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Abstract

This article reviews various models proposed in the literature to estimate the impact of taxation on the real and financial decisions of the firm, and uses one of these models to estimate the impact of the Tax Reform Act of 1986. The model that the authors use is composed of three recursive equations: a dividend payout rate equation, a leverage equation, and an investment equation. The equations are estimated and simulated with U.S. aggregate data. The authors find that the Tax Reform Act of 1986 will increase the dividend payout rate, reduce leverage, and may decrease the after-tax real cost of financing in the long run. On the other hand, mainly because of the removal of the Investment Tax Credit, the authors expect a significant reduction in corporate investment in machinery and equipment in the long run.

TAX POLICIES AND THE REAL AND FINANCIAL DECISIONS OF THE FIRM: THE EFFECTS OF THE TAX REFORM ACT OF 1986

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Previous studies of the effects of the Tax Reform Act of 1986 (henceforth TRA86) have assumed that the real and financial decisions of the firm are independent.¹ There is, however, empirical evidence that seems to contradict this assumption.² Furthermore, the consequences of such a misspecification may be important since the user cost of capital is, under the interdependent assumption, affected not only directly but indirectly, via the financial decisions of the firm.

The purpose of this article is to study the impact of TRA86 on corporate financing and investment in machinery and equipment using

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a simulation model that links the real and financial decisions and that is empirically relevant. The objective is to obtain more detailed and more accurate measures of these effects than those currently available.

The article is organized as follows. The first section reviews various models that have been proposed in the literature for analyzing the impact of tax changes on the real and financial decisions. Particular attention is paid to empirical and theoretical criticisms of these models to motivate the eclectic approach that follows. The next section summarizes the theoretical and empirical model that we use to investigate the joint impact of TRA86 on the real and financial decisions of the firm. The model is based on Nadeau (1988) and it is composed of three recursive equations: a dividend equation, an external financing mix equation, and an investment equation. The first two equations determine the firm's financial cost of capital and the third equation uses the financial cost of capital as a determinant of investment. The model is estimated with U.S. data. The third section uses this model to estimate the effects of some of the most salient provisions of TRA86 on corporate investment in machinery and equipment. The fourth section examines the robustness of these results to changes in the values of the parameters of the model.

By way of summary, we find that TRA86 will increase the dividend payout rate, reduce the tax advantage of debt financing over equity financing and hence leverage, and may decrease the after-tax real cost of financing if the reduction in personal income tax rates sufficiently reduces interest rates. On the other hand, the removal of the investment tax credit is expected to overshadow the aforementioned impact of tax reform on the cost of financing, to result in a substantial net increase in the rental price of machinery and equipment capital and to result in a reduction in corporate investment in machinery and equipment.

MODELING THE IMPACT OF TAX CHANGES ON THE FIRM'S REAL AND FINANCIAL DECISIONS

In this section, we review the literature and models relevant to the study of the impact of taxation on the real and financial decisions of

the firm. This literature is extensive and complex because it covers four areas of research in finance and economics that have individually received a great deal of attention. These areas are:

1. The determinants of the real investment decisions;
2. The determinants of the dividend decision;
3. The determinants of the debt financing decision;
4. The relationships among the dividend decision, the debt financing decision, and the investment decision.

Our review covers the models proposed in these four areas of research and their important findings. Unlike other reviews (e.g., Auerbach 1983), we restrict our discussion for the most part to macroeconomic policy-oriented models. We begin by discussing investment models that treat the financial decisions as exogenous. We then review financing models that treat the investment decision as exogenous. We complete the review by discussing models that examine the impact of taxation on investment and financing in a joint framework, and by indicating the remaining issues about which a more complete theoretical treatment might inform.

REAL INVESTMENT AND TAX POLICY MODELS

The two most popular models utilized to investigate the impact of taxation on business investment are the Neoclassical model pioneered by Jorgenson (1963) and the Tobin's Q model of Investment (Tobin 1969).³ Chirinko (1986) points out that these models entertain the common assumption that the firm invests to the point that the expected marginal benefit is equal to the expected marginal cost.⁴ However, they differ on several counts.

The Neoclassical Model

Most macroeconomic models of investment behavior are variants of the Jorgenson (1963) model. Under constant returns to scale, a typical Neoclassical investment equation has the form:⁵

$$I/K_{t-1} = \delta + \sum_{i=0}^{m_1} a_i \ln Y_{t-1} + \sum_{i=0}^{m_2} b_i \ln(w_{t-1}/c_{t-1}) + \gamma \ln K_{t-1} \quad (1)$$

where I is investment; K is capital stock; δ is the depreciation rate; Y is output; w is the wage rate; c is the so-called user cost of capital; and δ , $\{a_i\}$, $\{b_i\}$, and γ are parameters to be estimated statistically. The key variable in equation (1) is the user cost of capital which, in its simplest form, is:

$$c = \frac{(r + \delta) \cdot \bar{P}_t}{(1 - \tau_c)}$$

where r denotes the real after-tax cost of funds, \bar{P}_t is the net of tax considerations purchase price of capital,⁶ and τ_c is the rate of corporate income taxation.

There are a number of reasons why the Neoclassical model is so popular among tax analysts. First, it is based on explicit assumptions regarding the firm's optimizing behavior. Second, the data requirements to estimate the model are not prohibitive. Third, the large volume of empirical studies based on variants of the Neoclassical model have encouraged additional refinement and research and are a testimony to its empirical relevance.⁷ Fourth, the tax variables are explicit in the model, thus facilitating counterfactual policy simulations of different tax regimes.

The Neoclassical model is not, however, free from criticism.⁸ One common criticism of the Neoclassical model is its ad hoc treatment of expectations. The model in equation (1) assumes that expectations are extrapolative and essentially of an autoregressive scheme. As such, it is "backward-looking" and subject to the Lucas Critique (Lucas 1976). Another aspect of equation (1) that may be questioned is the implicit assumption that firms act as if all the components of the user cost of capital were generated by the same stochastic process.⁹ If this is in error then equation (1) will be misspecified with attending implications for the reliability of tax policy analysis.

The assumption in equation (1) that is of special interest to us is that the financial decisions are exogenous. One reason for making this

assumption is that, as will be discussed further below, there is not a settled theory of the cost of capital.¹⁰ Typically, the cost of capital is modeled as a weighted average of the cost of debt and the cost of equity; however, there is substantial disagreement in the literature concerning the determinants of these weights. If, on the other hand, the financial decisions are jointly determined, it is easy to imagine that the estimation of equation (1) could lead to incorrect inferences and unreliable simulation results.

It is well known that estimates of the effects of tax policy on investment based on the Neoclassical model are very sensitive to the specification of the cost of capital variable and of the investment equation. In a study of six quarterly macroeconomic models, Chirinko and Eisner (1983) found that a doubling of the investment tax credit for equipment led to increases in investment, after five years, of between 1.7% and 8.6% depending on the model used. They conclude that "one can get almost any answer one wants as to the effects of tax incentives for investment by making sure that the chosen model has specifications appropriate to one's purpose" (p. 163).

The Q Model

The Q theory is based on the work of Tobin (1969). According to Fischer and Merton (1984, 83), the " Q theory . . . is now the preferred theoretical description of investment." The Q framework is appealing because, unlike the Neoclassical framework, it takes explicitly into consideration forward-looking expectations, and is therefore not subject to the Lucas Critique.¹¹ Let Q denote the ratio of market value to replacement cost, that is,

$$Q = \frac{V}{\bar{P}_t \cdot K_{t-1}}$$

where V denotes the market value of the firm (equity shares plus bonds). Hayashi (1982) shows that under constant returns to scale, quadratic adjustment costs, and perfect capital markets, investment can be written as:

$$I/K_{t-1} = b_1 + b_2(Q_t - 1)$$

where b_1 and b_2 are parameters to be estimated. Expectations enter the econometric specification directly through the market value of the firm variable, which is measured using financial market data. Despite its theoretical appeal, the empirical record of the Q model is poor.¹² One reason is the difficulty of measuring Q accurately because of the volatility in stock market data.

Early specifications of investment behavior based on the Q theory abstracted from personal taxes, depreciation, and financial policy. Summers (1981) improved significantly the explanatory power of the Q model by incorporating personal taxes and depreciation considerations into the model. Chirinko endogenized the firm's external financing mix policy in a Q model of investment behavior; his empirical results led him, however, to conclude that the " Q theory is unlikely to provide the basis for a satisfactory investment model linking the real and financial sectors" (Chirinko 1987a, 86).

