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Tax reform and corporate investment: Theory and evidence of a Q theoretic approach

Elston, Julie Ann Michelle, Ph.D.

University of Washington, 1992

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Tax Reform and Corporate Investment: Theory and Evidence of a Q Theoretic Approach

by

Julie Ann Elston

A dissertation submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

University of Washington

1992

Approved by ______________________

(Chairperson of Supervisory Committee)

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Program Authorized
to Offer Degree Department of Economics

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Abstract

Tax Reform and Corporate Investment: Theory and Evidence of a Q Theoretic Approach

by Julie Ann Elston

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This research employs a Q theory of investment framework to examine the effects of U.S. tax reform on corporate investment in the 1980's. The Modigliani-Miller theorem suggests that a firm's real decisions regarding capital, labor, and investment will be independent of its financial decisions such as debt leverage, liquidity, and dividend payout under the assumption of perfect capital markets. By relaxing the assumption of perfect capital markets, it is possible to test the relationship between the firm's real and financial decisions. Specifically, this work tests for sensitivity of investment to liquidity constraints under two alternative processes for explaining firm dividend behavior.

This work adds to the existing literature by examining the role of dividend policy in determining investment behavior of the firm. This is accomplished by developing and testing two Q specifications based on alternative assumptions about the dividend process of the firm. Estimations are performed on a panel of 220 COMPUSTAT firms over a 14 year time period to investigate the dynamic nature of firm investment. The significance of liquidity constraints is tested by including a measure of cash flow in the reduced form investment equation. The econometric approach takes into account the endogenous nature of both cash flow and Q by using lagged endogenous variables as instruments and employs a Generalized Method of Moments (GMM) estimation procedure to account for heteroscedasticity in the data.

Findings indicate that liquidity constraints are important in determining firm investment behavior. This significance is confirmed for the All Firms category as well as for the larger firm size categories. Further, this finding appears to be robust to Q specification based on alternative dividend policy assumptions. Overall, results support the notion that investment growth did not fluctuate outside its normal range during the 1980's.

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DEDICATION

This dissertation is dedicated to Alain Gaillard. I am forever in his debt for his patience, emotional support, and all of the laundry.

Chapter 1

INTRODUCTION

1.1 Review of the Q Theory of Investment Literature

The Q theory of investment has its roots in the works of Brainard and Tobin (1968) and Tobin (1969). These works employ Q as a link between the financial and real sectors of the economy, where it is assumed the economy has assets of only money and capital. Mathematically, one can derive Q as the first order condition of the firm's dynamic optimization problem relating the firm's marginal costs of adjustment to the shadow price of a unit of capital. Under particular assumptions, this theoretical relationship can be estimated empirically because of the link between the unobservable shadow price of capital and the stock market valuation of existing capital. For purposes of empirical research then, Q can be defined as the ratio of market value of the firm over the replacement value of the firm's capital stock.[1]

Recently, there has been a renewed interest in empirically testing the Q theory of investment model. This interest is undoubtedly due in part to the availability of panel data sets as much as the increased awareness that this model offers a rich context in which to study firm investment behavior.

In Bischoff (1971) we find the first comparison of the performance of q with other investment models in explaining aggregate corporate investment. In these studies the q equations are outperformed by both the accelerator and neoclassical flexible

---

[1] While this definition of Q is standard in the Q literature, it is recognized that this definition relies on accounting data from the firm which is likely to introduce some amount of bias in the estimation of economic relationships.

accelerator equations.[2]

Malkiel, VonFurstenberg, and Watson (1980) provide the first study examining the effects of q on gross fixed investment at a disaggregated industry level. An important result of their study, which has been disputed[3], is that changes in q have a greater impact on fixed investment at the industry level than at the aggregated corporate level.

The incorporation of a tax bias theory into the q theory framework was introduced by Auerbach in 1979. His work emphasizes that it is because of the differential between taxation of dividends and capital gains, that the values of the marginal Q can fall below unity in spite of any future opportunities or monopoly rents available to the firm. This implies that a firm will equate the payment of $1 to shareholders, which provides the shareholder with $(1-\tau_y)$ dollars after personal taxes, with reinvestment of $1, which would provide the shareholder with a capital gains after personal taxes of $(1-\tau_c)$ dollars. Under these circumstances Q will not tend to unity but rather $\frac{(1-\tau_y)}{(1-\tau_c)}$. Thus a rational and efficient manager should be willing to spend a dollar to buy capital that is worth less than one dollar under certain tax policies. An underlying assumption of this model which has been maintained in the ensuing literature is that the repurchase of equity by the firm is constrained; that is to say it is assumed that there is no repurchasing of shares by the firm.

Auerbach's finding is significant because it illustrates how in the presence of taxes our optimality conditions for Q change. Recall in Tobin's taxless world, firms are willing to invest $1 up to the point where each dollar spent purchasing capital raises the market value of the firm by at least $1. In Tobin's model we use Hayashi's (1982) result that the average q is a reasonable proxy for the unobservable marginal q. In a taxless world then, q is equal to the value of the firm divided by its capital stock,

---

[2] For notational clarity let Q stand for the tax adjusted Q and q denote Tobin's q, or q in a taxless world.

[3] See Chappel and Cheng (1982).

which can alternatively be defined as the ratio of the market value of capital stock to its replacement cost.

Summers (1981) and Summers and Salinger (1983) outline a methodology for accounting for the effects various tax rates have on estimations of Q. Specifically they derive the mathematical link between the theoretical model of the firm and an econometric specification in terms of observable parameters. They analyze 30 Standard and Poors firms from 1959-1978 using the dividend policy assumption that dividends are set equal to the after-tax profits of the firms minus the costs of adjustment. One conclusion of their research is that the evolution of investment depends on the depreciation tax shields attributable to prior investments.

Thomas Downs (1990) provides further empirical evidence to support Summers assertion by showing that a significant proportion of the variation in Q occurs because of differences in accumulated tax depreciation shields. One implication of his work is that erosion of depreciation tax shields over time can be expected to decrease Q values.

Previous empirical papers which have sought to deal with testing the effects of financial factors on business investment include Fazzari, Hubbard and Peterson (1987), Devereux and Schiantarelli (1989), Oliner and Rudebusch (1989), and Gilchrist (1990). Using cash flow as a measure of liquidity these studies conclude that liquidity constraints matter most for firms with low dividend-payout ratios. Specifically, Devereux and Schiantarelli, who explicitly model the agency and financial distress costs for British manufacturing data, conclude that cash flow appears to play a more important role for larger rather than smaller firms. Gilchrist (1990) examines the role of financial and liquidity constraints in investment using both Q theory models and Euler equations on U.S. data. His results indicate that cash flow matters most for financially constrained firms and provide support for a model based on financing hierarchies that result from imperfect capital markets. Fazzari *et al.*

also support a model based on financing hierarchies but conclude that Q is at best one of the few significant explanatory variables for explaining firm investment.

These papers have also used various sorting strategies to examine the cross-sectional differences in the role of liquidity in the Q theory investment model. Hayashi and Inoue (1990) for example, develop a model of investment with multiple capital goods using panel data from Japanese manufacturing firms sorted by heavy and light manufacturing sectors. One interesting finding of theirs is that adjustment costs were less than half the gross profits net costs of adjustment, based on the Q coefficient. Regardless of the sorting strategy used however, these studies consistently found that liquidity constraints play an important role for firms facing financing constraints.

Many of the recent empirical studies have mentioned the importance of examining the role of dividend behavior in effecting the cost of capital facing firms. However, these studies either do not address the issue in the empirical work or resort to estimations based on subsets of the data which consist of one set of firms that do pay dividends and another that do not.[4] In fact while Devereux and Schiantarelli (1989) use the former approach they point out that without explicitly modeling why firms pay dividends it is not clear which firms are constrained by their earnings. This paper addresses this issue by explicitly modeling the firms dividend policy in the definition of Q which represents the firm's marginal cost of capital investment.

This work adds to the current literature by developing and employing a methodology which explicitly models the dividend process of the firm in testing the sensitivity of the Q investment model to liquidity constraints. Estimations are performed on a panel of U.S. firms from 1975-1989 subdivided into four groups based on firm size. Similar to Hayashi and Inoue (1990) the Q model is then estimated by a general-

---

[4] Devereux and Schiantarelli (1989) and Hayashi and Inoue (1990) do not attempt to account for differences between firm's dividend payout behavior. Fazzari, Hubbard and Peterson (1989) and Gilchrist (1990) run estimations on subsets of data divided by payout behavior but do not model the dividend process explicitly.

ized methods of moments procedure using lagged values of endogenous variables as instruments.

From a policy perspective, this study provides an important source of information on corporate investment behavior during a decade of frequent tax reform largely dedicated to improving firm incentives to invest in capital. Following the logic of the Lucus Critique, the 1980's are an ideal period to test the relationship between tax effects on Q and Q effects on corporate investment.[5]

This dissertation is organized as follows.

Chapter 2 develops a link between the theoretical model of the firm's optimizing behavior and the tax adjusted Q defined in terms of observable parameters. Using a methodology similar to Summers (1983) a new tax adjusted Q_1 is derived under the dividend policy assumption that firms offer a fixed dividend yield to stockholders on their equity. This approach allows us to compare Q performance under two plausible yet distinctly different processes for explaining firm dividend payout behavior.

In chapter 3 the new Q_1 and Summers Q_2 are calculated for 17 S&P firms for 1978 and 1988 for comparison. Investment equations are then estimated as a time series for each of the firms from 1975 to 1988 to test the hypothesis that changes in investment are positively correlated with changes in the marginal incentive to invest.

Chapter 4 examines the issue of sensitivity of the reduced equation investment model to Q specification and liquidity constraints. This issue is investigated by estimating the Q investment model using two alternative Q specifications and including a measure of cash flow in the reduced form investment equation. Estimations are performed on a panel of 220 Standard and Poor firms over a 14 year time period to investigate the dynamic nature of firm investment.

In chapter 5 the policy implications of tax reform are reviewed. Specifically, this work focuses on the *net* impact of the tax reforms and evaluates their overall

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[5] Robert Lucas (1976) points out that when policy changes it is an ideal time to study how our econometric models have fared during the period of change.

effectiveness in meeting the goal of increased investment growth.

Chapter 2

DEVELOPMENT OF THE Q THEORY OF INVESTMENT MODEL

2.1 Introduction

This research uses a Q theory of investment framework to examine the importance of dividend policy on the firm's decision to invest. There are primarily two ways that the firm's dividend policy can be expected to effect investment levels. The first is through the cost of capital, which is directly impacted by the definition of the dividend policy rule of the firm. The second is an indirect effect on investment because dividend payments effect the liquidity constraint of the firm; which in turn directly impacts the ability of the firm to invest.

In this chapter a formal link is developed between the model of the firm within an intertemporal framework and an empirical specification described strictly in terms of observable parameters. This process enables us to estimate and test tax adjusted Q's which are constructed from balance sheet information of the firm. In order to examine the importance of dividend policy specification a new tax adjusted Q, or Q_1, is developed based on the dividend policy rule that firms offer a fixed dividend yield to stock holders on their equity from Turnovsky (1990). Previous empirical studies in the Q literature have exclusively used a dividend policy rule which defines dividends residually as the difference between the after tax profits of the firm less costs of adjustment.

Theoretically, the new tax adjusted Q_1 is a more appealing way of describing the complex dividend process of firms than the traditional residual process explanation. This is because a fixed payout level is consistent with known characteristics about firm dividend payout behavior. One such stylized fact is the well known "sticky" nature of dividends. That is to say that once firms have set a dividend payout level they attempt to maintain that payout level because large variations may send the wrong signal to investors.[1] Empirically this dividend policy assumption is validated by estimations of the dividend payment regressed on the value of the firm.

2.2 The Model

Following Brock and Turnovsky (1981) we can model the behavior of the firm in accordance with the traditional neoclassical production function F with the firm using inputs of capital K and labor L. In this model we assume that both marginal products are positive but diminishing such that $F_l > 0$, $F_k > 0$ and $F_{ll} < 0$, $F_{kk} < 0$ and that $F_{kk}F_{ll} - F_{kl}^2 = 0$ where single and double subscripts denote first and second derivatives of the production function with respect to factor inputs. I also assume non-monopoly rents, a constant returns to scale production function with homogeneity of factors, and complementarity of factor inputs such that $F_{kl} = F_{lk} > 0$.

Under these assumptions, we can define the gross profits of the firm as

$$R = F(K, L) - wL \tag{2.1}$$

where F is the production function of the firm based on capital K and labor L inputs, and w is the real wage rate which is determined by the market because the firm is a price taker in this model.

If corporate profits are taxed at τ_f and the remainder is either paid out as div-

---

[1] Lintner (1956) concluded that consistency of the dividend payment was important to managers for a variety of reasons including a sense of prudence, fairness, and fear of adverse stockholder reactions.

idends D or kept as retained earnings RE, then the following equation describes corporate sources and uses of funds

$$(1-\tau_f)\,R = D + RE. \tag{2.2}$$

Since equipment requires installation we define a convex cost of adjustment H as a function of investment I and capital K by

$$H\left(\frac{I}{K}\right)K. \tag{2.3}$$

Costs of adjustment enter the model because firms cannot costlessly and instantly adjust the capital stock, rather they face costs of equipment installation and removal. Here we define a marginal cost of adjustment as an increasing function of the rate of investment where H_I, $H_{II} > 0$. This means that as the firm increases investment it becomes more costly to do so, that is to say there exists some diseconomies of scale with respect to increases in capital investment.

In this model, we also assume that there are adjustment costs for capital but not for labor. This construction implies the firm is always able to hire the desired quantity of labor, but will only gradually close the gap between the desired and the actual levels of capital stocks.

The financing constraint facing firms can then be defined as

$$RE + s\dot{E} = (1-b)H\left(\frac{I}{K}\right)K, \tag{2.4}$$

where b is the fraction of the capital stock of the firm that is maintained as debt, representing bond financing, s is the price of an issue, E is the outstanding stock of the firm, and τ_f is the corporate tax rate. The dot notation above the E denotes the time derivative of equity. This equation describes both the sources and uses of funds. In the most general case, financing can come from any combination of these three sources. However for operational simplicity throughout the remainder of this model we will assume that the firm does not use debt financing such that $\dot{b} = 0$; nor does it repurchase existing shares.

