + \sum_{j=0}^{m_3} c_{jci}\left(\frac{p}{c}\right)_{-j,i}$$

<u>Selected Regression Coefficients and Standard Errors</u>

i = Manufacturing, Durables

(1)	(2)	(3)	(4)	(5)	(6)
		ρ		ρ'	
Variable or Statistic	$(E+S)^a$	$(E+S)^1$	$(E+S)^2$	$(E+S)^1$	$(E+S)^2$
Constant	-.1633	-4.4899	-24.807	-3.1106	-9.1792
	(.2592)	(2.079)	(6.125)	(1.208)	(6.631)
$(E+S)_i^1$	.6371	-	-	-	-
	(.1083)	-	-	-	-
$(E+S)_i^2$	.2727	.5797	-	.6286	-
	(.0981)	(.0851)	-	(.0843)	-
$Y_i, \sum_j Y_{-j,i}$	.0231	.0897	.1578	.0821	.1230
	(.0070)	(.0198)	(.0119)	(.0193)	(.0159)
$K_i, \sum_j K_{-j,i}$	-.0202	-.0354	-	-.0381	-
	(.0052)	(.0128)	-	(.0110)	-
$\sum_j \left(\frac{p}{c}\right)_{-j,i}$	-	20.168	211.024	12.073	88.115
	-	(20.531)	(58.040)	(12.635)	(70.572)
Autocor. Coef.	-	-	-	-	.842
R^2	.988	.988	.979	.989	.974
S.E. Regression	.4385	.4429	.6003	.4298	.6666
DW	1.263	1.890	2.240	2.122	2.137

Table 7. Tax Scenarios: Direct Effects on 1977-IV Investment of Tax Credit, Accelerated Depreciation since 1953-IV, and Corporate Tax Rate Less than 52 Percent

Investment Equations Specified in Models, Billions of Dollars

	BEA	Chase	DRI	Michigan	MPS
Equipment, Predicted, 1977-IV	92.103	92.125	92.149	93.903	83.720
Predicted difference due to:					
ITC (k) = 0	-7.339	-4.281	-12.876	-1.406	-10.877
No Accelerated Depreciation*	-6.346	-5.227	-16.483	-5.830	-14.745
CPT(u) = .52	-2.539	-1.359	-5.720	+.940	-1.753
Structures, Predicted, 1977-IV	40.255	40.332	43.509	#	42.749
Predicted difference due to					
No Accelerated Depreciation*	-.473	-1.060	-5.068	#	-.729
CPT(u) = .52	-.810	-.539	-4.194	#	-.621

---

*Straight-line depreciation, 1953-IV lives. In the Michigan model tax depreciation rates held at values in 1953-IV. In the BEA and Chase models, the tax lives for structures did not vary from 1953 to the present. In our simulation we increased them in proportion to the increases that occured in the DRI and MPS models.

#In the Michigan model, no tax parameters enter the structures equation.

Table 8. BEA Simulations, Equipment and Structures Change in Investment, 1977-IV

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tax Parameters	Equation					
	Equipment		Structures			
			Putty-Putty		Putty-Clay	
	ρ	ρ'	ρ	ρ'	ρ	ρ'
	Billions of 1972 Dollars					
All always at 1953-IV levels, SL Dep.	-15.639	-13.992	-.810	-.581	-1.035	-.747
Changes in 1973-I: $k'_{et} = 2k_{et}$; $k'_{st} = 10\%$	+9.032	+7.955	+1.399	+1.132	+1.927	+1.485
$u'_t = .9u_t$	+2.752	+2.421	+.886	+0.624	+1.135	+0.806
$L'_t = .5L_t$	+9.025	+7.931	+1.912	+1.518	+2.576	+1.981
	As Percent of Baseline					
All always at 1953-IV levels, SL Dep.	-16.98	-15.08	-2.01	-1.36	-2.56	-1.79
Changes in 1973-I: $k'_{et} = 2k_{et}$; $k'_{st} = 10\%$	+9.81	+8.57	+3.48	+2.64	+4.77	+3.56
$u'_t = .9u_t$	+2.99	+2.61	+2.20	+1.46	+2.81	+1.93
$L'_t = .5L_t$	+9.80	+8.54	+4.75	+3.55	+6.38	+4.74