Compared to the Neoclassical model, substantially less empirical work on the effects of taxes on investment has been undertaken within the Q framework. Except for Summers (1981), most studies have been concerned with fitting the model to various data sets and have ignored the effects of taxes. Summers's work with the Q model suggests that taxes have significant effects on investment.

MODELS OF CORPORATE FINANCIAL POLICY THAT INCORPORATE TAX CONSIDERATIONS

The impact of taxation on corporate financial decisions has received far less empirical attention than the impact of taxation on the real investment decision. In this subsection, we examine models that concentrate exclusively on the impact of taxes on corporate financial policy. Three questions have been posed in the literature.

1. What is the effect of taxation on dividend distribution?
2. What is the effect of taxation on leverage?
3. What is the joint effect of taxation on dividend distribution and leverage?

Models of Dividend Behavior that Incorporate Tax Considerations

Given the fact that dividends are taxed more heavily than retained earnings in the U.S., it is difficult to understand why firms pursue a policy of paying substantial dividends. Poterba (1987) summarizes the explanations proposed in the literature for this state of affairs. One explanation is that shareholders are indifferent between retained earnings and dividends because share prices capitalize the tax penalty on dividends (Auerbach 1979; Bradford 1981). This is the so-called tax capitalization view. Under this view, firms should never pay dividends and issue new shares at the same time. This is clearly at odds with the observed dividend behavior of firms.

The "traditional view" of dividend taxation, however, rationalizes the fact that firms pay dividends in spite of their unfavorable tax treatment, by arguing that shareholders value dividends beyond the cash value. In particular, it is argued that shareholders value dividends as a signal of the firm's future prospects (John and Williams 1985). Closely related to this idea is the notion that dividends are a solution to an agency problem: paying dividends regularly forces firms into capital markets where they are scrutinized by investors (Easterbrook 1984). Another reason for the existence of dividends is that shareholders perceive cash dividends as a hedge against uncertain future income stream (Shefrin and Statman 1984). Poterba (1987) refers to these motives for the firm to pay dividends, even if it involves a tax penalty, as the *intrinsic* value of dividends.

Poterba and Summers (1983) and Scholz (1989) report the results of empirical tests of these competing hypotheses of dividend valuation. Their results support the traditional view of dividend taxation. In other words, they find that shareholders value dividends beyond the cash value.

Although there are several theoretical models to explain the existence of dividends, most empirical models are extensions of Lintner's partial adjustment model (Lintner 1956). The basic components of that model are: (1) an equation defining the firm's "optimal" amount of dividends in the current period and (2) a dynamic adjustment equation describing how dividends change when the current optimum level is not equal to the dividends distributed in the preceding period. The

optimal amount of dividends has been related to companies' net earnings (Anderson 1983; Lintner 1956), to some form of cash flow (Anderson 1983; Brittain 1964; Turnovsky 1976), to gross profits with an allowance for the tax determined opportunity cost of profit retentions in terms of dividends foregone (Feldstein 1970), to maximum net of tax profits (Feldstein 1970), and to after-tax profits plus nominal interest adjusted for inventory valuation and capital consumption allowances (Poterba 1987).

These empirical models have generally found that taxation had a significant impact on corporate dividend behavior.

Models of Taxation and Debt Policy

Most recent studies that focus on the effects of taxation on corporate debt issuance policy are concerned with demonstrating theoretically the existence (or nonexistence) of a relationship between the value of the firm and its capital structure. It is widely believed that the value of a firm in the U.S. can be increased by the use of debt since interest payments can be deducted from taxable corporate income. The attractiveness of debt financing is, however, reduced by the risk of bankruptcy associated to the use of debt. Hence the balancing of bankruptcy costs against the tax gains of debt finance gives rise to an optimal capital structure. Miller (1977) challenges this view and demonstrates that if the personal income tax rate applicable to income from bonds, then the gain from leverage can be very small (even negative). Companies following a low (high) leverage strategy will find a clientele among investors with high (low) tax rates applicable to income from bonds. Hence, although an equilibrium level of aggregate corporate debt exists, there is no optimum debt ratio for any individual firm (the firm will be indifferent between issuing debt and equity).

More recent studies of the effects of taxes on leverage make the point that debt issuance should be negatively related to the amount of the firm's available nondebt tax shields (DeAngelo and Masulis 1980). The rationale is that interest deductibility has value only if the firm's earnings before interests and taxes (EBIT) is positive.

There has been little done empirically to measure the effects of taxes on debt policy. In a microeconomic study, Bradley, Jarrel, and Kim

(1984) find, contrary to the theory of DeAngelo and Masulis (1980), a positive relationship between leverage and nondebt-related tax shields. Mackie-Mason (1988) finds no clientele tax effect, but does find a negative relationship between debt issuance and the amount of available nondebt tax shields as the theory predicts. The only macroeconomic study that we know of is by Pozdena (1987), who finds that debt issuance is not statistically related to personal income tax rate and nondebt tax shields.

Models of the Joint Impact of Taxation on Dividend and Debt

Two categories of studies focus on the impact of taxation on financial policy. The studies in the first category attempt to model the firm's financial cost of capital and, as a consequence, analyze the impact of taxation on the financial variables that comprise the financial cost of capital. The studies in the second category take for granted the traditional view of corporate finance that the financial cost of capital is a weighted average of the cost of debt and the cost of equity, and that the objective of financial policy is to choose these weights to minimize the cost of capital. We review these studies below.

Feldstein, Green, and Sheshinski (1979) present a theoretical model of corporate financial policy to study the impact of changes in taxes. The key assumptions in their model are: (1) that the cost of debt and the cost of equity are increasing functions of leverage; (2) that the cost of equity is a function of the net after-tax return on equity that depends on the dividend payout rate; and (3) that the firm's objective in determining its financial policy is the minimization of its cost of capital. To solve the problem of the zero dividend payout rate corner solution, they restrict the growth rate of the firm to be less than (or equal to) the exogenously given growth rate of the labor force. With these assumptions, they find that taxation is not neutral vis-à-vis the debt equity ratio and the dividend payout rate or vis-à-vis the net-of-tax rates of return earned on both equity and debt investments.

Another study that focuses exclusively on the impact of taxation on corporate financial policy is that of Ballentine and McLure (1980). In that study, a model of corporate financial policy is integrated into the Harberger general equilibrium model of the incidence of the corporate

income tax. Their objective is to analyze the economic impact of integrating corporate and personal income taxes. Like Feldstein, Green, and Sheshinski (1979), Ballentine and McLure assume that an objective of the firm is the minimization of its financial cost of capital, and that, as the debt-equity ratio rises, investors require higher risk premiums on both debt and equity. Ballentine and McLure find that corporate tax integration would reduce the cost of equity capital and, as a consequence, the firm's debt-equity ratio.

We are unaware of the existence of any macroeconomic model focusing exclusively on the effects of taxes on corporate financial policy.

MODELS OF TAXATION, FIRMS' FINANCIAL POLICY, AND REAL INVESTMENT

It is clear that the financial cost of capital is the link between the real and financial sectors of the economy. It is the discount rate that firms use in evaluating real investment projects. It is through the financial cost of capital that the effects of taxation on financial policy influence real investment. Here, we begin by summarizing important results concerning the financial cost of capital, and then discuss models that link taxation, firms' financial policy, and real investment.

Taxation and the Financial Cost of Capital

The theory of the financial cost of capital is, to say the least, unsettled.¹³ In their seminal article, Modigliani and Miller (1958) showed that in a world of certainty, of perfect capital markets, and without taxes, financial policy is irrelevant and the appropriate financial cost of capital is then, undistinguishably, the cost of debt or the cost of equity. By relaxing the assumption of no taxes, Modigliani and Miller (1963) argue that the firm should finance marginally by debt and that the financial cost of capital should be a weighted average of the cost of debt and the cost of equity. They are, however, unclear as to the determination of the weights. On the other hand, Stiglitz (1974) argues that even in a world with taxes, provided there is no bankruptcy, the firm's financial policy does not matter and the appropriate financial cost of capital is the before-tax cost of debt.¹⁴ King (1974) finds that

the financial cost of capital depends on optimal financial policy but that, assuming historically reasonable values for tax parameters, firms will never issue new share or pay dividends.

In an important study, Auerbach (1979) finds that the firm should proceed in two steps to maximize the wealth of its shareholders. First, the firm should determine the financial policy that minimizes the financial cost of capital faced in each period. Second, the firm should use the minimized financial cost of capital as its discount rate in determining the optimal investment strategy.