The value of outstanding equities V can then be described as

$$V = sE. \tag{2.5}$$

Hence prices are proportional to the outstanding value of the firm's equity and from equations (2.2) and (2.4) we then derive an expression for dividends of the firm where

$$D = (1 - \tau_f)\left[R - H\left(\frac{I}{K}\right)K\right] + s\dot{E}. \tag{2.6}$$

Combining equation (2.6) with the consumer optimality condition for equities and the time derivative of equation (2.5) we can derive the following equation for explaining the evolution of the value of the firm over time: [2]

---

[2] See Turnovsky (1990) for a complete development of all the consumer optimality conditions. Here we make use of the condition for equities :

$$\theta = (1 - \tau_y)\left(\frac{D}{sE}\right) + (1 - \tau_c) - \left(\frac{\dot{s}}{s}\right) \tag{2.7}$$

where τ_y is the personal income tax rate and θ is the real rate of return on equities. This condition states that at the margin, the rate of return on holding equities should be equal to the rate of return on dividends taxed at the ordinary income tax rate τ_y, plus capital gains taxed at the capital gains tax rate τ_c.

$$\dot{V} = \frac{\theta}{(1-\tau_c)}V - \left[(1-\tau_f)R - H\left(\frac{I}{K}\right)K\right] + \frac{(\tau_y - \tau_c)}{(1-\tau_c)}D, \tag{2.8}$$

where θ is the real required rate of return on equities which is adjusted by one minus τ_c, the tax rate on capital gains. τ_y is the tax rate on ordinary or personal income.

From equation (2.8) we see that if $\tau_y \neq \tau_c$ then dividend policy is important to the firm. Note that if dividend policy is related to V, as is the case here, then the value of equity will affect the cost of capital to the firm $\frac{\theta}{(1-\tau_c)}$.

If on the other hand, it is directed to the flow of earnings then it has no effect on the cost of capital, but instead impacts on the flows being accumulated. This model predicts that as long as $\tau_y > \tau_c$, as it is assumed here, then it is not optimal for firms to pay dividends. We note that in spite of this, for whatever reasons, firms do pay dividends and we shall consider two possible alternatives of dividend payment behavior:

I) $\frac{D}{V} = \bar{i}$

II) $D = (1-\tau_f)\left[R - H\left(\frac{I}{K}\right)K\right]$

Rule I) implies firms offer a fixed dividend yield to stockholders on their equity, i.e. firms set $\bar{i}$ to some minimum level representing a constrained optimal dividend policy. Note that when dividends are set to some minimum level by the firm this includes the possibility that the firm may choose to set dividends to zero.

To empirically investigate the feasibility of this dividend policy rule we can estimate the model $D_t = B_1 V_t + e_t$, where D_t is the dividend payment of the firm, V_t

is the value of the firm, and e_t is the error term at time t. The value of the firm at time t can be calculated by multiplying the number of outstanding shares of the firm by the closing price of shares of the firm at the end of each year. These estimations were done on a sample of seventeen $S\&P$ firms over a twelve year time period.

Results of least-square estimations of dividends D regressed on the value of the firm V are listed in table (2.1).

Table 2.1

Model: $Dividends_t = B_1 V_t + e_t$

Firm	β_1	t -statistic	r-squared
Aluminum Company of America	0.0307	5.5	0.90
American Brands	0.0390	4.2	0.95
American T and T	0.0342	6.5	0.97
Bethlehem Steel	0.0394	8.3	0.96
Eastman Kodak	0.0482	3.3	0.90
Exxon	0.0348	9.1	0.94
General Electric	0.0474	6.1	0.98
Goodyear Tire	0.0219	6.8	0.98
IBM	0.0291	3.3	0.96
International Paper	0.0328	7.2	0.96
Merck	0.0327	5.2	0.97
3M	0.0175	8.5	0.98
Proctor and Gamble	0.0285	8.6	0.98
Sears	0.0285	10.3	0.96
Texaco	0.0992	8.8	0.86
Union Carbide	0.0853	5.8	0.59
United Technologies	0.265	5.0	0.98

High r-squared values indicate a good fit of the model to the data, and t-statistics indicate that the coefficient on the value of the firm is consistently significant at the 1% level. Overall, the empirical evidence suggests that this dividend policy assumption is not only theoretically appealing but is in fact a very reasonable way to describe the dividend process of the firm.

Rule II) implies the marginal source of investment financing is through RE with dividends being determined residually as the after tax profits of the firm less costs of adjustment. This dividend policy process used by all previous empirical Q studies is based on Summers (1981).

2.2.1 Development of the Model Under Dividend Policy Rule I

Applying dividend policy rule I to equation (2.8) we derive the dividend policy specific differential equation:

$$\dot{V}_1 = \left[\frac{\theta}{1-\tau_c} + \bar{i}\left(\frac{\tau_y - \tau_c}{1-\tau_c}\right)\right] V - (1-\tau_f)\left[R - H\left(\frac{I}{K}\right)K\right]. \tag{2.9}$$

The firm's objective then is to maximize the initial value of equity $V(0)$ with respect to the inputs K, L, I. We can re-write (2.9) in the more generalized form as:

$$\dot{V} = \theta^{*} V - \gamma(K, L, I). \tag{2.10}$$

Here we can express the required rate of return on capital as:

$$\theta^{*} = \left[\left(\frac{\theta}{1-\tau_c}\right) + \bar{i}\left(\frac{\tau_y - \tau_c}{1-\tau_c}\right)\right] \tag{2.11}$$

where θ^{*} represents the rate of return after corporate but before personal income taxes or capital gains taxes. In this case the required rate of return is not the same as the cost of capital which is typically defined as the value of the marginal physical product of capital. It is important to note that this definition of the rate of return on capital includes the dividend payout $\bar{i}$ based on the value of the firm, which is discounted by the personal tax rate minus the capital gains tax rate over one minus the capital gains rate.

Integrating equation (2.10) we can express the firm's maximization as a function of the dividend policy problem over time as:

$$\mathrm{Max}_{K,L,I} V(0) = \int_t^{\infty} (1-\tau_f)\left[R - H\left(\frac{I}{K}\right)K\right] e^{-\int_t^s \theta^{*} du} ds \tag{2.12}$$

s.t.

$$\begin{aligned} \dot{K}(s) &= I(s) - \delta K(s) & (2.13)\\ K(0) &= K_0. & (2.14) \end{aligned}$$

Equation (2.12) suggests that the firm wishes to maximize the net present value of net revenues by choosing optimal capital, labor and investment levels subject to capital constraints. The first constraint, $\dot{K}(s)$ describes the capital accumulation path whereby the firm invests to replace a deteriorating proportional constant δ of the capital stock K. $K(0)$ is simply the initial capital stock level. At each point in time t then, the firm picks L_t and K_t to maximize the value of the firm V_t, while the optimal value of investment I_t is determined residually from the capital accumulation identity.

If we assume expectations about future dividend payments of the firm are formed with perfect foresight we can impose the following transversality condition to guarantee a unique solution to our maximization problem:

$$\lim_{s \to \infty} V(s)\, e^{-\int_t^s \theta^* du} = 0$$

Rewriting (2.12) in terms of observable parameters, the value of the firm in time t can be expressed:

$$V_{1t} = \int_t^\infty \Bigg[(F(K_t, L_t) - wL)(1 - \tau_f) -$$

$$\left(1 - ITC_t - Z_t + (1 - \tau_f) H\left(\frac{I_t}{K_t}\right) K_t\right) I_t \Bigg] e^{-\int_t^s \theta^* du} ds + B_t \tag{2.15}$$

where K_t and L_t are factor inputs and wL_t is the labor expense, all of which is adjusted by the statutory corporate tax rate τ_f. The next part of the expression represents the investment expenses where ITC_t is the investment tax credit, Z_t is the present value of depreciation allowances, and $(1 - \tau_f) H\left(\frac{I}{K}\right) K_t$ is the net convex costs of adjustment times the capital stock, all of which is multiplied by investment I_t. All of this is then discounted by θ^* the real required rate of return on capital. B_t is the present value of depreciation allowances on existing capital stock. Of course in maximizing (2.15) B_t becomes irrelevant to the firm because it is independent of any current or future decisions.

Tax parameters in (2.15) are allowed to change over time and can be defined as:

$$B(t) = \int_t^{\infty} \tau_f \delta^T e^{-\delta^r (s-t)} \mu(s) K_t ds \tag{2.16}$$

$$Z(t) = \int_t^{\infty} \tau_f \delta^T e^{-\delta^r (u-s)} \frac{\mu(u)}{\mu(s)} du \tag{2.17}$$

$$\mu(s) = e^{-\int_0^s \theta^* du} \tag{2.18}$$

Here, $B(t)$ is the present value of depreciation allowances on existing capital stock, which is a function of the corporate tax rate τ_f times the statutory depreciation rate on capital δ^T discounted by the tax adjusted required rate of return on capital θ^* times the capital stock K_t. The present value of depreciation allowances on new investment $Z(t)$ is a function of the corporate tax rate τ_f times the statutory depreciation rate on capital δ^T, discounted by the tax adjusted required rate of return on capital. The term $\mu(s)$ defines the discount factor which is derived from the consumer optimality conditions for equity. As defined in equation (2.18), it is a function of the required rate of return on capital after corporate but before personal income taxes and capital gains taxes. Empirical estimations used the real rate of interest to proxy for the required rate of return on capital. Other details on the construction of the various tax parameters are discussed in Appendix B.

Equation (2.15) can then be interpreted as the market value of the firm's equity at time t which is equal to the after tax profits of the firm less investment expenses adjusted for tax and depreciation allowances. Note that all of these variables have been specified in real terms so that there is no need to adjust for price levels. Choice variables such as K_t , L_t, and I_t have time subscripts to reflect the fact that they are chosen in each time period to maximize the value of the firm. Tax variables are of course allowed to change over time and are also time subscripted accordingly. The fact that the production function F and the wage w are not a function of time reflects the model assumption's that technology is constant and that firms have static expectations.

Maximizing equation (1.15) subject to the capital constraints allows us to derive the following optimality conditions for the firm:

$$F_L = w \tag{2.19}$$

$$[1 - ITC_t - Z_t - b] + (1 - \tau_f)\left[H\left(\frac{I_t}{K_t}\right)K_t + H'\left(\frac{I_t}{K_t}\right)I_t\right] = \lambda_t \tag{2.20}$$

$$\begin{aligned}(1 - \tau_f)F_k - \left[H\left(\frac{I_t}{K_t}\right) + H'\left(\frac{I_t}{K_t}\right)\frac{I_t}{K_t}\right](1 - \tau_f)I_t = \\ -\dot{\lambda}_t + \lambda_t[\theta_t^\star]\,.\end{aligned} \tag{2.21}$$

Equation (2.19) suggests that the firm will hire labor until the marginal product of labor is equal to the wage. Equation (2.20) characterizes the investment function. It defines a function which links investment to the shadow price of capital λ_t, to the tax parameters, and the convex costs of adjustment. Intuitively, the right hand side can be interpreted as the shadow price of an additional unit of capital goods, which should be equal to their marginal cost in after tax profits on the left hand side of the equation. Equation (2.21) describes the evolution of the shadow price of capital. It guarantees that the shadow price λ_t equals the present value of future marginal products of a unit of capital.

The condition for zero investment suggests that equation (2.20) becomes:

$$\lambda_t = [1 - ITC_t - Z_t]\,. \tag{2.22}$$

2.2.2 Development of the Model Under Dividend Policy Rule II

Under dividend policy II where we define the dividend process as $D = (1 - \tau_f)\left[R - H\left(\frac{I}{K}\right)\right]$ we can define Q_2 using a similar set of procedures but with an alternative set of model assumptions, retracing our steps from equation (2.1). To simplify this process this section will focus only on the development of the key equations for Q which are impacted by the differing behavioral and dividend policy assumptions of the firm. A complete derivation starting from equation (2.1) is detailed in Appendix A.

Starting with the financing constraint of the firm, if we allow for debt financing but assume that the firm neither issues new equity nor repurchases existing shares then the constraint contains a $b > 0$ and

$$RE + s\dot{E} = (1 - b)H\left(\frac{I}{K}\right), \tag{2.23}$$

where b again is the fraction of the capital stock maintained as debt, representing bond financing, s is the price of an issue, E is the outstanding stock of the firm, τ_f is the corporate tax rate, and $H\left(\frac{I}{K}\right)$ is the convex costs of adjustment. For notational simplicity we can define $C\left(\frac{I}{K}\right) = (1 - b)\,H\left(\frac{I}{K}\right)$ for the ensuing model development.

Under this dividend policy assumption the definition of the cost of capital, θ^* is a function of the real rate of return on equities adjusted for the capital gains tax only. This means that the dividend payout does not effect the cost of capital facing the firm and we define:

$$\theta^* = \left(\frac{\theta}{1 - \tau_c}\right).$$

The value of the firm under dividend policy II can then be specified in terms of real observable parameters as [3]:

$$V_{2t} = \int_t^\infty \Bigg[\left(F\left(K_t, L_t\right) - wL - bK_t r\right)\left(1 - \tau_f\right) -$$
$$\left(1 - ITC_t - Z_t - b + (1 - \tau_f)\,C\left(\frac{I_t}{K_t}\right)\right) I_t \Bigg] \left(\frac{1 - \tau_d}{1 - \tau_c}\right) e^{-\int_t^s \theta^* du} ds + B_t$$

(2.24)

where K_t and L_t are factor inputs, wL_t is the labor expense, and rbK_t is the expensed interest on the debt, all of which is adjusted by the statutory corporate tax rate τ_f. The next part of the expression represents the investment expenses where ITC_t is the investment tax credit, Z_t is the present value of depreciation allowances, b is the fraction of the capital that the firm maintains as debt, and $(1 - \tau_f)\,C\left(\frac{I}{K_t}\right)$ is the net convex costs of adjustment, all of which is multiplied by investment I_t. Consistent with Summers, this model does not multiply the convex costs of adjustment by the

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[3] Summers (1981) uses nominal terms, and the derivation in Appendix A is consistent with this. Here a real representation is used to be consistent with earlier derivations in this chapter.

capital stock in the investment expense equation. This specification also implies that the firm will expense interest payments on its debt which will reduce the after tax profits of the firm in the model. This model also expenses the adjustment costs of the firm making them ineligible for investment tax credit.

All of this is then discounted by $\left(\frac{1-\tau_d}{1-\tau_c}\right)$ times $\theta^{\star}$ the real required rate of return on capital. B_t is the present value of depreciation allowances on existing capital stock. Again in maximizing (2.24) B_t becomes irrelevant to the firm because it is independent of any current or future decisions. Tax parameters are allowed to change over time and are defined similarly to equations (2.16)-(2.18) with differences detailed in Appendix A.