Table 9. Chase Simulations, Equipment and Structures
Change in Investment, 1977-IV

A. From Equations With Autocorrelation Coefficients

(1) Tax Parameters	(2)	(3)	(4)	(5)
	Equation			
	Equipment		Structures	
	ρ	ρ'	ρ	ρ'
	Billions of 1972 Dollars			
All always at 1953-IV levels, SL Dep.	-11.736	-8.094	-2.547	-1.962
Changes in 1973-I: $k'_{et} = 2k_{et}$; $k'_{st} = 10\%$	+4.218	+2.804	+2.584	+1.990
$u'_t = .9u_t$	+1.806	+1.480	+1.037	+.799
$L'_t = .5L_t$	+3.192	+2.211	+2.380	+1.833
	As Percent of Baseline			
All always at 1953-IV levels, SL Dep.	-12.80	-8.74	-6.29	-4.86
Changes in 1973-I: $k'_{et} = 2k_{et}$; $k'_{st} = 10\%$	+4.60	+3.03	+6.38	+4.93
$u'_t = .9u_t$	+1.97	+1.60	+2.56	+1.98
$L'_t = .5L_t$	+3.48	+2.39	+5.88	+4.54

Table 9. Chase Simulations, Equipment and Structures
Change in Investment, 1977-IV

B. From Equations Without Autocorrelation Coefficients

(1)	(2)	(3)	(4)	(5)
Tax Parameters	Equations			
	Equipment		Structures	
	ρ	ρ'	ρ	ρ'
	Billions of 1972 Dollars			
All always at 1953-IV levels, SL Dep.	-11.768	-8.213	-1.341	-1.323
Changes in 1973-I: $k'_{et} = 2k_{et}$; $k'_{st} = 10\%$	+4.281	+2.840	+1.361	+1.342
$u'_t = .9u_t$	+1.699	+1.513	+ .546	+ .539
$L'_t = .5L_t$	+3.197	+2.244	+1.253	+1.236
	As Percent of Baseline			
All always at 1953-IV levels, SL Dep.	-12.77	-8.86	-3.33	+3.29
Changes in 1973-I: $k'_{et} = 2k_{et}$; $k'_{st} = 10\%$	+4.65	+3.07	+3.37	+3.34
$u'_t = .9u_t$	+1.84	+1.63	+1.35	+1.34
$L'_t = .5L_t$	+3.47	+2.42	+3.11	+3.08

Table 10. DRI Simulations
Change in Investment, 1977-IV

A. Equipment

(1) Tax Parameters	(2)	(3) Equations	(4)	(5)
	ρ	$\rho, p/c, Y$	ρ'	$\rho', p/c, Y$
		Billions of 1972 Dollars		
All always at 1953-IV levels,	-36.769	-8.518	-26.013	-4.475
Changes in 1973-I: $k'_{et} = 2k_{et}$	+13.075	+3.719	+11.333	+2.807
$u'_t = .9u_t$	+1.585	+.509	-.283	-.074
$L'_t = .5L_t$	+8.010	+2.395	+5.208	+1.265
		As Percent of Baseline		
All always at 1953-IV levels,	-39.90	-9.26	-28.38	-4.86
Changes in 1973-I: $k'_{et} = 2k_{et}$	+14.19	+4.04	+12.36	+3.05
$u'_t = .9u_t$	+1.72	+ .55	-.31	-.08
$L'_t = .5L_t$	+8.69	+2.60	+ 5.68	+1.37