Auerbach (1979), however, derives puzzling results concerning the firm's financial policies and cost of capital. In particular, under the assumption of no bankruptcy, he finds that the firm should never pay dividends and issue equity at the same time. Furthermore, under the additional assumption of no new shares, he finds that the financial cost of capital does not depend on the tax rate on dividend income (hence on the dividend payout rate) and, as King (1974) found, that the firm's debt-equity ratio depends on the shareholders tax attributes and is thus indeterminate. The key assumption underlying Auerbach's result that the financial cost of capital does not depend on the tax rate on dividend income is the assumption that no new shares are issued.¹⁵ Another puzzling result of Auerbach's study is that if the firm can invest in financial assets, then it should never distribute dividends.

Models of the Joint Impact of Taxation on Debt Financing and Real Investment

Very few models have been proposed in the literature to measure the joint impact of taxation on debt financing and real investment.¹⁶ Dotan and Ravid (1985) and Dammon and Senbet (1988) link theoretically the leverage decision to the investment decision by endogenizing real investment in the DeAngelo and Masulis (1980) capital structure model. In addition to the traditional result that investment policy depends on debt policy through the financial cost of capital variable, they find that debt policy itself depends on investment policy. Their argument is basically the following: the value of interest deductibility depends on the volume of the nondebt-related tax shields; a significant component of the nondebt-related tax shields, namely depreciation, depends on investments made by firms; and therefore

the debt decision depends on the investment decision.¹⁷ A limitation of their models is that they ignore the role of dividend taxation on debt financing and real investment. In addition, while their result that debt policy and investment policy has definite theoretical value, its value for empirical work is dubious because this dependency is only the result of a feedback (second-order) effect whose magnitude is greatly reduced by the loss carry-forward provisions in the tax code.

As mentioned earlier in this article, Chirinko (1987a) endogenizes the debt financing decision in the Q model of investment behavior. The empirical results are disappointing.

Models of the Joint Impact of Taxation on Dividends and Real Investment

Until recently, the joint impact of taxation on dividends and investment had been virtually ignored in the literature. There are, of course, models that relate dividends to real investment (e.g., Fama 1974) but they usually ignore the role of taxation. In fact, in the modern literature, there is only the model of Fazzari, Hubbard, and Petersen (1987, 1988), which concentrates exclusively on the joint impact of taxation on dividends and real investment. The key assumption in their model is that some firms face external financing constraints because of imperfections in the capital markets. Hence they derive that cash flow is relevant to the investment decision and conclude that dividends and tax policies that influence cash flow also influence real investment.

Models of the Joint Impact of Taxation on Dividends, Debt Financing, and Real Investment

There exist several empirical studies that relate dividends, debt financing, and real investment. But most of these studies have as their sole objective the testing of the Modigliani-Miller theorem and ignore the influence of taxation on corporate real and financial decision. (See, for example, Dhrymes and Kurz 1967; McCabe 1979; Peterson and Benesh 1983.)

Among the early attempts to model empirically the joint impact of taxation on dividend distribution, debt financing, and real investment are the studies of Brimmer and Sinai (1976) and Graddy and Strauss

(1984). In these studies, the real and financial decisions are linked by incorporating financial flow of funds constraints into a Jorgensonian formulation of investment behavior. Such an approach may be sensible because, at least from an accounting point of view, real investment expenditures are related to the financial flow of funds. On the other hand, by relying heavily on accounting identities, these models are not causal and thus provide little insight into the determinants of the real and financial decisions.

More recently, Nadeau (1988) proposes a model of the real and financial decisions of the firm that can be used to measure the total impact of taxation on corporate investment and financing behavior. The advantages of this model over the models previously cited are fourfold. First, the model is complete in the sense that both the dividend decision and the debt financing decision are treated as endogenous. Second, the model is derived from first principles (i.e., wealth maximization) and is therefore causal. Third, the predictions of the model are in accordance with the following stylized facts about corporate financing behavior.

1. Firms are financed both by debt and equity.
2. Firms that are highly leveraged pay a higher cost of debt.
3. It is common for firms to pay dividends and issue equity at the same time.

Fourth, this model is empirically verified and its parameterization is based on actual economic data. This model is therefore ideal for the simulation of the impact of the TRA86 on the real and financial decisions of the firm. The model is summarized in the following section.

A SIMULATION MODEL

The macroeconomic model used below to simulate the effects of TRA86 is based on Nadeau (1988). Figure 1 summarizes schematically the model and Table 1 lists the endogenous and exogenous variables. As in Auerbach (1979), the firm's investment-financing process is viewed as a two-step procedure.¹⁸ First, the firm chooses the

TABLE 1: The Variables in the Model

Endogenous variables	
λ^*	: the dividend payout rate
RS	: the before-tax real cost of equity
P^*	: the proportion of external funds coming from debt
RB	: the before-tax real cost of debt
R	: the before-tax real cost of funds
\bar{P}_k	: net-of-tax purchase price of real capital
r	: the real discount rate
c	: the rental price of capital
I^*	: investment target
i	: realized investment
Exogenous variables	
τ_p	: accrual equivalent capital gains tax rate
τ_d	: personal income tax rate
τ_u	: corporate tax rate on undistributed earnings
τ_e	: corporate tax rate on distributed earnings
ρ	: stockholder's opportunity cost of not investing funds in assets other than equity
$\bar{\xi}$: inflation rate in the price of capital goods
δ	: rate of decay of capital stock
δ_e	: rate of economic depreciation
l	: riskless rate of interest
u	: long-term expected inflation rate
P_k	: supply price of real capital goods
ITC	: rate of Investment Tax Credit
Z	: depreciation schedule
v	: inflation rate in labor wage
Y	: expected output level
w	: labor wage

the firm decides on a dividend payout rate, which affects the cost of equity financing. Second, given the cost of new equity financing and the cost of debt, the firm chooses the mixture of debt and equity that minimizes the financial cost of capital.

The econometric model specifies the firm's decision variables and is composed of three equations: a dividend equation, an external financing mix equation, and an investment equation.

THE DIVIDEND EQUATION

In our model, the firm chooses a dividend payout rate that comprises optimally between the intrinsic value of dividends and the tax penalty

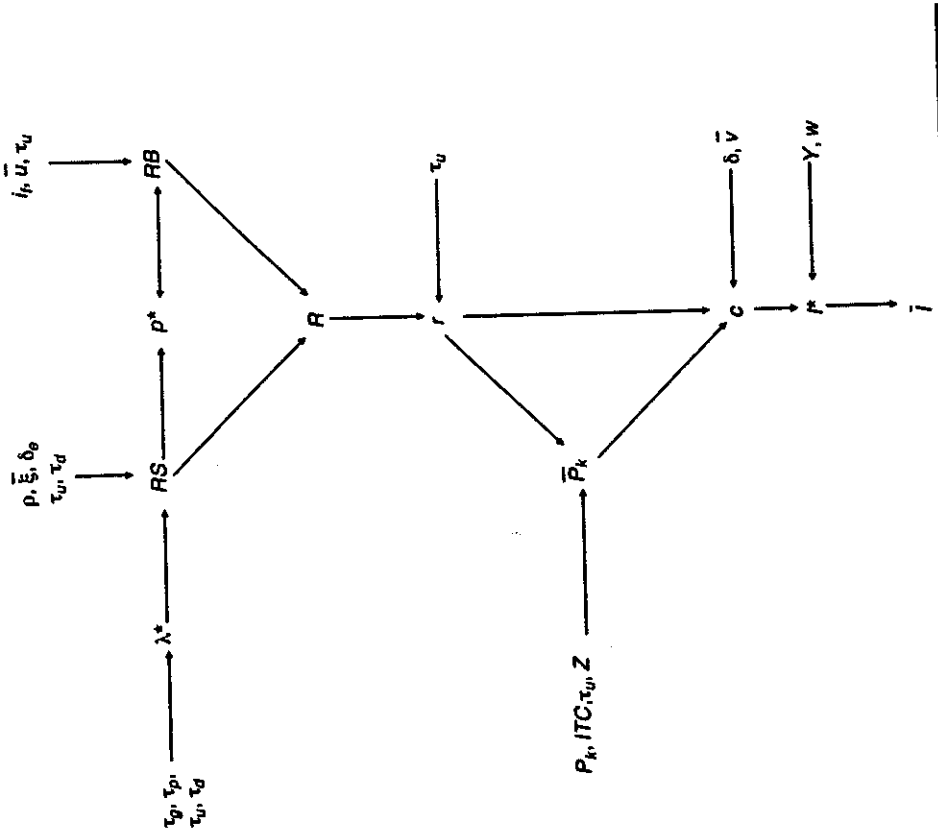


Figure 1: The Real and Financial Decision Process

financial policies that minimize its financial cost of capital. Second, the firm uses the minimized financial cost of capital as its discount rate in determining its optimal investment strategy. However, unlike in Auerbach (1979), dividends here are presumed to have some intrinsic value, and firms are expected to issue equity. As a result, dividend payout is not irrelevant in this model, and the minimization of the financial cost of capital is itself also a two-step procedure. First,

on dividends. A key assumption is that the intrinsic value of dividends is a concave function of the payout rate.¹⁹