Equation (2.24) can then be interpreted as the market value of the firm's equity at time t under dividend policy II, which is equal to the after tax profits of the firm less investment expenses adjusted for tax and depreciation allowances. Maximizing this equation subject to the capital constraints allows us to derive the following optimality conditions for the firm:

$$F_L = w \tag{2.25}$$

$$(1 - ITC_t - Z_t - b) + (1 - \tau_f)\left[C\left(\frac{I_t}{K_t}\right) + C'\left(\frac{I_t}{K_t}\right)\frac{I_t}{K_t}\right] = \lambda_t\left(\frac{1-\tau_c}{1-\tau_d}\right) \tag{2.26}$$

$$\begin{aligned}\left[(1-\tau_f)(F_k - br) - \left(\frac{I_t}{K_t}\right)^2 C'\left(\frac{I_t}{K_t}\right)(1-\tau_f)\right] = \\ \left[-\dot{\lambda}_t + \lambda_t(\theta_t^{\star})\right]\left(\frac{1-\tau_c}{1-\tau_d}\right).\end{aligned} \tag{2.27}$$

Equation (2.26) suggests that the firm will hire labor until the marginal product of labor is equal to the wage. Equation (2.27) characterizes the investment function which links investment to the shadow price of capital λ_t, the tax parameters and the convex costs of adjustment. Intuitively, the right hand side can be interpreted as the shadow price of an additional unit of capital goods, which should be equal to their marginal cost in after tax profits on the left hand side of the equation.

Equation (2.27) describes the evolution of the shadow price of capital. It guarantees that the shadow price λ_t equals the present value of future marginal products of a unit of capital.

The condition ior zero investment suggests that equation (2.27) becomes:

$$\lambda_t = \left(\frac{1-\tau_d}{1-\tau_c}\right)[1 - ITC_t - Z_t - b]\,. \tag{2.28}$$

2.3 Derivation of the Empirical Q Under Dividend Policy Rules I and II

Because we have a constant returns to scale production technology and homogeneity of the adjustment cost function by definition, then we can derive our empirical Q as follows. From Hayashi (1982) we have:

$$V_t^{\star} - B_t = \gamma K_t \tag{2.29}$$

where $V_t^{\star}$ is the stock market value of the firm when the optimal path is followed, B_t is the value of depreciation allowances, and their difference is equal to γK_t -a fixed proportion of the initial capital stock. The maximum principle implies then that

$$\lambda_t = \frac{dV_t^*}{dK_t}. \tag{2.30}$$

where λ_t is the shadow price of new investment or marginal Q.

Combining (2.29) and (2.30) we get:

$$\lambda_t = \frac{V_t^* - B_t}{K_t}. \tag{2.31}$$

Combining equations (2.20), (2.22), and (2.31) based on dividend policy I, we can derive our tax adjusted Q_1 in terms of observable parameters as:

$$Q_1 = \frac{I_t}{K_t} = \frac{\dot{K}}{K} + \delta^R = h\left[\frac{\left(\frac{V_t - B_t}{K_t}\right) - 1 + ITC_t + Z_t}{1 - \tau_f}\right] \tag{2.32}$$

where:

$$h(Q_1) = \left[H\left(\frac{I_t}{K_t}\right)K_t + H'\left(\frac{I_t}{K_t}\right)I_t\right]^{-1}.$$

Combining equations (2.26), (2.28), and (2.31) based on dividend policy II, we can derive our tax adjusted Q_2 in terms of observable parameters as:

$$Q_2 = \frac{I_t}{K_t} = \frac{\dot{K}}{K} + \delta^R = h\left[\frac{\left(\frac{V_t - B_t}{K_t}\right)\left(\frac{1-\tau_d}{1-\tau_c}\right) - 1 + b + ITC_t + Z_t}{1 - \tau_f}\right] \tag{2.33}$$

where:

$$h(Q_2) = \left[C\left(\frac{I_t}{K_t}\right) + C'\left(\frac{I_t}{K_t}\right)\frac{I_t}{K_t}\right]^{-1}.$$

2.4 Glossary

R =Gross Corporate Profits of the Firm

$F(K, L)$ =Production Function for the Firm

I =Real Investment

K =Real Capital

w =Real Wages

L =Labor

RE =Retained Earnings

V =Value of the Firm Based on the Value of Outstanding Equities

D =Dividends

θ =Required Rate of Return on Investment

$\theta^{\star}$ =Net Required Rate of Return on Investment

s =Price of Equities

E =Outstanding Stock of the Firm

b =Share b of all New Investment from Debt Issues

$\bar{i}$ = Fixed Dividend Payout Level of the Firm

H =Convex Cost of Adjustment

$C = H(1-b)$

$h(Q_1) = \left[H\left(\frac{I}{K}\right)K_t + H'\left(\frac{I}{K}\right)I_t\right]^{-1}$

$h(Q_2) = \left[C\left(\frac{I}{K}\right) + C'\left(\frac{I}{K}\right)\frac{I}{K}\right]^{-1}$

p =Output Price

τ_c =Capital Gains Tax

τ_d =Dividend Tax

τ_y =Personal Income Tax

τ_f =Corporate Income Tax

ITC =Investment Tax Credit

δ =Proportional Constant of Existing Capital Stock

δ^R =Real Rate of Depreciation Allowance

δ^T =Statutory Rate of Depreciation

q =Ratio of the Market Value of Capital Stock to its Replacement Costs

Q =Any Tax Adjusted q

Q_1 =Tax Adjusted q Under Dividend Policy Assumption I

Q_2 =Tax Adjusted q Under Dividend Policy Assumption II

Chapter 3

AN EMPIRICAL INVESTIGATION OF 17 *S&P* FIRMS: 1978 AND 1988

3.1 Introduction

The Q theory of investment framework outlined in chapter 3 provides the theoretical basis for linking the effects of tax code changes to firm investment decisions. This chapter will develop a procedure for empirically testing this link. Specifically, by allowing average Q to proxy for marginal Q, our measure of the marginal incentive for the firm to invest, we can estimate a time series of tax adjusted Q's to examine changes in incentives to invest at the firm level over time.[1] Q theory tells us that if a firm exhibits a Q value of less than one then there is no incentive for the firm to invest at the margin. Conversely, a Q value greater than one, indicates a firm has more than a dollar to gain from a dollars worth of capital investment, indicating an incentive for the firm to invest; and in the steady state the firm exhibits a Q value equal to one.

We can examine the effectiveness of tax reform incentives on firm investment incentives in the 1980's by estimating Q_2 values in 1978 and 1988 for comparison using 17 Standard and Poor firms. If the tax reforms of the 1980's resulted in an increase in the marginal incentive for the firm to invest then we would expect higher tax adjusted Q's in the 1980's than the 1970's.

In order to examine the possible effects of dividend policy assumptions on the

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[1] From Hayashi (1982) we know that all we can measure directly is the firms average Q even though Q theory is based on the marginal Q. I therefore use the observable average Q as a proxy for marginal Q in this work.

Q theory of investment model performance, the model is estimated for each firm under both dividend policies specifications. Results indicate that estimations of the investment equation support the Q theory of investment model under both dividend policy specifications. This is evidenced by the statistical significance of the overall investment equation, as well as the statistical significance of the tax adjusted Q in effecting investment growth. Further, positive coefficients on Q_1 and Q_2 for most firms support a correlative interpretation of Q with investment.

3.2 Estimation of the Investment Equation

From chapter 2 we can define the tax adjusted Q

under dividend policy I where $D = V\bar{i}$ as:

$$Q_{1t} = \left[\frac{\left(\frac{V_t - B}{K_t}\right) - 1 + b + ITC_t + Z_t.}{1 - \tau_f} \right], \tag{3.1}$$

Alternatively if we choose to specify a model where costs of adjustments enter the model as a cost of investment rather than being expensed, then we find that the statutory corporate tax rate τ_f does not enter our specification of Q and under dividend policy I we can define:[2]

$$Q'_{1t} = \left[\left(\frac{V_t - B_t}{K_t}\right) - 1 + b + ITC_t + Z_t \right]. \tag{3.2}$$

Under dividend policy II where $D = (1 - \tau_f)\left[R - C\left(\frac{I}{K}\right)\right]$ we have:

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[2] See Turnovsky (1990).

$$Q_{2t} = \left[\frac{\frac{(V_t - B_t)(1-\tau_c)}{K_t(1-\tau_d)} - 1 + b + ITC_t + Z_t}{1 - \tau_f} \right]. \tag{3.3}$$

Within the context of this model we can specify Tobin's q or q in a taxless world as:

$$q_t = \left(\frac{V_t}{K_t} \right). \tag{3.4}$$

The definition of Q_{2t} has an additional discount factor $\left(\frac{1-\tau_c}{1-\tau_d}\right)$ which does not show up in Q_1. This term is important because as long as $(\tau_d > \tau_c)$ this term will increase the value of the tax adjusted Q_2. If $\tau_c = \tau_d$ then the discount factor becomes a ratio equal to one and does not impact Q. This does not necessarily mean however that the two tax adjusted Q's will converge because the cost of capital which impacts Q through Z_t and B_t are not the same for Q_1 and Q_2.

Q'_{1t} differs from Q_{1t} only by a factor of $(1 - \tau_f)^{-1}$. This means that decreases in the statutory corporate tax rate can be expected to lower Q_{1t} while Q'_{1t} would remain uneffected by such changes in the tax code.

Using the fact that adjustment costs can take on a quadratic form which rises linearly investment and homogeneity of K_t and L_t then we can estimate the general form of the investment function as follows:

$$\frac{I_t}{K_t} = h(Q_{it}) = \beta_0 + \beta_1 Q_{it} + u_t \tag{3.5}$$

where β_0 is the regression constant, β_1 is the coefficient on Q_{it} under dividend policy i for time t , and u_t is the error term in time t.

In order to use this theoretical framework to examine the response of investment to tax policy changes we must first be clear on the relation between investment and our tax adjusted Q. This relation can be interpreted as tracing the economy's adjustment costs schedule for new investments. As the value of Q rises, firms seek to increase their investment until they are just indifferent between installing an extra unit of capital and paying out its cost in the form of increased investment.

For simplicity's sake we can assume that adjustment is costless until some level of investment is reached and then marginal adjustment costs rise linearly with investment. This implies a linear relationship between the ratio of investment to capital stock and Q, and thus the relation between investment and Q can be estimated via equation (3.5). This allows us to answer the question: Are changes in investment growth correlated with changes in the tax adjusted Q? If this is the case, we will expect to see the same sign on investment growth as the β_1 coefficient on Q_{it}.

It is also important to note that these estimations are *not* intended to provide the best possible explanation for investment behavior. We could, for instance, consider adding other variables to the model in an attempt to improve the fit of the model to the data. However, adding other variables would render a different interpretation of the coefficient on Q, which is currently interpreted as a measure of marginal adjustment costs. In addition, it is recognized that Q is not a wholly exogenous variable for the firm; this and other related econometric issues will be addressed explicitly in chapter 4.

3.3 Empirical Results for 17 S&P Firms

The data used in estimations consisted of 20 years of balance sheet information from 1970-1989 for 17 firms from the COMPUSTAT Annual Industrial database. The seventeen firms in the study were chosen to update estimated Q_2 values for the same firms reported in Summers (1983).[3] The data are deflated using 1982 as a base year. Details on the derivation of the variables used to estimate Q investment equation are discussed in Appendix B.

3.3.1 Estimation of Tobin's q and Q_2 for 17 Firms: 1978 and 1988

Updating Summers (1983), both q and Q_2 are estimated for 1988 and compared with the results published on q and Q_2 for 1978. Figures (3.1),(3.2), (3.3), and (3.4) plot q and Q_2 for 1978 and 1988 for comparison.

In figure (3.1) we see the tax adjusted Q_2 and Tobin's q plotted for 1978. The dashed line on the graph at one indicates the steady state value of Q. While both series move together in general the gap between them suggests that it is important to consider the tax adjusted Q for studies of investment behavior. These two series, from Summers (1983) indicate that eight or about half of the firms have tax adjusted Q_2 values below unity indicating a situation were the firm has no incentive to invest at the margin. Remember any Q value less than 1 denotes a firm with a incentive to disinvest. Negative Q values are only possible in the tax adjusted case and can also be interpreted as a situation where the firm has no incentive to invest.[4]

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[3] Of the original 30 firms in the Summers (1983) study, 13 were excluded for reasons which include continuity within the COMPUSTAT data set for the period of this study, merger activities, and missing values.

[4] Historically we note that firms with no incentives to invest may still do so. One possible reason for this is failure of the model's assumption that capital is homogeneous and malleable. That is

Figure (3.2) plots the updated Q_2 and q for 1988. The gap between q and the tax adjusted Q_2 appears to have shrunken since 1978 for nearly all the firms in the study. This would be consistent with the hypothesis that the tax reforms have been relatively ineffectual in providing incentives for the firm to invest. Examining results for individual firms in the study for 1988 we find that only 3 firms had Q_2 values less than one. While the total is fewer than that in 1978 many of the firms experienced decreases in values that did not actually drop below one.

Examining figure (3.3) which plots the tax adjusted Q_2 for 1978 and 1988 we find that eight of the firms experienced a decrease in Q_2 from 1978 to 1988, while the other nine had higher Q_2 value in 1988 than 1978. This implies that there was an uneven effect on the firms between the two periods and we cannot say that firms experienced a unilateral improvement in investment incentives as measured by the tax adjusted Q_2.

Finally figure (3.4) plots Tobin's q for 1978 and 1988. Here we find clear signals regarding changes in q values over time. That is twelve firms experienced increases in q values over the decade of the study and no q values were less than one in 1988. However since this does not measure the tax adjusted incentives to invest we can infer that the tax adjustments, the only difference between Q and q, are the reason that any of the Q values are less than one.

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to say, in the real world, even firms with low market values may still find some type of investment desirable.