Table 10. DRI Simulations
Change in Investment, 1977-IV

B. Structures

(1) Tax Parameters	(2)	(3) Equations	(4)	(5)
	ρ	$\rho, p/c, Y$	ρ'	$\rho', p/c, Y$
		Billions of 1972 Dollars		
All always at 1953-IV levels, SL Dep	-11.997	-10.311	-10.030	-8.669
Changes in 1973-I:				
$k'_{st} = 8.1\%$	+2.754	+3.080	+3.396	+3.164
$u'_t = .9u_t$	+1.107	+1.132	+.386	+.248
$L'_t = .5L_t$	+3.335	+3.549	+3.333	+2.923
		As Percent of Baseline		
All always at 1953-IV levels, SL Dep	-27.53	-23.74	-22.87	-19.76
Changes in 1973-I:				
$k'_{st} = 8.1\%$	+6.33	+7.09	+7.74	+7.21
$u'_t = .9u_t$	+2.54	+2.61	+.88	+.57
$L'_t = .5L_t$	+7.67	+8.17	+7.60	+6.66

Table 11. Michigan Simulations, Equipment (Production, Agriculture and
Other) and Structures
Change in Investment, 1977-IV

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tax Parameters	Equations							
	Equipment						Structures	
	EX,c	EX,c'	EA,c	EA,c'	EO,c	EO,c'	S,c	S,c'
	Billions of 1972 Dollars							
All always at 1953-IV levels, SL Dep.	-2.870	-1.142	-.053	+.239	-4.501	-6.900	0	0
Changes in 1973-I: $k'_{et} = 2k_{et}$	+.523	+.218	+.029	+.078	+.839	+1.298	0	0
$u'_t = .9u_t$	-.363	-.145	-.008	+.022	-.579	-.890	0	0
$TD'_t = 2TD_t$	+2.890	+1.150	+.103	-.043	+4.570	+7.034	0	0
	As Percent of Baseline							
All always at 1953-IV levels, SL Dep.	-15.24	-6.18	-1.01	+5.00	-6.45	-9.84	0	0
Changes in 1973-I: $k'_{et} = 2k_{et}$	+2.78	+1.18	+.55	+1.62	+1.20	+1.85	0	0
$u'_t = .9u_t$	-1.93	-.79	-.15	+ .45	-.83	-1.27	0	0
$TD'_t = 2TD_t$	+15.34	+6.22	+1.95	- .91	+6.55	+10.03	0	0

Table 12. MPS Simulations
Change in Investment, 1977-IV

A. Equipment

(1) Tax Parameters	(2)	(3)	(4)	(5)
	Equations			
	ρ	ρ with Constant Term	ρ'	ρ', with Constant Term
		Billions of 1972 Dollars		
All always at 1953-IV levels, SL Dep.	-25.383	-20.273	-19.365	-6.621
Changes in 1973-I: $k'_{et} = 2k_{et}$	+12.656	+9.304	+8.133	+2.707
$u'_t = .9u_t$	+1.605	+1.190	+1.117	+.372
$L'_t = .5L_t$	+7.790	+5.730	+4.967	+1.658
		As Percent of Baseline		
All always at 1953-IV levels, SL Dep.	-30.32	-23.26	-19.73	-6.81
Changes in 1973-I: $k'_{et} = 2k_{et}$	+15.12	+10.68	+8.28	+2.78
$u'_t = .9u_t$	+1.92	+1.37	+1.14	+.38
$L'_t = .5L_t$	+9.30	+6.57	+5.06	+1.71