Let λ denote the dividend payout rate, τ_d denote the accrual equivalent capital gains tax rate, τ_p denote the representative shareholder personal income tax rate, and θ denote the tax opportunity cost of retained earnings in terms of dividends foregone. That is,

$$\theta = \frac{1 - \tau_p}{1 + \tau_d - \tau_p - \tau_e}$$

where τ_e is corporate tax rate on undistributed earnings, and τ_e is the corporate tax rate on distributed earnings.²⁰ For econometric convenience, it is assumed that the intrinsic value of dividends takes the form:

$$\psi(\lambda) = \omega\lambda + \beta\lambda^\gamma$$

where α , β , and γ are constants. Thus the benefit of a payout rate, λ , to a typical shareholder is

$$SB(\lambda) = \omega\lambda + \beta\lambda^\gamma + [(1 - \tau_d)(1 - \lambda) + (1 - \tau_p)\theta\lambda],$$

which is maximized when the payout rate is equal to

$$\lambda^* = A_\lambda[(1 - \tau_d) - (1 - \tau_p)\theta - \omega]^{1/\gamma} \quad (2)$$

where $A_\lambda = (\gamma\beta)^{\gamma-1}$ and $B_\lambda = 1/\gamma-1$. The assumption that the intrinsic value of dividends is a concave function of the payout rate implies that α and A_λ are greater than zero and that B_λ is less than zero. Thus, according to this model, the optimal payout rate is an exponentially decreasing function of the tax penalty on dividends.

To relate the optimal payout rate to the observed payout, we postulate the existence of a partial adjustment process similar to Lintner (1956). Thus, given equation (2), we model the observed payout rate as:

$$\lambda_t = (1 - \alpha_\lambda)\lambda_{t-1} + \alpha_\lambda A_\lambda \{[(1 - \tau_{d,t})\theta_t - \omega]^{1/\gamma} + s_{\lambda,t}\} \quad (3)$$

where α_λ is a response adjustment constant ($0 < \alpha_\lambda < 1$) and $s_{\lambda,t}$ is a stochastic error term. Equation (3) can be readily estimated by maximum likelihood methods.

THE EXTERNAL FINANCING MIX EQUATION

Let p represent the proportion of external funds coming from new debt issuances, RB represent the unit cost of debt, and RS represent the cost of new equity capital. Thus the before-tax cost of financing a unit of capital using external funds is:

$$R = pRB + (1 - p)RS. \quad (4)$$

We assume that the supply of saving is inelastic, that technology is constant returns to scale, and that the firm always has sufficient EBIT to claim interest expense. As a result, the cost of debt can be modeled as an increasing function of leverage and as an independent function of the capital stock.²¹ More specifically, we let i denote the before-tax, real riskless rate of interest:

$$i = i_f - \frac{\bar{u}}{1 - \tau_u}$$

where i_f is the riskless rate of interest, \bar{u} is the long-term expected inflation rate in the price of consumer goods, and we specify the before-tax real cost of debt as:

$$RB = i + b_1 p^{b_2} \quad (5)$$

where b_1 and b_2 are parameters such that $b_1 > 0$ and $b_2 > 1$.

The cost of equity capital is the rate of return on a dollar of equity-financed investment that must be achieved by the firm so that the suppliers of capital obtain a rate of return on their investment equal to the rate of return they could obtain by investing their funds in other assets of the same risk class. Let ξ denote the inflation rate in the price of real capital goods; δ_e denote the rate of economic depreciation; and ρ denote the stockholders opportunity cost of not investing funds in

assets other than equity. Under these conditions, and based on Nadeau (1988), the before-tax real cost of equity capital is:

$$R_S = \frac{\rho - [\bar{E}(1 - \delta_2) - \delta_2] \cdot (1 - \tau_k)}{[\omega\lambda + \beta\lambda' + (1 - \tau_p)\theta\lambda + (1 - \tau_k)(1 - \lambda)] \cdot (1 - \tau_u)} \quad (6)$$

Thus, according to this model, the cost of equity capital varies inversely with the benefit that shareholders receive from a payout rate λ and is therefore influenced by the firm's dividend policies.

Using equations (5) and (6), the financial mix minimizing equation (4) is:

$$P^* = A_p \cdot (RS - i)^{B_p}$$

where $A_p = [1/b_1(b_2 + 1)]^{1/b_2}$ and $B_p = 1/b_2$. Assuming the existence of a typical partial-adjustment process toward the optimal financing mix, we express the observed financing mix by:

$$P_t^* = (1 - \alpha_p) \cdot P_{t-1} + \alpha_p \cdot A_p \cdot (RS_t - i_t)^{B_p} + \varepsilon_{p,t} \quad (7)$$

where α_p is the response adjustment constant ($0 < \alpha_p < 1$) and $\varepsilon_{p,t}$ is a stochastic error term.

THE INVESTMENT EQUATION

Assume that the firm faces a problem of cost minimization rather than profit maximization; that there are two productive factors — capital and labor; that there are no delivery lags; and that the financial markets are perfect. Assume also that a Cobb-Douglas production function with constant returns to scale is used; that capital is putty-clay; and that the productivity of capital decays exponentially at a rate δ . Assume further that the firm acts as if labor wages (w) will increase at a constant rate v ; that the firm's expectations about future output demand, denoted Q_{t-1} , are economically rational (see Feige and Pearce 1976); and that the firm uses its current after-tax cost of funds, that is,

$$r = (1 - \tau_u)R_p$$

as the discount rate for future costs. Let \bar{P}_k denote the net-of-tax purchase price of real capital goods:

$$\bar{P}_k = P_k \cdot (1 - ITC - \tau_p PVDA(r))$$

where P_k is the supply price of capital goods, ITC is the rate of investment tax credit and $PVDA\{r\}$ is the present value of depreciation allowances, which is a function of the firm's discount rate r . Under these conditions, it is shown in Appendix A that the rental price of capital is

$$c_t = \frac{\bar{P}_{k,t} \cdot [1 + r_t - (1 + v_t)(1 - \delta)]}{(1 - \tau_{k,t})}$$

and that real investment at time t is

$$I_t = B \cdot \left(\frac{w_t}{c_t}\right)^\mu \cdot \Delta Y_{t-1} \quad (8)$$

where μ is the elasticity of output with respect to labor, B is a scaling constant, and ΔQ_t is the expected value of the gross increment in output given information available at time $t - 1$:

$$\Delta Y_{t-1} = Y_{t-1} - (1 - \delta)Y_{t-1}$$

Henceforth, equation (8) will be referred to as planned (or targeted) investment.

Completing a planned investment requires, in general, expenditures over a certain number of periods. To model these necessary lags, we assume that in each time period in the planning interval ($t-t, t$), the firm orders a portion of the discrepancy between the investment need it anticipates for t and the previous orders it made to be delivered at t . Consequently, realized investment at time t takes the form of a distributed lag of investment needs anticipated in the previous time

periods for time t . To model the firm's anticipations about future investment needs, we make the additional assumptions that the price of capital goods will increase at a rate $\bar{\xi}$ in the future and that the cost of debt will remain constant. Incorporating these considerations into equation (8) and extending the approach used to predict output one period ahead, we may write investment expenditures at time t as:

$$\bar{I}_t = \sum_{j=0}^h \phi_j \cdot \left(\frac{w_{t-j}}{c_{t-j}} \right)^\mu \cdot \Delta Y_{t-j-1} + \varepsilon_{I,t} \tag{9}$$

where

$$w_{t-j} = w_{t-j} (1 + \bar{v}_{t-j}),$$

$$c_{t-j} = \frac{\bar{P}_{K,t-j} (1 + \bar{\xi}_{t-j}) \cdot [1 + r_{t-j} - (1 + \bar{v}_{t-j}) (1 - \delta)]}{(1 - \tau_{w,t-j})},$$

$\Delta Y_{t-j-1} = Y_{t-j-1} - (1 - \delta)Y_{t-j-2}$, and $\varepsilon_{I,t}$ is a stochastic term.