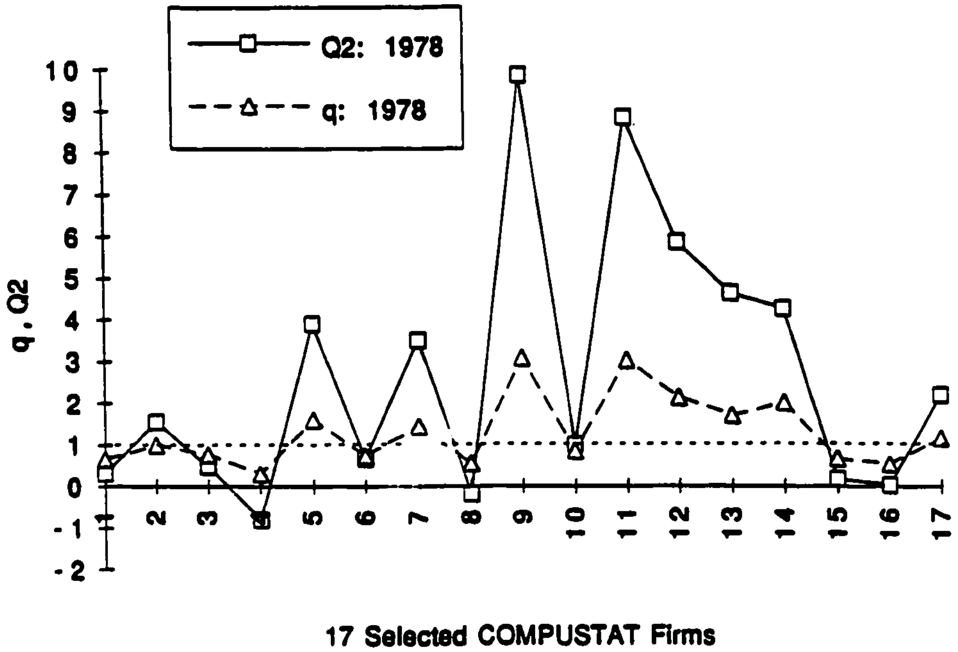

Figure 3.1: Tobin's q and Tax Adjusted Q_2 for 17 Firms: 1978

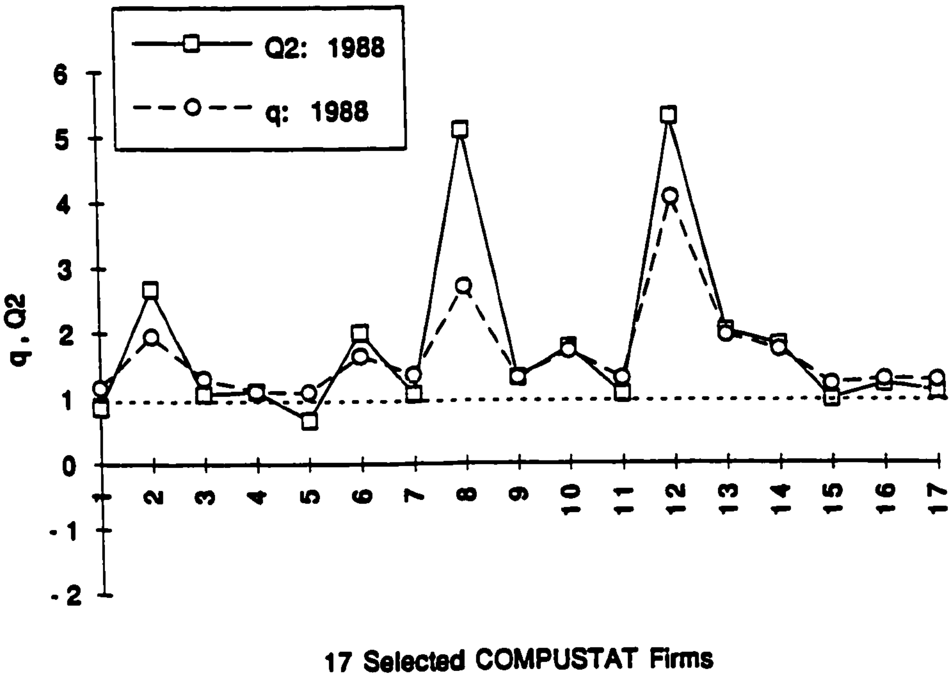

Figure 3.2: Tobin's q and Tax Adjusted Q_2 for 17 Firms: 1988

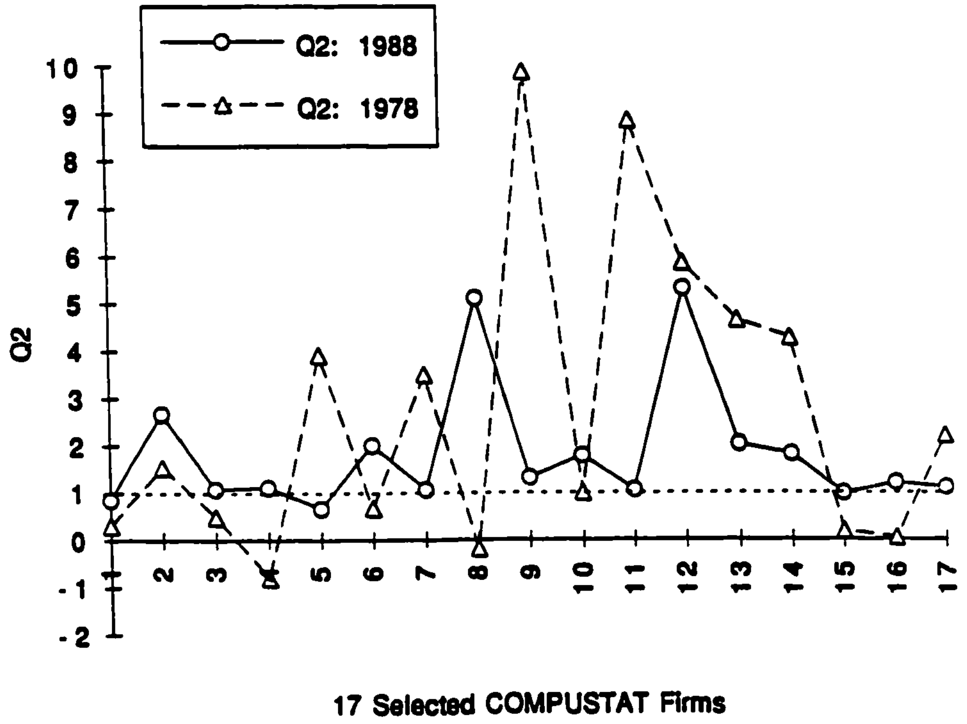

Figure 3.3: Tax Adjusted Q_2 for 17 Firms: 1978 and 1988

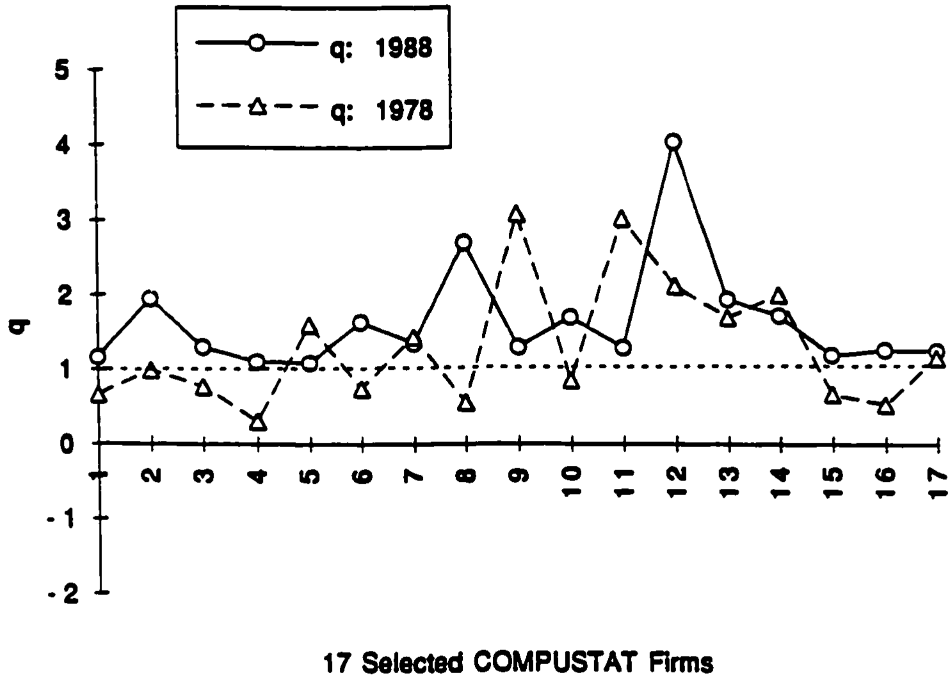

Figure 3.4: Tobin's q for 17 Firms: 1978 and 1988

3.3.2 Comparing q, Q_1, Q'_1 and Q_2 Investment Models Estimations for 17 Firms: 1970-1989

Estimating equation (3.5) for each of these firms for the time period 1970 to 1989 will allow us to see how the Q theory model performed in relating changes in Q to investment growth over time. By estimating the investment model for each firm using the tax adjusted $Q's$ as well as Tobin's q we can determine if there is empirical evidence to support the hypothesis that tax effects are important in explaining firm investment behavior.

Tables (3.2), (3.3), (3.4) and (3.5) show investment parameter estimates for q, Q_1, Q'_1, and Q_2 for the 17 firms averaged over 1970-1989. Since all the models had Durbin-Watson values indicating a first-order serial correlation problem, estimates listed in these tables were adjusted using a Cochrane-Orcutt corrective procedure.[5]

In table (3.2) 13 of the 17 firms had R^2 values indicating that at least 60% of the variation in investment could be explained by variation in the Tobin's q. In addition, 15 of the 17 firms had t-values for the β_1 coefficients which were significant at the 5% level.

In table (3.3) 12 of the 17 firms had R^2 values indicating that at least 60% of the variation in investment could be explained by variation in the tax adjusted Q_1. In addition, 13 of the 17 firms had t-values for the β_1 coefficients which were significant at the 5% level.

In table (3.4) 13 of the 17 firms had R^2 values indicating that at least 60% of the variation in investment could be explained by variation in the tax adjusted Q'_1. In addition, 13 of the 17 firms had t-values for the β_1 coefficients which were significant at the 5% level.

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[5] Summers also found a first-order serial correlation problem, but chose not to transform the data because most of the power in the relation between investment and q is found at lower frequencies. In this case transforming the data would place a larger weight on high frequencies and may possibly be inappropriate.

Looking at estimation results for Q_2 listed in table (3.5) we see that 12 of the firms had R^2 values in excess of .60, and that 12 of the t-values on the β_1 coefficient were significant at the 5% level.

In general then, R^2 and t-values are consistent with a good fit of the model to the data supporting the Q theory of investment model under both dividend policy specifications as well as with Tobin's q. Considering the interpretation of these models as a measure of the correlation of Q with investment between the sets of estimates we find no real difference. Specifically, theory predicts that decreases in the marginal cost of investment should result in increased investment, which implies that the sign of the β_1 coefficient would be positive—consistent with the positive sign on investment. The sign of the β_1 is positive for fifteen firms when Tobin's q or Q_1' is used, fourteen firms in regressions using Q_1, and thirteen firms using Q_2 under dividend policy II. Taken together these results provide general support for the correlative interpretation of the investment regression. Curiously, these results do not indicate superior explanatory power of using a tax adjusted Q vs a non-tax adjusted q to explain changes in investment levels.

Table 3.2

Model: $\frac{I}{K} = \beta_0 + \beta_1 q + e_t$

t-statistic below

Firm	β_0	β_1	R -squared
Aluminum Company of America	-0.0007	0.0016	0.71
	-1.03	2.58	
American Brands	0.0147	-0.0041	0.24
	6.18	-2.48	
American T and T	-0.0056	0.0083	0.85
	-1.56	3.38	
Bethlehem Steel	0.0093	0.0070	0.91
	1.53	2.52	
Eastman Kodak	-0.0065	0.01388	0.70
	-2.96	6.37	
Exxon	0.0026	0.0037	0.80
	1.59	5.23	
General Electric	-0.0043	0.0051	0.79
	-2.40	3.95	
Goodyear Tire	0.0010	0.0042	0.56
	0.23	1.95	
IBM	-0.0095	0.0274	0.62
	-1.01	3.38	

Table 3.2 (continued)

Model: $\frac{I}{K} = \beta_0 + \beta_1 q + e_t$

t-statistic below

Firm	β_0	β_1	R-squared
International Paper	-0.0034	0.0047	0.41
	-0.92	2.79	
Merck	-0.0329	0.0484	0.71
	-1.95	3.62	
3M	-0.0177	0.0314	0.82
	-0.61	5.23	
Proctor and Gamble	0.0152	0.0167	0.77
	1.02	2.65	
Sears	0.0155	0.0138	0.81
	1.29	2.48	
Texaco	0.0076	0.0026	0.86
	1.78	0.78	
Union Carbide	-0.0117	0.0336	0.73
	-0.72	3.6	
United Technologies	0.3903	-0.2524	0.51
	3.41	-2.66	

Table 3.3

Model: $\frac{I}{K} = \beta_0 + \beta_1 Q_1 + e_t$

t-statistic below

Firm	β_0	β_1	R -squared
Aluminum Company of America	0.0006	0.0006	0.71
	2.82	2.51	
American Brands	0.0104	-0.0009	0.16
	7.45	-1.18	
American T and T	0.0011	0.0036	0.77
	0.48	2.53	
Bethlehem Steel	0.0203	0.0064	0.89
	5.21	5.02	
Eastman Kodak	0.0053	0.0040	0.70
	13.6	6.22	
Exxon	0.0058	0.0018	0.80
	4.29	5.23	
General Electric	-0.0004	0.0025	0.78
	-0.41	3.66	
Goodyear Tire	0.0058	0.0012	0.52
	2.10	1.44	
IBM	0.0139	0.0088	0.58
	4.08	3.03	

Table 3.3 (continued)

Model: $\frac{I}{K} = \beta_0 + \beta_1 Q_1 + e_t$

t-statistic below

Firm	β_0	β_1	R-squared
International Paper	-0.0003	0.0025	0.43
	-0.09	2.97	
Merck	0.0086	0.0184	0.74
	1.22	4.24	
3M	0.0118	0.0165	0.84
	0.49	5.81	
Proctor and Gamble	0.0270	0.0090	0.75
	2.56	2.77	
Sears	0.0286	0.0062	0.84
	3.46	2.48	
Texaco	0.0110	-0.0003	0.86
	6.18	-0.25	
Union Carbide	0.0154	0.0143	0.79
	3.05	3.6	
United Technologies	0.1236	-0.0354	0.47
	3.12	-1.09	

Table 3.4

Model: $\frac{I}{K} = \beta_0 + \beta_1 Q'_1 + e_t$

t-statistic below

Firm	β_0	β_1	R -squared
Aluminum Company of America	0.0009	0.0010	0.70
	8.9	2.2	
American Brands	0.0102	-0.0021	0.21
	11.9	-1.8	
American T and T	0.0039	0.0048	0.78
	2.18	1.56	
Bethlehem Steel	0.0093	0.0070	0.91
	1.53	2.52	
Eastman Kodak	0.0075	0.0072	0.79
	38.4	6.13	
Exxon	0.0066	0.0033	0.80
	4.18	4.8	
General Electric	0.0012	0.0042	0.72
	1.67	2.67	
Goodyear Tire	0.0077	0.0010	0.47
	0.3.2	0.71	
IBM	0.0198	0.0105	0.42
	7.96	1.69	

Table 3.4 (continued)