Table 12. MPS Simulations
Change in Investment, 1977-IV

B. Structures

(1) Tax Parameters	(2)	(3)	(4)	(5)
		Equations		
	ρ	ρ, with Constant Term	ρ'	ρ', with Constant term
		Billions of 1972 Dollars		
All always at 1953-IV, SL Dep.	-1.449	-1.928	-1.141	-2.145
Changes in 1973-I:				
k'_{st} = 8.5%	+2.420	+3.094	+1.824	+3.171
$u'_t = .9u_t$	+.957	+1.222	+.716	+1.240
$L'_t = .5L_t$	+2.452	+3.137	+1.840	+3.197
		As Percent of Baseline		
All always at 1953-IV levels, SL Dep.	-3.39	-4.61	-2.46	-4.60
Changes in 1973-I:				
k'_{st} = 8.5%	+5.66	+7.40	+3.93	+6.80
$u'_t = .9u_t$	+2.24	+2.92	+1.54	+2.66
$L'_t = .5L_t$	+5.74	+7.50	+3.96	+6.86

Table 13. Wharton Simulations, Equipment and Structures Investment

Change in Investment, 1977-IV

(1)	(2)	(3)	(4)	(5)
Tax Parameters	Equation			
	Equipment		Structures	
	ρ	ρ'	ρ	ρ'
	Billions of 1972 Dollars			
Changes in 1973-I: $k'_{et} = 2k_{et}$; $k'_{st} = 10\%$	+5.100	+3.200	+2.400	+1.500
$u'_t = .9u_t$	+.500	+.200	+.300	+.100
$L'_t = .5L_t$	+2.100	+1.100	+1.000	+.500
	As Percent of Baseline			
Changes in 1973-I: $k'_{et} = 2k_{et}$; $k'_{st} = 10\%$	+4.88	+2.94	+4.96	+2.98
$u'_t = .9u_t$	+.48	+.18	+.62	+.20
$L'_t = .5L_t$	+2.01	+1.01	+2.07	+.99

Table 14. Comparison of Simulations, Change in Investment, 1977-IV, Resulting from 1973-I Doubling of Investment Tax Credit for Equipment and Institution of 10 Percent Credit for Structures, Original and Revised Model Specifications, Billions of 1972 Dollars

(1) Model	(2)	(3)	(4)	(5)	(6)	(7)
	Equipment		Structures		Total	
	Original	Revised	Original	Revised	Original	Revised
BEA	9.032	7.955	1.399	1.132	10.431	9.087
Chase	4.281	2.840	1.361	1.342	5.642	4.182
DRI ($k'_s = 8.1\%$)	13.075	2.807	2.754	3.164	15.829	5.971
Michigan	1.391	1.594	0	0	1.391	1.594
MPS ($k'_s = 8.5\%$)	12.656	2.707	2.420	3.171	15.076	5.878
Wharton	5.100	3.200	2.400	1.500	7.500	4.700
Mean	7.589	3.517	1.722	1.718	9.312	5.235
Actual Investment	91.507	91.507	40.149	40.149	131.656	131.656
Mean Difference as Percent of Actual Investment	8.29%	3.84%	4.29%	4.28%	7.07%	3.98%

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GLOSSARY

CCCA	Capital Consumption Adjustment, Corporate
CTR	Federal Corporate Tax Receipts
D	Tax Depreciation Allowances, Current Law
D_A	Tax Depreciation Allowances, 10-5-3
D_B	Tax Depreciation Allowances, OTA Alternative
E	Investment Expenditures on Producers' Durable Equipment, Constant Dollars
E$	Investment Expenditures on Producers' Durable Equipment, Current Dollars
$I_j\$$	Producers' Investment Expenditures for Sector j, Current Dollars
k_e	Rate of Investment Tax Credit, Equipment
k_s	Rate of Investment Tax Credit, Structures
$\hat{k}_j$	Effective Rate of Investment Tax Credit for Sector j
L_e	Tax Life of Equipment
L_s	Tax Life of Structures
PCCA	Capital Consumption Adjustment, Proprietors
PTR	Federal Personal Tax Receipts
s	Corporate Share of Nonresidential Business Capital Consumption Allowances
S	Investment Expenditures on Producers' Structures, Constant Dollars
S$	Investment Expenditures on Producers' Structures, Current Dollars
TD_j	Tax Depreciation for Sector j
u	Rate of Federal Business Income Taxation