The expression in equation (9) for investment responds to several of the criticisms of the traditional Neoclassical investment model, previously noted. First, unlike the traditional Neoclassical model, equation (9) is forward-looking. On the other hand, unless expectations are formulated exactly as assumed, it is not based on rational expectations. Compared to the Q model, however, equation (9) has several advantages. The most important ones are that it allows for the measurement of the impact of taxation on investment via financing, that it is not based on the ad hoc assumptions that adjustment costs are quadratic, and that its empirical implementation does not require the use of noisy stock market data.

AN ESTIMATED MODEL

The estimation of the model described above is performed using U.S. aggregate time-series data. The investment variable that is esti-

TABLE 2: The Estimated Model

The payout rate equation:

$$\hat{\lambda}_t = (1 - 0.336)\lambda_{t-1} + 0.336 \cdot 0.315 \cdot [(1 - \tau_p)_t - (1 - \tau_{p,t})\theta_t - 0.273] \cdot \frac{-0.022}{(0.01)} \tag{0.03} \tag{0.01}$$

$$\hat{R}^2 = 0.938; \hat{\rho}_\lambda = -0.05.$$

The external financing mix equation:

$$\hat{\rho}_t = (1 - 0.155)\rho_{t-1} + 0.155 \cdot 1.096 \cdot (RS_t - i_t) \cdot \frac{0.253}{(0.05)}$$

$$\hat{R}^2 = 0.988; \hat{\rho}_\rho = -0.01.$$

The investment equation:

$$\hat{I}_t = 0.057 \cdot \left[\frac{w_{t-1}}{c_{t-1}} \right] \cdot \frac{0.937}{(0.12)} \cdot \Delta Y_{t-1} + 0.034 \cdot \left[\frac{w_{t-1}}{c_{t-1}} \right] \cdot \frac{0.937}{(0.12)} \cdot \Delta Y_{t-2} - 12.12D_t \tag{0.01} \tag{2.8}$$

$$\hat{R}^2 = 0.965; \hat{\rho}_I = -0.31.$$

Cross-correlation of residuals:

$\hat{\varepsilon}_\lambda$	$\hat{\varepsilon}_\rho$	$\hat{\varepsilon}_I$
1.00	-0.25	0.19
$\hat{\varepsilon}_\rho$	1.00	-0.23
$\hat{\varepsilon}_I$		1.00

NOTE: Asymptotic standard errors are between parentheses. The interpretation of \hat{R}^2 is difficult here because there is no intercept in the equations. ρ refers to the autocorrelation coefficient of order 1 of the residuals.

mated is producer's durable equipment. Data cover the period from 1934 to 1980 and a description of the key variables is given in Appendix B. The parameters of the model are estimated by the maximum likelihood method. The estimated model is presented in Table 2. It appears that the coefficients of the models are, in general, statistically significantly different from zero. It also appears that the residuals are not significantly autocorrelated over time²² and not significantly correlated across equations. On the other hand, our model probably overestimates labor's share of income [the coefficient μ in equation (9)]. Its estimated value is 0.937 while its true value has averaged about 0.7 (for the economy as a whole) over the last forty-

five years. This result does not discredit our model however, because the probability of obtaining an estimate of μ of 0.937 or higher, if the true value is 0.7, is about 2.3%, which is not negligible.²³

THE EFFECTS OF THE TAX REFORM ACT OF 1986

The model in the preceding section allows us to measure the impact of some of the most salient provisions of the Tax Reform Act of 1986 (TRA86). The key parameters relevant for both the old law (that is, the Economic Recovery Tax Act, or ERTA) and TRA86 are listed in Table 3. With respect to personal income taxation, TRA86 lowered the tax rate on personal income and removed the capital gains exclusion. With respect to corporate taxation, TRA86 lowered the tax rate on corporate income, removed the Investment Tax Credit, and lengthened the average recovery periods for new post-1986 capital assets.²⁴ TRA86 also included a number of changes that are too industry-specific to be modeled here. It is also worth noting that because of the repeal of the Investment Tax Credit, machinery and equipment is the type of corporate asset most adversely affected by TRA86.

METHODOLOGY

The methodology used to estimate the effects of TRA86 is based on counterfactual simulations. The counterfactual results of simulating TRA86 are compared with the counterfactual results of simulating the relevant tax provisions in ERTA over the period from 1975 to 1980. In other words, the analysis presented in this article is the result of the following four step procedure:

1. Estimation of the coefficients of the model with the 1934-1980 data;
2. Simulation of the provisions in ERTA over the years 1975 to 1980 to obtain a benchmark estimate of the endogenous variables;
3. Simulation of the provisions in TRA86 over the years 1975 to 1980 to obtain a different set of estimates for the endogenous variables;
4. The difference between the output of step 2 and the output of step 3 constitutes the impact of TRA86.

TABLE 3: Parameters under ERTA and TRA86

	ERTA	TRA86
Individual income taxation		
Personal income tax rate (τ_p)	0.50	0.33
Capital gains exclusion	0.60	0.00
Corporate income taxation		
Profit tax rates (τ_c, τ_e)	0.46	0.34
Investment Tax Credit for equipment (ITC)	0.10	0.00
Depreciation schedule for equipment (Z)		
year 1	0.17	0.18
2	0.28	0.30
3	0.19	0.19
4	0.16	0.12
5	0.13	0.11
6	0.07	0.07
7	0.00	0.03
8	0.00	0.01

This approach to simulation eliminates the need to forecast, or assume, future values for the exogenous variables of our model (e.g., inflation rates, wage rates). The period from 1975 to 1980 was chosen arbitrarily; it is recent enough to have some relationship with what may happen in the economy in the near future, and it is long enough to allow the analysis of the dynamics of the system.

A consideration in the simulation of the effects of TRA86 is the relationship between taxes and output. In our simulation, we considered output as given. This is an oversimplification. On the other hand, to have specified complete and credible relationships between taxes and output would have gone far beyond the scope of this article in that it would have required the specification of a complete macroeconomic model.²⁵

Another consideration is the relationship between taxes and the riskless rate of interest i . The model summarized in the previous section takes i as given. On the other hand, TRA86 is expected to affect interest rates.²⁶ By reducing marginal tax rates, TRA86 increases after-tax returns on interest-bearing investments and thus increases the demand for bonds.²⁷ There is no consensus in the literature on the elasticity of saving with respect to after-tax rates of return.²⁸ Hence we

conduct our simulations under two polar scenarios. The first scenario corresponds to the assumption that TRA86 will not influence i_f . This scenario yields lower bounds for the effect of TRA86 on financing and investment. The second scenario corresponds to the assumption that the change in i_f is commensurate to the change in the highest marginal statutory tax rate on personal income. More specifically, we assume under Scenario 2 that the riskless rate of interest becomes

$$i_{f2} = i_f \cdot \frac{(1 - \tau_p)}{(1 - \tau_p^*)} = 0.74i_f,$$

where the variables superscripted * refer to values under TRA86. This formula is based on the assumption that the real after-tax interest rate arbitrages to the lender's nominal rate of time preference and hence that the elasticity of i_f with respect to $(1 - \tau_p)$ is -1 . This scenario yields upper bounds for the effects of TRA86 on financing and investment variables.

RESULTS

The results of our simulations are reported in Table 4. These figures are percentage changes of average values computed over the simulation period. The first four columns in the table report the partial effects of the changes in the exogenous variables. The fifth column reports the combined effects of the changes.