Model: $\frac{I}{K} = \beta_0 + \beta_1 Q'_1 + e_t$

t-statistic below

Firm	β_0	β_1	R-squared
International Paper	0.0012	0.0045	0.38
	0.52	2.49	
Merck	0.0186	0.0318	0.69
	3.19	3.58	
3M	0.0174	0.0301	0.82
	0.66	5.4	
Proctor and Gamble	0.0361	0.0133	0.76
	3.72	2.11	
Sears	0.0322	0.0107	0.87
	3.82	2.56	
Texaco	0.0182	0.0035	0.91
	3.49	1.55	
Union Carbide	0.0109	-0.0011	0.84
	8.18	-0.45	
United Technologies	0.0223	0.0256	0.78
	5.82	3.38	

Table 3.5

Model: $\frac{I}{K} = \beta_0 + \beta_1 Q_2 + e_t$

t-statistic below

Firm	β_0	β_1	R -squared
Aluminum Company of America	0.0012	-1.4600	0.49
	13.8	-0.98	
American Brands	0.0076	.00430	0.78
	9.06	6.60	
American T and T	0.0041	.00330	0.90
	4.12	2.30	
Bethlehem Steel	0.0148	.00534	0.92
	5.35	7.12	
Eastman Kodak	0.0158	.00830	0.45
	6.95	3.85	
Exxon	0.0081	.00225	0.77
	9.14	6.12	
General Electric	0.0029	.00158	0.84
	9.75	0.31	
Goodyear Tire	0.0146	-.00001	0.30
	6.04	-2.24	
IBM	0.0304	.01725	0.87
	2.02	0.23	

Table 3.5 (continued)

Model: $\frac{I}{K} = \beta_0 + \beta_1 Q_2 + e_t$

t-statistic below

Firm	β_0	β_1	R -squared
International Paper	0.0115	-.00002	0.79
	17.25	-6.98	
Merck	0.0418	.02750	0.78
	10.6	5.91	
3M	0.0239	.01924	0.80
	1.16	5.80	
Proctor and Gamble	0.0353	.01054	0.83
	6.99	5.90	
Sears	0.0290	.01453	0.68
	6.40	5.70	
Texaco	0.0140	.00536	0.80
	9.67	3.02	
Union Carbide	0.0255	.000005	0.32
	6.57	0.34	
United Technologies	0.0784	-.00009	0.56
	2.02	-0.23	

3.4 Summary of Results

Investment models estimated using q, Q_1,Q'_1, and Q_2 generally support the tax adjusted Q theory of investment for the period 1970-1989 based on statistical significance measures of R^2 and t-values. Conclusions based on signs of the coefficients also provide support of the investment model as a test of correlation between investment and Q.

Comparison of Tobin's q and tax adjusted Q_2 indicate that some firms fared better in the 1980's than others. This uneven effect across firms provides evidence that only some firms experienced improved incentives to invest, while others appear to have had incentives reduced. In addition, the importance of using a tax adjusted Q to measure firm investment incentives is underscored by the fact that the values of Tobin's q and the tax adjusted Q's are different over time.

The reason behind the mixed incentives to invest for these firms is not so clear. The negative impacts of the various tax code provisions on capital formation may have been greater than the positive effects such as decreases in the statutory corporate tax rate for many firms. Impacts of the specific tax code provisions on firm investment behavior and policy implications of these results will be explored in more detail in chapter 5.

Chapter 4

THEORY AND EVIDENCE USING U.S. FIRM LEVEL PANEL DATA FROM 1975-1988

4.1 Introduction

Fazzari, Hubbard, and Peterson (1987) conclude that Q is at best one of the few significant explanatory variables in determining firm investment behavior. However, this seminal study on U.S. firm behavior did not explicitly model the firm's dividend process. Devereaux and Schiantarelli (1989) point out that without modeling the dividend process of the firm, it is not possible to determine which firms are constrained by their earnings.

This chapter estimates an investment model which incorporates two alternative processes for explaining firm dividend behavior. The methodology, which is based on Hayashi and Inoue (1990) takes into account the cross-sectional and time series nature of the COMPUSTAT data in estimations. This approach avoids Q related econometric problems by using an instrumental variable technique to account for the endogeneity of Q and cash flow, and employing a Generalized Method of Moments (GMM) estimation technique to correct for heteroscedasticity in the data.

In addition, this chapter will outline a process for testing the sensitivity of investment to liquidity constraints for a panel of 220 U.S. firms from 1975 to 1988. Using the two definitions of Q developed in chapter 2, this framework will also allow us to test for robustness of the Q investment model to dividend policy specification.

4.2 Econometric Issues

Many previous Q studies are plagued with two non-trivial econometric problems.

The first econometric problem is that both Q and cash flow are endogenous. Hayashi and Inoue (1990) verify the endogenous nature of Q by showing how it is essentially a function of the technology shock and is therefore econometrically endogenous. The error term in the Q model then represents technology shocks to the profit function which includes adjustment costs. When this endogeneity is not accounted for, it is not surprising that variables such as output and cash flow, which are affected by technology shocks, are significant when added to the Q model estimations. Therefore it is important to correct for this problem when attempting to estimate an investment equation which contains Q, cash flow, and output on the right hand side.

The second econometric difficulty stems from the possibility that the variances across firms may not be equal. In addition, by using a panel data set rather than data from a random sample one must correct for the fact that the error term may be correlated across firms in the model. Further, as Gilchrist (1990) notes, if the investment model is misspecified such that Q is no longer a sufficient statistic for investment, then cash flow may simply be capturing this misspecification. He suggests that a strong correlation between cash flow and investment may only be reflecting the fact that firms with good investment opportunities tend to have high cash flows. These problems associated with previous Q estimations will be addressed presently.

The issue of misspecification is explored by estimating the Q investment equation with and without cash flow to test for the significance of cash flow in the model. And because Wildasin (1984) shows that under a specific set of assumptions including Hicks aggregation, that Q is independent of the composition of investment; no attempt is made to discriminate between capital and labor inputs in the model.

The problem of endogeneity of Q and cash flow is resolved by using a set of lagged endogenous variables as instruments in the estimation. Specifically, if we assume an error term in our investment model u_t that is linearly additive consisting of a permanent component v_t which contains all of the correlation across firms, and a temporary component w_t which is serially uncorrelated, then we can remove the correlation across firms contained in v_t by first differencing the data.[1]

The correlation of the temporary component of the error term with our right hand side variables can be resolved by using an instrumental variable approach with values of the lagged endogenous variables as valid instruments. To account for the fact that the variances are not likely to be equal across firms we can use a GMM estimation technique to obtain heteroscedastic consistent parameter estimates. This two-step procedure minimizes an objective function using an optimal weighting matrix where each equation is weighted by an estimate of the inverse of the standard error of the equation to correct for cross equation heteroscedasticity.

4.3 Generalized Method of Moments Estimation

The Generalized Method of Moments (GMM) Estimation procedure is a non-linear instrumental variable technique that estimates parameters by fitting sample moments to population moments. This method was popularized by Hansen and Singleton in (1982) for estimating first order conditions of dynamic optimization problems.

In matrix notation we can specify a system of $(t-1)$ equations in a reduced form as:

$$\mathbf{Y_t} = \beta \mathbf{Z_t} + \mathbf{e_t}$$

where $\mathbf{Y_t}$ is a single dimensional matrix of dependent variables, $\mathbf{Z_t}$ is matrix of endogenous variables, and e_t is the error term of the equation. Since $\mathbf{Z_t}$ is endogenous

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[1] This specification of the error term $u_t = v_t + w_t$ is supported by findings of Hayashi and Inoue (1990).

we need to find valid instruments, here we can use lagged endogenous variables as valid instruments.

The GMM estimator $\hat{\beta}$ is then given by:

$$\hat{\beta} = \left(\mathbf{Z}'\mathbf{X}\mathbf{V}^{-1}\mathbf{X}'\mathbf{Z}\right)^{-1}\mathbf{Z}'\mathbf{X}\mathbf{V}^{-1}\mathbf{X}'\mathbf{Y}$$

where $\mathbf{X}$ is a block diagonal matrix of instruments and $\mathbf{V}^{-1}$ is the inverse of the weighted sample covariance.

$\hat{\beta}$ minimizes the objective function:

$$J = N\left(\frac{\varepsilon'\mathbf{X}}{N}\right)\mathbf{V}^{-1}\left(\frac{\mathbf{X}'\varepsilon}{N}\right) \sim \chi^2_{(m-n)}$$

where N is the sample size and ε is the stacked error vector. The J statistic is asymptotically distributed as a χ^2 with $(m-n)$ degrees of freedom, where m is the total number of instruments or orthogonality conditions and n is the number of parameters. The J statistic can then be used to test the set of over-identifying restrictions that there are more orthogonality conditions than parameters.

4.3.1 Computation of Parameter Estimates

Computation of parameter estimates requires a two-step procedure. The algorithm can be outlined as follows:[2]

Step 1

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[2] See Hansen and Singleton (1982) for a complete derivation of the GMM estimator.

1) Choose starting values for the parameters.

2) Calculate β using the initial parameter values.

3) Compute $\mathbf{V} = \sigma_{tv}\left(\frac{\mathbf{X_t X'_v}}{N}\right)$.

4) Set the weight matrix, $\mathbf{W} = \mathbf{V}^{-1}$.

5) Use the weight matrix to minimize the J-statistic. Iterate on the J-statistic until convergence where the iteration algorithm follows Newey and West (1986).

Here σ_{tv} is a consistent estimate of $cov\,(\varepsilon'_t\varepsilon_v)$, and the instrumental variable set X_t includes lagged and future endogenous variables that do not overlap with the time periods over which the first difference is taken. Step one produces consistent but not asymptotically efficient estimates.

Step 2

1) Re-compute the weight matrix as outlined above using the final parameter estimates derived in Step 1.

2) Use this new weight matrix to minimize the J-statistic. This gives the most efficient estimates among the class of estimators that minimize a function such as J. T times the resulting J-statistic will be distributed χ^2 with degrees of freedom equal to the number of independent orthogonality conditions.

4.4 The Reduced Investment Model

In chapter 2, the Q model is derived from the first order conditions of the firms dynamic optimization problem with adjustment costs. Assuming competitive firms with constant returns to scale production technologies, the marginal adjustment cost of investment should be equal to the shadow price of capital after taxes. The resulting Q investment model has the following testable implications. First, is cash flow a significant determinant of investment? And second, how sensitive is the Q model to alternative specifications of Q based on dividend policy assumptions?

The following Q investment equation is estimated for 14 years of annual *COMPUSTAT* data subdivided by firm size. Hayashi and Inoue (1990) discuss the appropriateness of using a generalized method of moments procedure to estimate the Q equation model using a set of instruments that are orthogonal to the error term under the null hypothesis of no misspecification. The empirical model can be specified:

$$\frac{I_{jt}}{K_{jt}} = b_0 + b_1 \frac{I_{jt-1}}{K_{jt-1}} + b_2 Q^i_{jt} + b_3 Q^i_{jt-1} + b_4 \frac{CF_{jt}}{K_{jt}} + e_{jt} \tag{4.1}$$

where Q^i_{jt-1} is firm j's Q at the beginning of the period t under dividend policy specification i and Q^i_{jt} is firm j's Q at the end of period t, under dividend policy specification i. The purpose of including Q's from both periods is to account for the possibility that cash flow may simply provide new information not contained in the beginning of period t's Q. CF_{jt} is firm j's cash flow for period t, and the error term is the forcing variable from the investment adjustment cost function.[3] $\frac{I_{jt-1}}{K_{jt-1}}$ is firm j's investment in period $t-1$. Chrinko (1987), and others, have established the importance of including lagged investment in the Q model specification.

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[3] One interesting variation for future research might be to incorporate a measure of liquidity constraint effects directly into the Q definition.

Since e_{jt} is not correlated with variables dated $t-1$ or earlier by assumption, equation (4.1) can be estimated using an instrumental variable approach, with instruments consisting of (t-2) and (t-3) lagged values of $Q, \frac{I}{K}, \frac{Y}{K}, \frac{CF}{K}$, and time dummies to account for time related anomalies in the data.

Significance of the cash flow variable can be determined by estimating the investment equation with and without cash flow. Under the null hypothesis that the coefficient on cash flow is not statistically different from zero, the difference in the values of the resulting objective functions times the number of observations is distributed χ^2_Δ with one degree of freedom. The robustness of the Q-model to the different dividend policy assumptions I and II can be examined by comparing the results of the specification tests.

4.5 Empirical Results

Tables (4.1), (4.2), and (4.3) show summary statistics on all the firms across the sample time period as well as by firm size. Firm size is based on the replacement cost of plant, property and equipment of the firm over the sample period. Size 1 denotes firms with capital assets valued at less than 35 million dollars, size 2 denotes firms valued at more than 35 million dollars but less than 110 million dollars, size 3 denotes firms valued at greater than 110 million dollars but less than 350 million dollars, and size 4 denotes firms who had capital assets valued in excess of 350 million dollars. The cut off values for these groups were selected to divide the entire sample into four groups of roughly equal size.

Investment I, sales Y, and cash flow CF are all normalized by K, the capital stock in each period in order to focus on the growth of the variables of interest. RE measures the firms level of retained earnings , and the debt/equity ratio is calculated as changes in firms short term plus long term debt holdings divided by changes in the firms equity issues. DIV/OI is the ratio of the firm's dividend payment over the operating income of the firm. Appendix B contains details on the construction of these variables.

In table (4.1) we find that the largest firm sizes 3 and 4 have Q_1 and Q_2 values above the mean of the sample. This would be consistent with the notion that larger firms faced lower marginal costs of adjustment during the sample period than smaller firms.[4] It is also clear that cash flow, retained earnings, and the debt to equity ratios are much higher for the largest firm size than the smaller three size groups.

Tables (4.2) and (4.3) list means of some of the firm's important variables from 1975 to 1988 for each year. Investment growth and Q values seemed to have generally increased until the early to mid 1980's then dropped off somewhat after 1986.

Tables (4.4) and (4.5) report the results from estimating equation (4.1) with and without cash flow for the overall sample and four sub-sample groups divided by firm size. Table (4.4) contains the results of tests for over-specification of the model and the significance of cash flow under dividend policy I. The χ^2 statistic for the investment regression run both with and without cash flow tests the hypothesis of over-identifying restrictions in the model with $(m - n)$ degrees of freedom where m is the total number of instruments, or orthogonality conditions, and n is the number of parameters. The χ^2_Δ statistic can then be interpreted as a test of the significance of cash flow in the model with one degree of freedom. Focusing on χ^2_Δ, cash flow is significant for the All Firms category, as well as for the largest firm size group at the 5% level. Cash flow is not found to be significant at the 5% or 10% for firm sizes 1, 2, and 3.

Table (4.5) displays the results of tests under dividend policy assumption II. Looking at the All Firms category we find that the hypothesis of a nonsignificant cash flow

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[4] It should be kept in mid that the terms 'larger' and 'smaller' in this sample do not span the entire possible range of firm sizes in the general population. All the firms in this study are *S&P* publicly held firms, not single owner private businesses, so they can in a sense all be considered large with respect to the total population of firms.

is easily rejected at the 5% level. Furthermore, when we break down the firms by size, we find that cash flow appears to be significant for the two largest firm categories at the 5% level.