Impact on Financing

In reducing the differential between the tax rate on dividend income and the tax rate on capital gain income, TRA86 reduces significantly the tax advantage of retained earnings over dividends. According to our model, the estimated effect of this change is a 13.1% increase in the dividend payout rate. This increase is smaller than the one reported by Poterba (1987), who predicts a 20% dividend increase in the long run. The reason is that Poterba's estimate, unlike ours, depends on the level of after-tax corporate earnings.²⁹

The substantial increase in the payout rate, combined with the increase in the value to the shareholders of one dollar earned by the

TABLE 4: Impact of Tax Reform (in percentage relative terms)

Endogenous	Exogenous				Combined Effect
	New τ_p	New τ_d	New ITC	New Z	
λ	13.1%	0%	0%	0%	13.1%
RS	-14.4	-18.2	0	0	-29.9
RS - i_f	-14.6	-26.5	0	0	-38.5
RS - i_2	-6.4	-22.4	0	0	-26.6
ρ_1	-3.6	-6.8	0	0	-10.6
ρ_2	-1.6	-5.6	0	0	-6.9
RB ₁	-12.8	20.6	0	0	10.1
RB ₂	-304.4	138.4	0	0	-160.2
r_1	-9.7	23.0	0	0	11.6
r_2	-31.1	27.1	0	0	-9.0
\bar{P}_{K1}	-0.6	24.5	21.1	0.2	45.2
\bar{P}_{K2}	-1.5	25.5	21.6	0.2	46.0
c_1	-3.1	8.2	21.1	0.2	22.7
c_2	-7.5	8.2	21.6	0.2	17.4
i_1	3.0	-6.5	-15.1	-0.2	-15.8
i_2	7.2	-6.6	-15.5	-0.2	-12.8

NOTE: The variables subscripted 1 correspond to the scenario in which i_f is not influenced by tax reform, while the variables subscripted 2 correspond to the scenario in which i_f is influenced by tax reform.

firm (because of reduced personal and corporate income tax rates), is likely to reduce the cost of equity to the firm. Our model predicts that the real cost of equity will decrease by almost 30% in relative terms. This estimate is large. In particular, it is larger than the one reported by Downs and Hendershott (1987), who predict that the tax changes will raise equity values by 10% to 13%. One reason why their study yields a smaller estimate than ours is that they ignore the impact of changes in personal income tax rates.

Unlike previous researchers, we expect that TRA86 will reduce the corporate reliance on debt financing in the long run.³⁰ According to our model, tax reform will significantly reduce the tax advantage of debt financing over equity financing. In fact, in addition to a decrease in the real before-tax cost of equity, tax reform may increase the real

before-tax cost of debt,³¹ thus reducing further the desirability of debt over equity financing. According to our model, we can expect a reduction of between 26% and 39% in the advantage of debt financing over equity financing. A substantial decrease in leverage should therefore be expected in the long run. Because of the inertia in the system, however, only a 7% to 11% relative decrease in leverage is predicted in the short run. From a broader policy point of view, this result implies that tax reform will reduce the risk of bankruptcy and its associated social cost. This result should be welcome by those who are concerned with the current high level of firms' indebtedness in the U.S. (see, for example, Bernanke and Campbell 1988).

TRA86 is expected to affect the real cost of debt in at least three ways. First, the decrease in personal income tax rates is expected to reduce leverage and thereby reduce the risk premium component of the cost of debt. Second, the decrease in corporate income tax rates reduces the value of interest deductions for tax purposes and therefore raises the after-tax cost of debt. Third, the decrease in personal income tax rates may reduce the riskless rate of interest. The total effect of tax reform on the real cost of debt is thus a priori ambiguous: The decrease in personal income tax rates reduces the real cost of debt, whereas the decrease in corporate tax rates increases the real cost of debt. However, we cannot expect the reduction in the risk premium to be large enough to compensate for the reduction in the value of interest deductions for tax purposes (at least in the short run). Hence the combined effect of the tax changes on the cost of debt depends primarily on the relationship between taxation and the real riskless rate of interest. If we assume that the riskless rate of interest will not be affected by tax reform, our model predicts a 10.1% relative increase in the real cost of debt. If we assume, however, that the real riskless rate of interest will adjust fully to the changes in personal income tax rates, our model predicts close to a 150% relative decrease in the real cost of debt.

From these results, we can infer that the decrease in both personal and corporate income tax rates brought about by tax reform should reduce the real after-tax financial cost of capital, that is, the firm's discount rate, in the long run. However, because of the slowness of the adjustment process in the system, the shift toward equity financing may not be rapid enough to compensate for the increase in the after-tax

cost of debt in the short run. Hence our model predicts that, in the short run, tax reform may actually result in an 11.6% relative increase in the firm's discount rate if the riskless rate of interest is left unchanged. This affects the investment decision as shown below.

Impact on Real Investment

There is no agreement in the literature on the importance of the effects of tax policy on investment behavior. For example, Chirinko and Eisner (1983) and Chirinko (1987b) find that the impact of tax policy on net investment is negligible, whereas Feldstein (1982, 1987) finds that taxation can have significant adverse effects on capital formation. Our model indicates that investment is very sensitive to tax policy and suggests that TRA86 substantially reduces capital investment in machinery and equipment.

According to our model, TRA86 affects two components of the rental price of machinery and equipment capital. First, it affects the firm's discount rate. This effect may, as we have seen, be positive or negative in the short run depending on the impact of personal taxes on debt rates. Second, the elimination of the investment tax credit and the reduction in the present value of the stream of depreciation deductions (because of reduced corporate tax rates and a longer depreciation schedule) are expected to increase substantially the net-of-tax purchase price of machinery and equipment capital: We estimate this increase to be approximately 45%. The combination of these two effects is expected to yield an increase of between 17% and 23% in the rental price of machinery and equipment capital depending on the extent to which debt rates will be influenced by the changes in personal income tax rates. This estimate is substantially lower than the one reported by Hendershott (1988), who predicts an increase of between 65% and 90% in the rental price of machinery and equipment capital; the principal reason is that he ignores the impact of the reduction in personal income tax rates via the financial variables. It is also important to note that the increase in the rental price of machinery and equipment capital that we estimate stems principally from the removal of the investment tax credit.³² This is in accordance with Musgrave's (1987) observation that lower corporate tax rates would not be likely

to counterbalance the negative impact of the repeal of the Investment Tax Credit.

Finally, according to our model, tax reform is expected to substantially reduce new corporate investment in machinery and equipment: We predict a decrease of between 13% and 16%. We remind the reader that this estimate is, however, the result of a partial analysis in that it ignores the effects of tax reform on output. There are reasons to believe that tax reform may actually increase output, which would offset somewhat the reduction in investment incentives. For example, it is argued that tax reform will encourage growth by reducing inefficiencies and tax distortions (see, for example, Gravelle 1989). Although this would decrease our negative estimate of the impact of tax reform on investment, it is doubtful that it could offset completely the negative impact of the reduction in investment incentives.³³

SENSITIVITY ANALYSIS

The model used in the preceding section to simulate the impact of the TRA86 was parameterized with data for the period from 1975 to 1980 for the exogenous variables and with statistically estimated coefficients. This approach is objective and unbiased; it is objective because it is based on assumptions that are supported by the data, and it is unbiased because, given the exogenous conditions prevailing during the estimation period, the simulation model reproduces the observed values of the endogenous variables during the simulation period. On the other hand, this approach yields results whose precision depends on whether the values of the exogenous variables are realistic beyond the estimation period and on the sampling distribution of the estimated coefficients. With respect to our model, the values of at least one class of exogenous variables and one coefficient may be deemed unrealistic. The exogenous variables are the inflation rates; the coefficient is the labor's share of income μ . In this section, we examine the impact on our simulation results of using "more" realistic values for these parameters than those used in the previous section.

The period from 1975 to 1980 was a period of extraordinarily high inflation. For that reason, we simulate here the impact of TRA86

assuming that expectations about long-run inflation rates are currently 2% lower than they were in that period. To perform this simulation we need to make some assumptions regarding the relationship between inflation and the other exogenous variables. It is assumed that inflation is output-neutral, but that the interest rate variables ρ and i_t are affected in the following manner by a change ($\Delta\pi^e$) in expected inflation rates:³⁴

$$\rho^* = \rho + \Delta\pi^e,$$

$$i_t = i_t + \frac{\Delta\pi^e}{1 - \tau_p}$$

in Scenario 1, and

$$i_t = \left(i_t + \frac{\Delta\pi^e}{1 - \tau_p} \right) \left(\frac{1 - \tau_e}{1 - \tau_p} \right)$$

in Scenario 2, and where the variables superscripted * refer to values under TRA86. According to Table 5, if it is assumed that nominal interest rates are not influenced by income tax rates, than a 2% lower expected inflation rate dampens the impact of TRA86 on investment in machinery and equipment (from a 15.8% reduction to a 14% reduction). On the other hand, if it is assumed that the elasticity of nominal interest rates with respect to $(1 - \tau_p)$ is -1, then a 2% lower expected inflation rate magnifies the reduction in investment (from a 12.8% decrease to a 13.6% decrease). These results indicate that the estimated impact of TRA86 is not overly sensitive to the choice of the long-run expected inflation rates.

The other parameter of our simulation model whose value may be deemed unrealistic is the labor share of income μ . The estimated value of μ is 0.937 which is, as pointed out earlier, much larger than the observed ex post average value of 0.7. Using this smaller value for μ reduces, of course, the magnitude of the impact of TRA86 on investment but does not affect the impact of TRA86 on financial variables. The impact of TRA86 on investment is reduced by about 24% (under both scenarios). The remaining impact is still far from negligible.

CONCLUSION

This article reviewed models of the impact of taxation on the real and financial decisions and used such a model to estimate the impact of TRA86. This methodology allowed us to obtain richer and possibly more reliable estimates of the impact of TRA86 than previous studies that have ignored the link between the real and financial decisions. In particular, we expect TRA86 to increase the dividend payout rate, to significantly reduce the real cost of equity, and to reduce the tax advantage of debt financing over equity financing. Because of the increased desirability of equity financing over debt financing, we expect, unlike previous studies, a decrease in leverage and hence a decrease in the likelihood of bankruptcy and its associated social costs.

The impact of TRA86 on the real after-tax financial cost of capital is, on the other hand, ambiguous: Our estimate of the impact on the real after-tax financial cost of capital varies between a 9% relative decrease and an 11.6% relative increase, depending on our assumption about the impact of the reduction in personal income tax rates on debt rates. The 9% relative decrease corresponds to the assumption that a change in the highest marginal statutory tax rate on personal income will result in a commensurate change in the riskless rate of interest. The 11.6% relative increase corresponds to the assumption that nominal debt rates are not influenced by changes in personal income tax rates.

Irrespective of the sign of its impact on the cost of funds, however, our model estimates that TRA86 increases significantly the rental price of machinery and equipment capital. This increase is principally due to the removal of the investment tax credit. We must point out, however, that our estimate is significantly smaller than estimates proposed elsewhere (e.g., Hendershott 1988). One reason is that we account for the reduction in personal income taxes, which affects favorably the rental price of capital through the financial variables.

Given the estimated increase in the rental price of machinery and equipment capital, and ignoring the effect of TRA86 on output, our model predicts a substantial decrease in corporate investment in machinery and equipment: a decrease of more than 12%. The robustness of these results to changes in the parameters of the simulation model was confirmed by a sensitivity analysis. Finally we should point

TABLE 5: Impact of Tax Reform (subjective parameters)

Endogenous	Parameters	
	$\Delta\pi^0 = -2\%$	$\mu = .7$
λ	13.1%	13.1%
RS	-31.2	-29.9
RS - i_1	-30.7	-38.5
RS - i_2	-28.9	-26.6
P_1	-8.1	-10.6
P_2	-7.6	-6.9
RB ₁	-43.8	10.1
RB ₂	-456.5	-150.2
r_1	-0.8	11.6
r_2	-6.0	-9.0
\bar{P}_{K_1}	46.2	45.2
\bar{P}_{K_2}	46.4	46.0
c_1	19.6	22.7
c_2	18.6	17.4
i_1	-14.0	-11.8
i_2	-13.6	-9.5

NOTE: The variables subscripted 1 correspond to the scenario in which i_1 is not influenced by tax reform, while the variables subscripted 2 correspond to the scenario in which i_2 is influenced by tax reform.

What we can conclude from this sensitivity analysis is that our simulation results are quite robust to changes in the parameters of the model. The basic result that TRA86 will substantially reduce corporate investment in machinery and equipment is left intact. The reason is actually quite simple. The rental price of capital variable is more sensitive to variations in the Investment Tax Credit than in the financial cost of capital variable. Hence the 100% reduction in the Investment Tax Credit would need to be compensated by a more than 100% reduction in the financial cost of capital for TRA86 to be investment-neutral. None of our simulations comes close to predicting such a large reduction in the financial cost of capital.

out that the results of this study cannot be used to make inferences about the impact of TRA86 on corporate investment other than machinery and equipment because machinery and equipment was by far the component of corporate investment most adversely affected by the reform.

As a postscript to this study, we examine very briefly the impact of the currently informally discussed proposals of allowing a 40% capital gains exclusion. Our model predicts that this tax change would not significantly affect either the financial cost of capital or corporate investment in machinery and equipment: a 0.01% reduction is shown in the financial cost of capital and a 0.01% increase is shown in investment in machinery and equipment (irrespective of the impact of the reduction in personal income tax rates on debt rates).

APPENDIX A

Derivation of the Investment Equation

To derive our investment equation, we assume that the objective of the firm is to minimize the present value of the cash outflow incurred producing the stream of outputs $\{Y_t\}$, subject to the constraints of a production function. Let $I_{t,s}$ denote the quantity of capital of vintage t still in operation at time s , $Y_{t,s}$ denote the quantity of output produced on $I_{t,s}$ and $L_{t,s}$ denote the amount of labor assigned to $I_{t,s}$. Thus, given some production function F , $Y_{t,s}$ is subject to the following production constraint:

$$Y_{t,s} = F(I_{t,s}, L_{t,s}).$$

For convenience, let I_t denote investment at time t ; that is, $I_t = I_{t,t}$. In addition to its net-of-tax considerations purchase cost $P_t I_t$, an investment I_t will incur a sequence of additional wage costs of the form $(1 - \tau_w)_t w_t L_{t,t+p}$ ($1 - \tau_{w,t+1}) w_{t+1} L_{t,t+1}, \dots$, with a total present value at time t of

$$\sum_{s=t}^{\infty} (1 - \tau_{w,t+s}) w_{t+s} L_{t,t+s} \left(\frac{1}{1+r_s} \right)^{s-t}.$$

Thus at time $t = 0$, the firm must choose the sequence of investment expenditures $\{I_t\}$ and the associated sequence of labor inputs $\{L_{t,s}\}$, solving the minimization problem:³⁶

$$\min \sum_{t=0}^{\infty} \left[P_t I_t + \sum_{s=t}^{\infty} (1 - \tau_{w,t+s}) w_{t+s} L_{t,t+s} \left(\frac{1}{1+r_s} \right)^{s-t} \right] \cdot \left(\frac{1}{1+r_t} \right)^t \tag{A1}$$

subject to the production constraint

$$\sum_{s=0}^{\infty} F(I_{t,s}, L_{t,s}) = Y_t \quad \text{for all } t \tag{A2}$$

where

$$Y_t = \sum_{s=0}^{\infty} Y_{t,s}$$

The assumption that capital is putty-clay (i.e., constant capital-labor ratio) and decreases exponentially at a rate δ , as well as the assumption of constant returns to scale greatly simplify the minimization problem above. In fact, under those conditions, we have that

$$I_{t,s} = (1 - \delta)^{s-t} I_{t,t} \tag{A3}$$

$$L_{t,s} = (1 - \delta)^{s-t} L_{t,t} \tag{A4}$$

and that gross increment in output

$$\Delta Y_t = Y_t - (1 - \delta) Y_{t-1}$$

is given for all t . Thus the objective function (A1) becomes

$$\min \sum_{t=0}^{\infty} \left[P_t I_t + \sum_{s=t}^{\infty} (1 - \tau_{w,t+s}) \left(\frac{w_s}{1+r_s} \right) \left(\frac{1-\delta}{1+r_s} \right)^{s-t} L_{t,t} \right] \cdot \left(\frac{1}{1+r_t} \right)^t$$

and the constraint (A2) becomes³⁶

$$F(I_t, L_{t,p}) = \Delta Y_t \quad \text{for all } t.$$

Hence at each time period t the firm minimizes

$$C_t = \bar{P}_k A_t + \sum_{s=t}^{\infty} (1 - \tau_{u,s}) \left(\frac{w_s}{1 + r_s} \right) \left(\frac{1 - \delta}{1 + r_s} \right)^{s-t} \cdot L_{t,p}$$

subject to the constraint

$$F(I_t, L_{t,p}) = \Delta Y_t$$

If we make the additional assumptions that the firm acts as if tax variables will remain constant over the future; that wages will increase at a constant rate \bar{w} ; that the firm uses its actual cost of funds r_t as the discount rate for future costs; and that the production technology is Cobb-Douglas with an elasticity of output with respect to labor of μ , then it follows that at any time period t the firm must minimize, with respect to I_t and $L_{t,p}$ the function

$$C_t = \bar{P}_k A_t + \left(\frac{w_t(1 - \tau_{u,t})}{1 + r_t - (1 + \bar{w})(1 - \delta)} \right) \cdot L_{t,p}$$

subject to the constraint

$$A \cdot I_t^{1-\mu} \cdot L_{t,p}^{\mu} = \Delta Y_t.$$

Optimal investment at time t is thus

$$I_t = B \left(\frac{w_t}{C_t} \right)^{\mu} \cdot \Delta Y_t$$

where

$$C_t = \frac{\bar{P}_k A \cdot [1 + r_t - (1 + \bar{w})(1 - \delta)]}{(1 - \tau_{u,t})}$$

and B is a scaling term.