While the result that cash flow matters most for larger firms may seem counter intuitive, these findings are consistent with those of Gilchrist (1990) and Devereux and Schiantarelli (1989). This result may simply reflect the fact that larger firms may have a lower *relative* cash flow, or that they may have a more diverse ownership structure, which tends to increase agency costs.

Comparing the results between dividend policy assumptions I and II we find that both model specifications show a similar pattern in significance of cash flow variable as one moves from the smaller to the larger firms; consistent with the pattern of cash flow significance found in Devereux and Schiantarelli (1989) for British firms.

These results support the hypothesis that the Q investment model is robust with respect to assumptions about the nature of the dividend payout process.

Table 4.1
Summary Statistics
1975-1988

Standard Deviations Below

Variable	All firms	Size 1	Size 2	Size 3	Size 4
Means		$pk \leq 35$	$35 \leq pk \leq 110$	$110 \leq pk \leq 350$	$pk \geq 350$
	obs=3332	obs=903	obs=873	obs=866	obs=690
I/K	0.276	0.272	0.261	0.282	0.268
	.13	.24	.11	.19	.17
Y/K	3.881	5.163	3.278	3.577	3.498
	6.4	3.8	1.8	2.8	3.2
CF/K	1.056	0.793	0.784	0.778	2.076
	2.2	0.78	0.62	0.69	4.6
RE	0.406	0.253	0.265	0.288	0.931
	1.1	1.2	0.26	0.21	1.9
Debt/Equity	0.833	0.865	0.648	0.756	1.12
	2.6	2.9	1.3	1.4	4.2
Div/OI	0.023	0.038	0.025	0.013	0.007
	0.09	0.06	0.14	0.04	0.02
Q1	1.16	1.03	1.12	1.28	1.24
	0.91	0.83	0.87	1.01	0.87
Q2	1.77	1.63	1.69	1.89	1.90
	1.08	1.01	0.99	1.11	1.14

Table 4.2
Summary Statistics
1975-1981
Standard Deviations Below

Variable Means	1975	1976	1977	1978	1979	1980	1981
I/K	0.15	0.19	0.20	0.22	0.24	0.27	0.29
	0.11	0.03	0.08	0.05	0.10	0.12	0.13
Y/K	1.445	2.13	2.36	2.71	3.07	3.56	3.96
	1.95	2.1	2.6	3.4	5.5	6.8	7.5
CF/K	0.248	0.472	0.521	0.598	0.713	0.812	0.918
	0.37	0.19	0.42	0.44	1.21	1.41	1.40
RE	0.171	0.223	0.246	0.279	0.334	0.402	0.446
	0.25	0.26	0.33	0.41	0.62	0.9	0.99
Debt/Equity	0.72	0.63	0.65	0.61	0.61	0.60	0.74
	1.7	1.1	1.6	0.8	0.6	0.6	1.5
Div/OI	0.047	0.043	0.034	0.031	0.029	0.042	0.019
	0.07	0.09	0.05	0.04	0.06	0.24	0.06
Q1	0.50	0.99	0.95	0.92	1.04	1.19	1.10
	1.22	0.69	0.63	0.56	0.72	0.93	0.73
Q2	0.82	1.52	1.52	1.49	1.69	1.76	1.69
	1.3	0.72	0.66	0.61	0.80	1.04	0.87

Table 4.3
Summary Statistics
1982-1988

Standard Deviations Below

Variable Means	1982	1983	1984	1985	1986	1987	1988
I/K	0.31	0.31	0.32	0.32	0.32	0.31	0.31
	0.17	0.18	0.17	0.15	0.16	0.17	0.18
Y/K	4.07	4.27	4.77	4.72	4.76	5.18	5.42
	6.9	8.1	9.3	9.8	8.9	9.9	11.8
CF/K	1.03	1.15	1.37	1.47	1.64	1.83	1.98
	1.7	1.1	2.4	3.0	3.5	3.6	4.1
RE	0.464	0.472	0.478	0.497	0.484	0.491	0.710
	1.1	1.1	1.1	1.1	1.1	1.3	2.7
Debt/Equity	0.69	0.79	0.69	0.95	1.2	1.3	1.4
	1.2	2.8	1.3	0.09	2.3	4.4	5.6
Div/OI	0.012	0.009	0.007	0.007	0.006	0.005	0.008
	0.01	0.03	0.01	0.01	0.01	0.01	0.04
Q1	1.33	1.55	1.35	1.53	1.55	1.17	1.09
	0.88	0.98	0.81	1.05	1.02	0.86	0.79
Q2	1.90	2.19	1.98	2.27	2.42	1.82	1.79
	1.02	1.19	0.95	1.17	1.37	1.11	1.01

Table 4.4
IV GMM Estimation of Q_1 Investment Model Under Dividend Policy I

Coefficient (Standard Errors)	$\frac{CF}{K_t}$	$\frac{I_{t-1}}{K_{t-1}}$	Q_t	Q_{t-1}	χ^2	χ^2_Δ
All Firms	.1503	.1915	.1147	-.1345	13.95	9.23
	(.17)	(.14)	(.60)	(.12)		
	-	.1998	.0032	.0150	4.72	
	-	(.41)	(.44)	(.06)		
Size 1	.3558	.4512	-.0016	-.0268	1.83	0.52
	(.16)	(.10)	(.18)	(.05)		
	-	.7992	.2019	.0283	0.31	
	-	(.18)	(.73)	(.08)		
Size 2	.3227	.6328	-.0227	-.0341	7.44	1.23
	(.73)	(.58)	(.16)	(.05)		
	-	.7295	.2769	-.0165	6.21	
	-	(.18)	(.21)	(.10)		
Size 3	.2591	.4784	-.1731	.0417	2.03	1.89
	(.44)	(.48)	(.07)	(.06)		
	-	.3861	.2440	.8821	0.14	
	-	(.42)	(.49)	(.19)		
Size 4	.7545	.1709	-.0505	.1713	16.9	3.84
	(.48)	(.16)	(.07)	(.04)		
	-	.2205	.9994	.9810	13.11	
	-	(.32)	(.79)	(.69)		

Table 4.5
IV GMM Estimation of Q_2 Investment Model Under Dividend Policy II

Coefficient (Standard Errors)	$\frac{CF}{K_t}$	$\frac{I_{t-1}}{K_{t-1}}$	Q_t	Q_{t-1}	χ^2	χ^2_Δ
All Firms	.1508	.6992	.1138	.0896	32.58	10.79
	(.33)	(.09)	(.06)	(.03)		
	-	.6864	-.0374	.1106	21.79	
	-	(.08)	(.08)	(.03)		
Size 1	2.602	.3993	.0010	.0532	3.38	1.39
	(1.0)	(2.0)	(.68)	(.15)		
	-	4.218	.8371	-.0009	1.99	
	-	(9.2)	(1.7)	(.34)		
Size 2	0.018	1.767	-.7166	-.2077	2.740	1.67
	(.87)	(1.7)	(.65)	(.18)		
	-	3.912	-1.107	-.3489	1.07	
	-	(4.7)	(1.7)	(.48)		
Size 3	.5540	.1636	.0183	-.0599	16.19	12.59
	(.61)	(.57)	(.10)	(.06)		
	-	3.260	-.0684	-.0548	3.60	
	-	(.56)	(.20)	(.12)		
Size 4	.3116	.7273	.2594	.0709	33.50	3.94
	(.49)	(.16)	(.07)	(0.03)		
	-	.8469	.0234	.1068	29.56	
	-	(.12)	(.10)	(.03)		

4.6 Conclusions

Results indicate that liquidity constraints are important in the Q investment model. Specifically, when we move from smaller to larger firms, we find that cash flow is a significant determinant of investment in the model. Furthermore, we find that this pattern generally holds under both Q specifications; that is, cash flow is significant whether we define the dividend payout process as one where the firm pays a fixed dividend to stockholders on their equity or, more traditionally, as one that pays the difference between after-tax profits less the costs of adjustment. Overall, these results imply that the Q-theory model is robust to alternative Q's based on dividend-payout behavior.

In addition, while means of investment growth appear relatively stable over the period of the study, Q values displayed much more variation. Sharp declines in both Q's after 1986 support the notion that the net impact of the 1986 tax reforms on capital investment was an increase in the marginal cost of investment to the firm.

Chapter 5

POLICY IMPLICATIONS OF THE TAX REFORM ACTS OF 1981, 1982, AND 1986

5.1 Introduction to Tax Reform in the 1980's

The 1980's were an active period for tax reform in the United States, with one minor and three major tax reforms passed into law before the end of the decade. Policy makers had several goals in mind with these reforms, but many felt the primary goal was to stimulate firm investment in capital. This work analyzes the effectiveness of these tax reforms with respect to their impact on the growth of firm investment. Other goals of the tax reforms not evaluated in this study which were met with varying degrees of success include: increased equity of the tax burden with respect to the sentiment that businesses were not paying their fair share of taxes, neutrality of taxation with respect to different types of capital investment, and neutrality of taxation with respect to inflation.

Evaluating the overall success or failure of these tax reforms is an important task in spite of the statistical problems and limitations encountered in doing so. From an economists perspective, the frequent reforms of the 1980's render it an ideal period to study the effects of fiscal tax shocks on firm investment behavior over time. For policy makers it is becoming increasingly important to determine the effectiveness of tax reforms in order to address the problems of capital formation and stimulation.

Overall, empirical results confirm the widespread belief that the link between the tax reforms and investment growth in the 1980's was weak. This observation is supported by lack of correspondence between movements in the aggregate growth rate of investment and movements in the firm's marginal incentive to invest as measured by the tax adjusted Q. That is not to say that tax reform can be considered altogether impotent in effecting firm investment behavior; rather, that estimating the marginal effects of tax code changes on the marginal incentive to invest requires a model that can control for all other effects on investment behavior in addition to taxes. The task of controlling for all possible factors on the firm's decision to invest is at best an onerous one. However, to the degree that modeling the firm's dividend policy was effective in capturing more of the variation in firm investment behavior than previous studies, this model represents an improved attempt to measure the tax code effects on investment.[1]

In addition, it is also important to note that many of the reforms had negative as well as positive impacts on firm investment growth, indicating a need to evaluate the *net* impact of these reforms on investment.

5.2 Tax Reform: Theory and Practice

There are three ways in general that the tax structure can provide incentives for the firm to invest. First, any tax that decreases the effective price of new capital goods will provide an incentive for the firm to invest. Tax cuts that decrease the effective price on new capital include increases in the investment tax credit (ITC), accelerated depreciation, and depletion allowances. The second way the tax law can provide investment incentives is through cuts in the statutory corporate tax rate. The third would be a decrease in taxes on the returns to investment at the personal level. This would include a reduction in the statutory personal tax rate or a reduction in the capital gains tax.

The decade of reform started out with the Economic Recovery Tax Act (ERTA) of 1981. This tax legislation introduced measures to encourage firm investment in

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[1] See chapter 4 for empirical results on the reduced investment equation estimated under dividend policy assumptions I and II.

capital by reducing the tax burden on the firm through such measures as accelerated depreciation allowances and allowing firms to sell unused tax credits. In 1982 the Tax Equity and Financial Responsibility Act (TEFRA) was enacted in an attempt to make the tax law more neutral and improve the raging government deficit by taking back many of the cuts given out in the previous year.[2] Finally, the 1986 Tax Reform Act (TRA) was passed with significant, but mixed, tax incentive effects on investment. This reform is widely believed to have increased the marginal cost of new investment to the firm.

5.2.1 Provisions of the 1981 and 1982 Tax Reform Acts

Proponents of the 1981 and 1982 Tax Acts argued that these tax cuts would promote economic recovery by providing greater incentives to work and invest. In order to determine incentive effects we must look at the marginal tax rates, that is to say, the extra tax incurred on an additional dollar of income. The arrows next to each of the major tax reform provisions below indicate the effect of the particular provision on the firm's marginal incentive to invest. An ⇑ indicates a positive effect on the firms marginal incentive to invest, a ⇓ indicates a negative impact on the firms investment incentive, and an ⇔ indicates an inconclusive effect.[3]

Specific Provisions of the 1981 Economic Recovery Tax Act (ERTA) include:

⇑ 1) A 23% reduction in personal income tax rates applied to all but the top bracket.

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[2] In 1984 another similar but less significant tax act was passed as part of the Deficit Reduction Act or (DEFRA).

[3] Stephen Meyers, "Tax Cuts: Reality or Illusion?", Federal Reserve Bank of Philadelphia, Federal Reserve Bulletin, pages 3-16.

⇔ 2) Inflation indexing of tax brackets, personal exemptions, and the zero brackets. These were all increased by the percentage increase in prices that occurred during the year ending the previous September 30th.

⇑ 3) A substantial speedup of depreciation deductions used in calculating business taxes.

⇑ 4) "Safe-Harbor" leasing provisions that allow firms to sell unused tax credits to reduce their tax liabilities.

Provision 1 provides a decrease in the personal income tax which translates into a disincentive for the firm to retain earnings. This is expected to positively impact firm investment. In the context of the model developed in chapter 2, this effect is appropriately accounted for only in the Q_2 measure based on dividend policy assumption I. Indexing the tax brackets does not explicitly provide an investment incentive but should nonetheless positively impact the firm's ability to invest. The purpose of this provision was to eliminate bracket creep for the years following 1984.

The Accelerated Cost Recovery System or (ACRS) described by provision 3 provided a strong incentive for the firm to invest in two ways. First, it effectively decreased the effective price of new capital goods by allowing firms to write off the cost of equipment more quickly. Secondly, it increased the after tax profits to the firm. Tax provision 4 allowed firms to reduce their tax liabilities through sales of unused tax credits thereby increasing the firm's after tax profits, which is expected to positively impact the firm's economic well being. Overall, these benefits to the firm lowered the marginal cost of investment as well as positively impacted the firm's after tax profits.

From a federal revenue perspective, it is estimated that these 1981 tax revisions were to have reduced tax revenues by 60 billion dollars during 1981 and 1982 and would have resulted in further reductions of 250 billion dollars during 1983 and 1984.[4] Concerned about the revenue loss, Congress adopted the Tax Equity and Fiscal Responsibility Act in 1982, which contained the following provisions:

⇓ 1) Restricted sales of unused tax credits.

⇓ 2) Reduced depreciation allowances by half of any investment tax credit claimed.

Both the curtailing of the sales of unused tax credits and the reduction in depreciation allowances reduced net profits to firm. Further, the later provision had the additional negative impact of increasing the effective price of new capital. Both of these provisions negatively impacted the marginal incentive of the firm to invest in capital.

5.2.2 Provisions of the 1986 Tax Reform Act

Specific Provisions of the 1986 Act were:

⇑ 1) Reduction in the corporate tax rate.

⇓ 2) Lengthening of Depreciation life times. Previously lives were set at 5 years for most equipment, 3 years for light equipment, and 19 years for business structures. Now most equipment is written off in 7 years, and nonresidential structures in 31.5 years.

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[4] Meyers concludes that the 1981 and 1982 tax acts had the net effect of cutting federal revenue by a total of 245 billion dollars from what it would have been under the prior law from 1981 to 1984. In addition he states that the real effects of the tax cuts will be undone by continuing bracket creep, rising social security taxes, and increasing indirect taxes.

⇓ 3) Repealment of the investment tax credit, previously equal to 10% of qualifying investment structures, primarily those on new machinery and equipment, with a retroactive effective date of January 1986.

⇓ 4) Full taxation of capital gains income for individuals.

Provision 1 specified a graduated reduction plan for the statutory corporate tax rate which was 46% in 1986. The 1987 rate was reduced to 40%, and for years 1988-1990 the rate was set at 34%. This reduction should have provided a positive incentive to invest. Provision 2 describes the tax code for lengthening depreciation life times, which had a negative impact on the firm's incentive to invest. Provision 3 describes the reduction of the investment tax credit from 10% to 0%, providing a strong disincentive for the firm to purchase new equipment. Finally, provision 4 made capital gains income taxable at the same rate as ordinary personal income rather than being treated favorably as 60% excludable from taxable income.

Overall, the TRA of 1986 shifted the U.S. tax burden from households to businesses while raising the overall tax burden facing new investment. The tax burden on different types of investment was also shifted. The repeal of the investment tax credit caused the effective tax rate on new equipment to rise, while the corresponding rate on business structures not qualifying for the investment tax credit fell, as the corporate rate reduction outweighed the impact of longer depreciation life times.[5]

5.3 Effects of Tax Reform on Debt vs Equity Financing

The tax reform acts also impacted investment levels of the firm through its effect on the financing decisions of the firm. Tax code changes at both the individual and firm

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[5] Alan Auerbach and Kevin Hassett,"Investment, Tax Policy and the Tax Reform Act of 1986, December 1989, Conference Paper.

levels influenced the firm's optimal choice of debt-equity financing.

Historically, personal income taxes have been in place in the United States since 1913, and for most of this time, taxes on personal income τ_y have been different from taxes on equity income. Taxes on equity income include income in the form of dividends or capital gains τ_c. Specifically, while dividend income has been taxed the same as regular income, capital gains have been taxed more favorably. From the investors perspective we can model firm's optimal financial mix as:

$$(1 - \tau_y) \gtrless (1 - \tau_y)(1 - \tau_f)$$

where (τ_f) is the statutory corporate tax rate. If the left hand side of the equation is larger than the right hand side the investor is said to prefer debt financing to equity financing for the firm. If the right hand side is larger than the left hand side, then equity financing is preferred. Note that there is a preference for debt financing whenever: there is an increase in the corporate tax rate (τ_f), or there is a decrease in the personal income tax rate (τ_y), or there is an increase in taxes on equity income (τ_c).

Of course historically, firms use both types of financing which Miller suggests is because firms have different "clienteles" of investors reflecting the different tax rates faced by individuals in society. [6]

In the presence of imperfect capital markets, the firm's debt-equity decisions are believed to be determined in a hierarchical fashion. Studies such as Gilchrist (1989) which have modeled the cost differential between internal and external funds, find evidence to support the presence of financing hierarchies. Specifically, it has been shown that firms exhibit a hierarchical preference for different types of financing with internal funds revealed preferred to external funds, and debt financing preferred to equity. Taxes effect the cost of financing through such factors as non-debt shields such

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[6] See Merton Miller, "Debt and Taxes" *Journal of Economics*, May 1977, pp 261-275.

as depreciation and depletion allowances, and the ITC. It is also true that non-debt shields can reduce the expected shield benefit of additional debt. This means that the contribution to the value of the firm of an additional unit of debt is not constant but declines with expanded debt usage because it increases the probability that the debt shields will be redundant for any given amount of non-debt shielding.

The 1981 TRA provided a decrease in the personal income tax which we would expect to increase investor preference for debt financing of the firm. This tax act provided further encouragement for debt financing by including a provision for an accelerated cost recovery system. The 1986 TRA increased depreciation lives, reduced the ITC, and eliminated the special treatment of capital gains, all of which supported a debt preference in corporate financing. Results listed in figure (5.1) indicate that overall there was an increase in the use of debt financing during the 1980's and particularly after 1984.

The higher levels of corporate debt financing has had at least two adverse side effects on the economy.[7] The first adverse effect evolved from the fact that increases in corporate leverage tend to result in deterioration of the *quality* of the firm's debt on the margin. One reason for this effect is that the increased leverage simply reduces the capital buffer against default and thereby increases the risk of a corporation's default on its debt. The debt rating agencies and market response to such an increase in risk is to downgrade the quality assessment or rating of that firm's debt. This is consistent with the recent increases observed in "junk" debt, that is to say, debt that is valuated below investment grades.

The second adverse effect of a higher level of corporate leveraging, is the tendency for this to make the firm more susceptible to adverse changes in income. Thus an unanticipated economic downturn would have a magnified effect on the general economic health of the firm. This is consistent with Bernanke's (1989) work which warns

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[7] See Randall Johnston Pozdena, (1989) *Tax Policy and Corporate Capital Structure*, Federal Reserve Bank of San Francisco, pp 37-50.

that the widespread loss of confidence in the liabilities of U.S. corporations could have a depressing systemic effect on economic activity that exceeds the aggregate of the individual losses that firms face.

5.4 Net Impact of the Tax Reform Era

Regarding the 1986 TRA, Auerbach and Hassett (1989) find that for equity financed investments, the drop in the statutory corporate rate was outweighed by the reduced value of depreciation allowances and ITCs. They also conclude that the net effect of the provisions of the 1986 TRA was to increase the tax burden on newly purchased equipment; with a relatively stronger growth in equipment as compared to structures. The differing impact on structures versus equipment can be attributed at least in part to changes in technology which are not well captured by the model.[8]

Overall, they conclude that tax factors moved in the opposite direction of investment growth in the post 1986 TRA era. That is to say, that the 1986 TRA has not appeared to have played a significant role in explaining the investment patterns in equipment and structures over the past few years. Clearly there may be other significant macroeconomic factors which must explain these non results such as technological innovation.

Considering the net impact on the financing decisions of the firm, the reduction of the corporate tax rate lowered the benefits of the interest deduction associated with debt-financed investment, while the reduction in the individual rates and the repeal of the capital gains tax preference shifted the relative costs of equity and debt financing. The net result appears to have been a substantial increase in the use of debt financing in the 1980's.

Interpretation of the results from testing the reduced form investment equation in

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[8] They also find that the boon associated with information processing and the decline in petroleum exploration explain much of the significant divergence between the performance of the equipment and structures categories in their study.

chapter 4 only weakly supports the hypothesis that the tax adjusted Q is an important determinant of investment behavior. Coefficients on Q and lagged Q are small but significant across firm size categories under both dividend policy specifications. It is also important to recognize that in attempting to measure and draw conclusions about tax effects on firm investment in this model, that other factors, such as the cost of funds to the firm and profitability of investment, are held constant in this study.

Finally, focusing on Q and investment growth aggregates over time, there appears to be a very weak correspondence as depicted in figures (5.2) and (5.3). Figure (5.2) indicates that investment growth was relatively weak during the 1980's. In figure (5.3) Q_2 values defined under dividend policy II seem to be increasing in the 1980's with a distinct drop following 1986. Under dividend policy I Q_1 shows little growth over time indicating a better correspondence than Q_2 to the sluggish investment growth of the 1980's. However, both Qs drop after 1986 indicating a decrease in the firm's marginal incentive to invest which is consistent with the 1986 tax reform measures, but inconsistent with the slow investment growth of the post 1986 period.

5.5 Conclusions

Investment rates have not appeared to have fluctuated outside of their normal range in the 1980's indicating an ambiguous effect of the tax reforms on corporate investment growth. The reasons for this weak evidence on the link between taxes and investment are not clear. One reason might be the violation of assumptions of the theoretical model or simple model misspecification in the empirical estimations. This might include exclusion of important effects, or inability to determine the proper lags to use in measuring the effects of a tax reform effect on firm investment behavior. In addition, with such frequent tax reforms one wonders how taxpayer expectations are formed; specifically whether they really regard any tax code change as a permanent one.

Perhaps the most convincing reason is the mixed signals given out by the tax reform acts themselves. Many of the stimulatory provisions of the reforms were either paired with negative tax laws resulting in a net effect that was either weakly negative or weakly positive, or they were immediately revised in the subsequent reform to provide the opposite incentive. In fact both these types of "netting out" of investment incentives of various tax code measures were observable in the 1986 TRA, and the 1981 ETRA and 1982 TRA, respectively.

Policy makers of the nineties also need to keep in mind that while two particular tax cuts may cost the same in terms of federal revenue loss, they may have very different stimulatory effects on the firm. For instance, if the goal of the reform is to stimulate new investment it makes much more sense to increase the investment tax credit rather than cut the statutory corporate tax rate. The ITC or accelerated depreciation stimulate more investment for dollar of tax cut than a more general cut in the statutory corporate tax rate. This "bang-for-the-buck" consideration in selecting tax cuts to stimulate investment underscores the message that not all tax cuts are created equal.

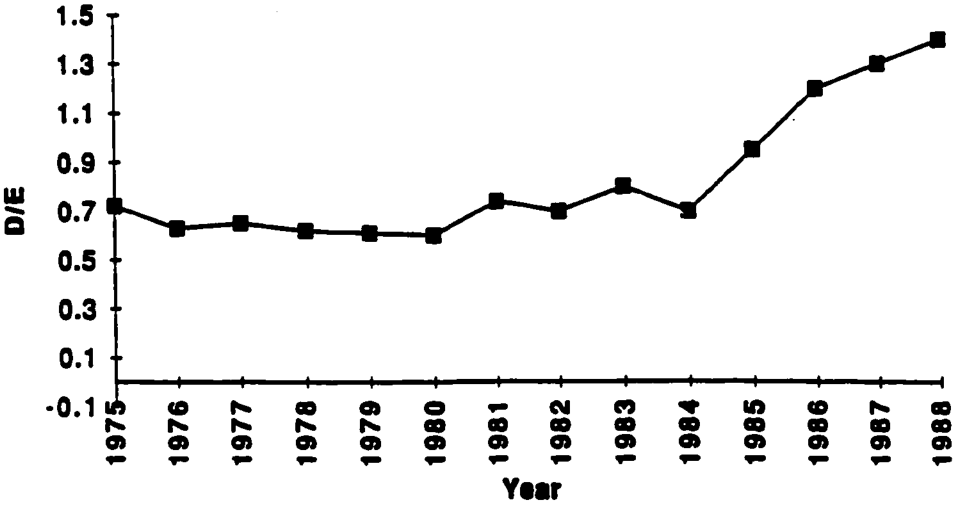

Figure 5.1: Debt to Equity Ratio 1975-1988

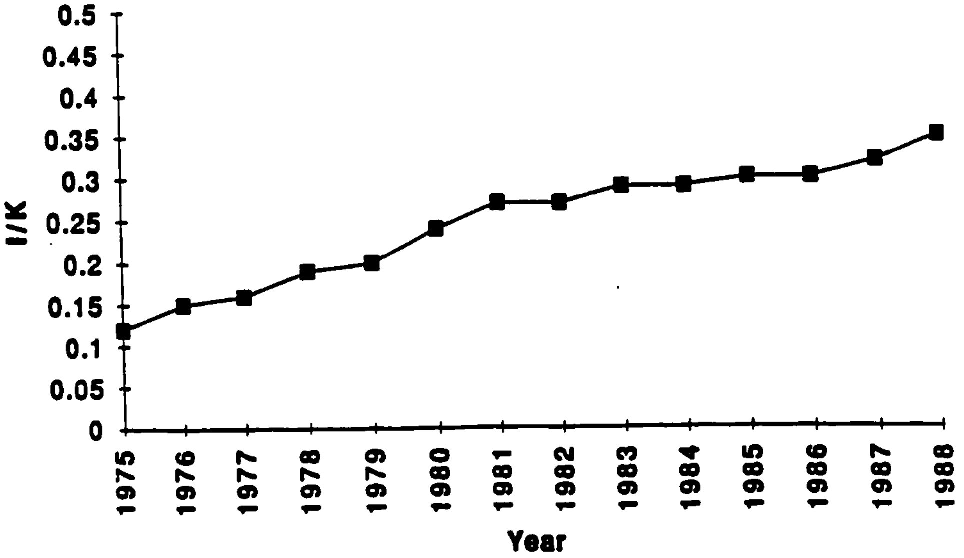

Figure 5.2: Investment Growth 1975-1988

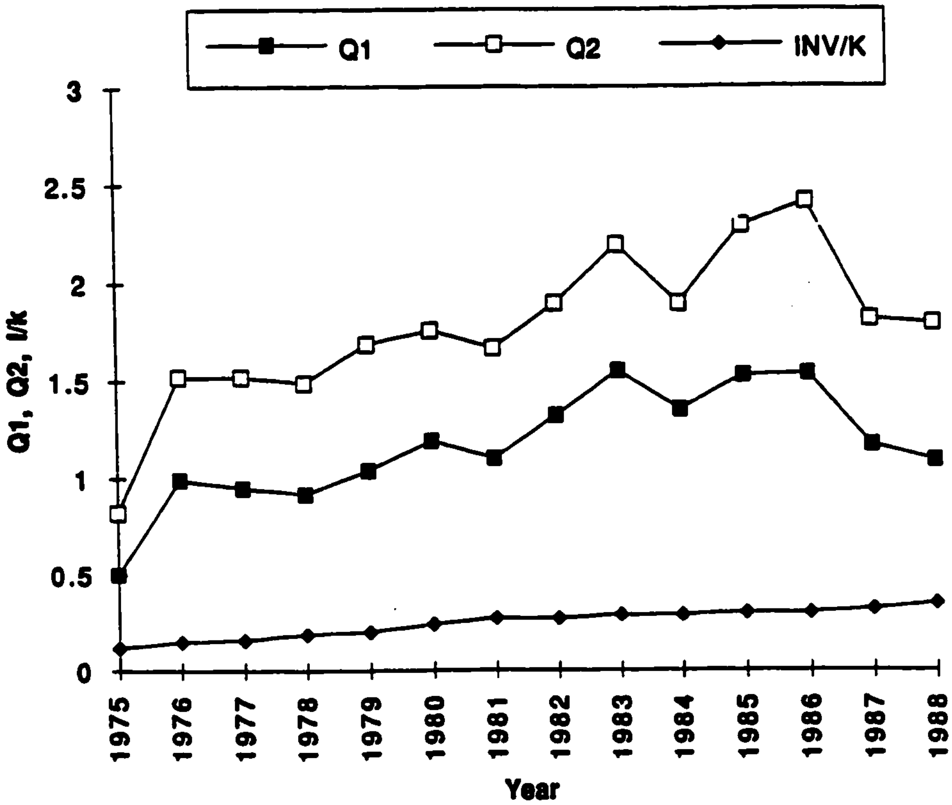

Figure 5.3: Investment Growth, Q_1 and Q_2 1975-1988

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Appendix A

DERIVATION OF TAX ADJUSTED Q_2 BASED ON SUMMERS (1981)

A.1 The Model

We can model the behavior of the firm in accordance with the traditional neoclassical production function F with the firm using inputs of capital K and labor L. In this model we assume that both marginal products are positive but diminishing such that $F_l > 0$, $F_k > 0$ and $F_{ll} < 0$, $F_{kk} < 0$ and $F_{kk}F_{ll} - F_{kl}^2 = 0$ where single and double subscripts denote first and second derivatives of the production function with respect to factor inputs. We can also assume non-monopoly rents, a constant returns to scale production function with homogeneity of factors, and complementarity of factor inputs such that $F_{kl} = F_{lk} > 0$.