Assuming that the firm is risk neutral and denoting the expected value of ΔY_t given the information available at time $t - 1$ by ΔY_{t-1} yields equation (9) in the text.

APPENDIX B Data Estimates

An extensive description of the data used for estimating the econometric model presented in this article is given in Nadeau (1986) and is available on request. This appendix describes only key data.

The variable ρ was set equal to the post-tax rate of return on preferred stocks, and the variable i_p was measured as the yield on U.S. government long-term bonds. The payout rate λ was calculated as the ratio of cash dividend over cash flow. The variables Q and I were measured as Business Gross Product and Producer's Nonresidential Durable Equipment, respectively.

The tax rate variables used were the highest marginal statutory rates. The variable τ_g was constructed using the formula (Auerbach 1983):

$$\tau_g = \frac{(1 - g) - \{(1 - \bar{\tau}_g)[(1 + g)^T - 1] + 1\}^{1/T}}{g}$$

where g is the growth rate in value of the asset, τ_g is the capital gains tax rate, and T is the holding period for corporate equities. The existence of nonprofit entities was ignored in the computation of τ_g and τ_p .

There is no consensus in the literature on an appropriate value for the holding period of corporate stock. A frequently used rule of thumb is that the effective tax rate on capital gain is halved due to deferral, and halved again due to the exemption at death (see, for example, Poterba 1987; Gordon and MacKie-Mason 1990). Assuming a growth rate in the value of corporate stocks of 7%, this rule of thumb implies a holding period of approximately 70 years, which seems exceedingly long. On the other hand, based on a weighted average of the length of period held of corporate stock transacted in 1962, Nadeau (1988) uses a holding period of 3.8 years. However, this figure is probably too small because it ignores the exemption at death. The holding period that we use is between the two extremes discussed above: 40 years. This period length is suggested in Bailey (1969) and is based on a careful study of the relationship between accrued capital gains and realized capital gains. It is also used in Gravelle (1989).

NOTES

1. For example, Poterba (1987) examines in detail the effects of TRA86 on dividend payout rate, but he is unclear as to the effects on corporate borrowing and corporate investment. Pozdena (1987) and Warshawsky (1989) examine the effects of the reforms on corporate borrowing but

- ignore the effects on dividend payout and real investment. Downs and Hendershott (1987) analyze the direct impact of the reforms on stock prices and the rental price of capital but ignore the indirect impact via the dividend payout rate and the firm's leverage. Hendershott (1988) examines the impact of the reforms on economic growth in general, and real corporate investment in particular, but ignores the impact on corporate financial policy. Gordon and MacKie-Mason (1990) examine the impact on real corporate investment. Auerbach (1987) acknowledges the importance of linking the real and financial decisions when analyzing the impact of tax reforms, but, because of "the unsettled state of the theory" (Auerbach 1987, 76), carries out his analysis considering only alternative "polar" cases of the firm's financial decisions. Gravelle (1989) analyzes, in a general equilibrium framework the efficiency gain brought about by the TRA86 reduction in the differential between taxes on corporate and noncorporate capital, but neither the debt-equity ratio nor the dividend payout rate are endogenous in her model. Fullerton, Henderson, and Mackie (1987) also analyze the impact of TRA86 in a general equilibrium framework that treats the financial decisions as exogenous.
2. See, for example, Fazzari, Hubbard, and Petersen (1988), who find a relationship between the dividend decision and the investment decision. Nadeau (1988) finds that endogenizing the firm's financial decisions statistically improves the specification of the Neoclassical model of investment behavior.
 3. Chirinko (1986) critically reviews the most common investment specifications with an emphasis on the role of tax policy.
 4. Chirinko (1988a) goes even farther by showing that Jorgenson's model and the Q model are both special cases of a general Neoclassical framework.
 5. This is the form of the investment-in-equipment equation of the Bank of Canada RDXF econometric model (Scotland 1981).
 6. The net-of-tax considerations purchase price of capital is the purchase price of capital corrected for any Investment Tax Credit and the discounted value of tax depreciation allowances.
 7. There are also studies that "statistically" compare the Neoclassical model with other models of investment behavior. One such study is Jorgenson (1971). A more recent study is Chirinko (1988b). These studies generally indicate a superior performance of the Neoclassical model in terms of predictive power.
 8. See Chirinko (1986, 1988a) for detailed critiques of the Neoclassical model.
 9. It is difficult, for example, to accept the assumption that firms believe that interest rates and the Investment Tax Credit variable are generated by the same stochastic process.
 10. See Auerbach (1983) for a review of the different theories of the cost of capital.
 11. Another advantage of the Q framework is that it allows for the joint determination of output and investment.
 12. See Chirinko (1986) and Sumner (1989) for critiques of the Q model.
 13. See Auerbach (1983) for an in-depth review of the literature on the cost of capital.
 14. Stiglitz (1973) also shows that with no risk of bankruptcy, corporate profit taxes are nondistortionary.
 15. See Edwards and Keen (1984). The intuition behind Auerbach's result is that since the price of shares capitalizes the tax penalty on eventual dividend distribution, the tax rate on dividend income will influence the selling price of shares but will not influence the marginal cost of capital if new equity is not used to finance investment. So if new equity financing is ruled out by assumption, then the cost of capital is not influenced by the tax rate on dividend income.
 16. At a more general level, there are very few models that link together the dividend decision, the leverage decision, and the real investment decision. See Ravid (1988) for a review of the literature on the interaction between the real and financial decisions.

17. In Dammon and Senbet (1988), the sign of the relationship between debt and investment depends, in particular, on the firm's production technology.

18. In this model, the property that the investment-financing process is a two-step procedure is the result of three assumptions:

31. Tax reform may, however, yield a 5.9% decrease in the real riskless cost of debt (figure not reported in Table 4) if the riskless cost of debt is reduced by the changes in personal income tax rates.

32. This indicates that in comparison to the models of investment behavior examined by Chirinko and Eisner (1983), our model is quite sensitive to changes in the rate of Investment Tax Credit.

33. An increase of between 14% and 19% in output would be necessary to compensate fully for the reduction in investment incentives. Such an increase is highly unlikely.

34. The underlying assumption is that real interest rates arbitrage to the rate of time preference.

35. We assume that investment goods labeled I_t are purchased at the beginning of the year stretching from t to $t + 1$ and that output Y_t is produced at the end of each year.

36. Note that the constraint (A2) is satisfied if and only if the constraint

$$\sum_{s=0}^t F(I_s, J_s) - (1 - \delta) \sum_{s=0}^{t-1} F(I_{s+1}, J_{s+1}) = \Delta Y_t$$

is satisfied for all t . Now, using (A3) and (A4), and because of constant returns to scale, we have that

$$(1 - \delta)F(I_{s+1}, J_{s+1}) = F((1 - \delta)I_{s+1}, (1 - \delta)J_{s+1}) = F(I_s, J_s)$$

for all s . Thus

$$\sum_{s=0}^t F(I_s, J_s) - (1 - \delta) \sum_{s=0}^{t-1} F(I_{s+1}, J_{s+1}) = F(I_t, J_t)$$

for all t , and the equality constraint (A2) is satisfied if and only if the equality constraint

$$F(I_t, J_t) = \Delta Y_t$$

is satisfied for all t .

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Abstract

Benefits of collective bargaining in the local public sector are always nonrival for covered employees. In states with public sector right-to-work laws, they are also nonexcludable. Among 10,308 county and city departments that were nonunion in 1977, the probability of engaging in collective bargaining as of 1982 was significantly and substantially lower in states with right-to-work laws. Furthermore, the larger the department the greater the reduction in the probability of forming a bargaining union. These results are the first nonexperimental evidence of the effects of free riders on the provision of a public good. They support the hypothesis that, without excludability, free riders reduce the levels of public good provision.

EXCLUDABILITY AND THE EFFECTS OF FREE RIDERS: RIGHT-TO-WORK LAWS AND LOCAL PUBLIC SECTOR UNIONIZATION

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Free riders appear frequently in the theoretical and experimental literature regarding public goods. In principle, they could threaten public good provision through their strategic misrepresentations of preferences. In practice, however, no empirical study has identified actual effects of free riders in nonexperimental data. This article attempts such an identification by estimating the effects of nonexcludability on the provision of collective bargaining in the local public sector.

Benefits of collective bargaining agreements are nonrival goods for all employees covered by a bargaining union. They are excludable goods when the contract contains a clause that requires covered employees to become union members or to pay a fee in lieu of