The gross profits of the firm can then be defined as

$$R = pF(K, L) - wL - prbk \tag{A.1}$$

where p is the current price level and F is the production function of the firm based on capital K and labor L inputs. The term w is the real wage rate which is determined by the market because the firm is a price taker in this model. The term r is the nominal rate of interest, b is the fixed share of the capital stock that the firm maintains as debt, and the term $pbkr$ reflects the fact that the firm expenses interest payments on the debt.

If corporate profits are taxed at τ_f and the remainder is either paid out as dividends D or kept as retained earnings RE then the following equation describes corporate sources and uses of funds

$$(1 - \tau_f)\,R = D + RE. \tag{A.2}$$

Since equipment requires installation we define a convex cost of adjustment H as a function of investment I and capital K by

$$H\left(\frac{I}{K}\right). \tag{A.3}$$

Costs of adjustment enter the model because firms cannot costlessly and instantly adjust the capital stock, rather they face costs of equipment installation and removal. Here we define a marginal cost of adjustment as an increasing function of the rate of investment where H_I , $H_{II} > 0$. This means that as the firm increases investment it becomes more costly to do so, that is to say there exists some diseconomies of scale with respect to increases in capital investment.

The financing constraint facing firms can then be defined

$$RE + s\dot{E} = (1 - pb)H\left(\frac{I}{K}\right), \tag{A.4}$$

where b again is the fraction of the capital stock maintained as debt, representing bond financing, s is the price of an issue, $\dot{E}$ is the outstanding stock of the firm, and τ_f is the corporate tax rate. The dot notation above the E denotes the time derivative of equity. This equation describes both the sources and uses of funds. In the most general case, financing can come from any combination of these three sources. Throughout the rest of this model Summers assumes that the firm neither issues new equity nor repurchases existing shares. And since we allow for bond financing then $b > 0$.

The value of outstanding equities V can then be described as

$$V = sE. \tag{A.5}$$

Hence prices are proportional to the outstanding value of the firm's equity and from equations (A.2) and (2.4) we then derive an expression for dividends

$$D = (1 - \tau_f)\left[R - C\left(\frac{I}{K}\right)K\right] + s\dot{E}, \tag{A.6}$$

where $C\left(\frac{I}{K}\right) = H\left(\frac{I}{K}\right)(1 - pb)$ for notational simplicity. Combining equation (A.6) with the consumer optimality condition for equity and the time derivative of equation (A.5) we can derive the following equation for explaining the evolution of the value of the firm over time.[1]

$$\dot{V} = \frac{\theta}{(1 - \tau_c)}V - \left[(1 - \tau_f)R - C\left(\frac{I}{K}\right)K\right] + \frac{(\tau_y - \tau_c)}{(1 - \tau_c)}D \tag{A.7}$$

where θ is the real required rate of return on equities which is adjusted by one minus τ_c, the tax rate on capital gains and τ_y is the tax rate on ordinary or personal income.

From equation (A.7) we see that if $\tau_y = \tau_c$ then dividend policy is important to the firm. Applying this dividend rule to equation (A.7) we derive the dividend policy specific differential equation:

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[1] From Summers (1981) the cost of capital is defined as the real rate of return on equity or θ.

$$\dot{V}_2 = \left(\frac{\theta}{1-\tau_c}\right)V - \left(\frac{1-\tau_y}{1-\tau_c}\right)(1-\tau_f)\left[R - C\left(\frac{I}{K}\right)K\right]e^{-\int_t^s \theta_* du}ds. \tag{A.8}$$

There are several interesting implications that equation (A.8) suggests. First of all, $\dot{V}_2$ implies that the cost of capital $\theta^\star$ is equal to $\left(\frac{\theta}{1-\tau_c}\right)$. Focusing on tax policy implications, if all financing is out of RE, then the personal tax rate τ_y has no effect on the long-run capital to labor ratio. If however, all profits of the firm are paid out as dividends, then τ_c , the capital gains tax rate becomes irrelevant. This rule leads to a long-run undervaluation of equities.

The firm's objective is to maximize the initial value of equity $V(0)$ with respect to the inputs K, L, I. We can re-write (A.8) in the more generalized form as:

$$\dot{V} = \theta^\star V - \gamma(K, L, I). \tag{A.9}$$

Integrating (A.9) we can express the firm's maximization as a function of the dividend policy problem over time as:

$$\text{Max}_{K,L,I} V(0) = \int_t^\infty (1-\tau_f)\left[R - C\left(\frac{I}{K}\right)K\right]\left(\frac{1-\tau_d}{1-\tau_c}\right)e^{-\int_t^s \theta_* du}ds \tag{A.10}$$

s.t.

$$\begin{aligned} \dot{K}(s) &= I(s) - \delta K(s) && \text{(A.11)} \\ K(0) &= K_0. && \text{(A.12)} \end{aligned}$$

Equation (A.10) suggests that the firm wishes to maximize the net present value of net revenues by choosing optimal capital, labor and investment levels subject to capital constraints. The first constraint, $\dot{K}(s)$ describes the capital accumulation path whereby the firm invests to replace a deteriorating proportional constant δ of the capital stock K. $K(0)$ is simply the initial capital stock level. At each point in time t then, the firm picks L_t and K_t to maximize the value of the firm V_t, while the optimal value of investment I_t is determined residually from the capital accumulation identity.

If we assume expectations about future dividend payments of the firm are formed with perfect foresight we can impose the following transversality condition to guarantee a unique solution to our maximization problem:

$$\lim_{s\to\infty} V(s)\, e^{-\int_t^s \theta_u du} = 0$$

Rewriting (A.10) in terms of observable parameters, the value of the firm can be expressed:

$$V_{2t} = \int_t^\infty \Big[(F(K_t, L_t) - wL - bK_t r)(1 - \tau_f) -$$

$$\left(1 - ITC_t - Z_t - b + (1 - \tau_f) C\left(\frac{I_t}{K_t}\right)\right) I_t + pbK_t\left(\pi - \delta^R\right)\Big] \left(\frac{1 - \tau_d}{1 - \tau_c}\right) e^{-\int_t^s \theta_u du} ds + B_t \tag{A.13}$$

where K_t and L_t are factor inputs, wL_t is the labor expense, and rbK_t is the expensed interest on the debt, all of which is adjusted by the statutory corporate tax rate τ_f. The next part of the expression represents the investment expenses where ITC_t is the investment tax credit, Z_t is the present value of depreciation allowances, b is the fraction of the capital that the firm maintains as debt, and $(1 - \tau_f)\, C\left(\frac{I_t}{K_t}\right)$ is the net convex costs of adjustment, all of which is multiplied by investment I_t. All of this is then discounted by $\left(\frac{1-\tau_d}{1-\tau_c}\right)$ times $\theta^{\star}$ the real required rate of return on capital. B_t is the present value of depreciation allowances on existing capital stock. Of course in maximizing (A.13) B_t becomes irrelevant to the firm because it is independent of any current or future decisions.

Tax parameters in (A.13) are allowed to change over time and can be defined as:

$$B\,(t) = \int_t^{\infty} \tau_f \delta^T e^{-\delta^{\tau}(s-t)} \mu\,(s) K_t ds \tag{A.14}$$

$$Z\,(t) = \int_t^{\infty} \tau_f \delta^T e^{-\delta^{\tau}(u-s)} \frac{\mu\,(u)}{\mu\,(s)} \left(\frac{1-\tau_c}{1-\tau_d}\right) du \tag{A.15}$$

$$\mu\,(s) = e^{-\int_0^s \theta_* du} \tag{A.16}$$

Here, $B\,(t)$ is the present value of depreciation allowances on existing capital stock, which is a function of the corporate tax rate τ_f times the statutory depreciation rate on capital δ^T discounted by the tax adjusted required rate of return on capital $\theta^{\star}$ times the capital stock K_t. $Z\,(t)$, the present value of depreciation allowances on new investment is a function of the corporate tax rate τ_f times the statutory depreciation rate on capital δ^T, discounted by the tax adjusted required rate of return on capital. The term $\mu\,(s)$, defines the discount factor which is derived from the consumer optimality conditions for equity. As defined in equation (A.16), it is a function of the required rate of return on capital after corporate, but before personal income taxes and capital gains taxes.

Equation (A.13) can be interpreted as the market value of the firm's equity at time t which is equal to the after tax profits of the firm less investment expenses adjusted for tax and depreciation allowances. Maximizing this equation subject to the capital constraints allows us to derive the following optimality conditions for the firm:

$$F_L = \frac{w}{p} \tag{A.17}$$

$$(1 - ITC_t - Z_t - b) + (1 - \tau_f)\left[C\left(\frac{I_t}{K_t}\right) + C'\left(\frac{I_t}{K_t}\right)\frac{I_t}{K_t}\right] = \frac{\lambda_t}{p_t}\left(\frac{1-\tau_c}{1-\tau_d}\right) \tag{A.18}$$

$$\begin{aligned}\left[(1-\tau_f)(F_k - br) - \left(\frac{I_t}{K_t}\right)^2 C'\left(\frac{I_t}{K_t}\right)(1-\tau_f) + br\left(\pi - \delta^R\right)\right] = \\ \left[-\frac{\dot{\lambda}_t}{p_t} + \frac{\lambda_t}{p_t}(\theta_t^\star)\right]\left(\frac{1-\tau_c}{1-\tau_d}\right).\end{aligned} \tag{A.19}$$

Equation (A.17) suggests that the firm will hire labor until the marginal product of labor is equal to wages adjusted by the current price level. Equation (A.18) characterizes the investment function, it defines a function which links investment to the real shadow price of capital $\frac{\lambda}{p_t}$, the tax parameters and the convex costs of adjustment. Intuitively, the right hand side can be interpreted as the shadow price of an additional unit of capital goods, which should be equal to their marginal cost in after tax profits on the left hand side of the equation.

The condition for zero investment suggests that equation (A.19) becomes:

$$\frac{\lambda_t}{p_t} = \left(\frac{1-\tau_d}{1-\tau_c}\right)[1 - ITC_t - Z_t - b]\,. \tag{A.20}$$

Equation (A.19) describes the evolution of the shadow price of capital. It guarantees that the shadow price of capital equals the present value of future marginal products of a unit of capital.

A.2 Derivation of the Empirical Q

Because we have a constant returns to scale production technology and homogeneity of the adjustment cost function by definition, then we can derive our empirical Q as follows. From Hayashi (1982) we know :

$$V_t^{\star} - B_t = \gamma p_t K_t \tag{A.21}$$

where V_t is the stock market value of the firm when the optimal path is followed, B_t is the value of depreciation allowances, which is equal to a fixed proportion γK_t of the initial capital stock. The maximum principle implies then that

$$\lambda_t = \frac{dV_t^{\star}}{dK_t}. \tag{A.22}$$

where $\frac{\lambda}{p_t}$ is the shadow price of new investment or marginal Q.

Combining (A.21) and (A.22) we get:

$$\lambda_t = \frac{V_t^{\star} - B_t}{p_t K_t}. \tag{A.23}$$

Combining equations (A.18), (A.20), and (A.23) we can derive the tax adjusted Q_2 in terms of observable parameters as:

$$Q_2 = \frac{I_t}{K_t} = \frac{\dot{K}}{K} + \delta^R = h\left[\frac{\left(\frac{V_t - B_t}{p_t K_t}\right)\left(\frac{1-\tau_d}{1-\tau_c}\right) - 1 + b + ITC_t + Z_t}{1 - \tau_f}\right] \qquad \text{(A.24)}$$

where:

$$h(Q_2) = \left[C\left(\frac{I_t}{K_t}\right) + C'\left(\frac{I_t}{K_t}\right)\frac{I_t}{K_t}\right]^{-1}.$$

Appendix B

VARIABLE CONSTRUCTION

All variables, except tax rates, were constructed from data provided in the *COMPUSTAT* Industrial Annual data set. Estimations were performed on a sub-sample consisting of 220 firms from 1975-1988.

Firm Variables

V_t, the market value of equity at time t, was determined by adding the end of year closing prices on stocks times the number of outstanding shares (E) to the market value of preferred stock. The market value of preferred stock was derived by dividing preferred dividends, (PS), by the preferred stock yield (PSY):

$$V_t = sE + \frac{PS}{PSY}$$

Capital stock, K_t, is valuated at replacement cost based on taxable net property, plant, and equipment:

$$K_t = TNPPE_t = \left(\frac{TNPPE_{t-1} + PPI_t}{PPI_{t-1} + I_t}\right) \times \left(1 - \frac{2}{L}\right)$$

where I_t is investment in period t, PPI_t is the producer price index in period t, $TNPPE_t$ is the taxable net property, plant, and equipment in period t, and L is the useful life of capital goods. The useful life of capital goods is defined as gross property, plant, and equipment lagged one period plus current investment, divided by current book value depreciation.

Inventories were also valued at replacement cost. This involved adjusting inventories for both inflation and the inventory method used. Unless inventories were reported as being LIFO, a FIFO equivalent accounting measure was assumed in order to simplify the valuation process. The process for weighting the portion of inventories reported by each method is explained in Summers (1981). Inventories were added to capital stock in the denominator of the tax adjusted Q equation.

The market value of debt was proxied by adding the book value of long-term debt to the book value of short-term debt. All calculations assume a real fixed rate of return on equity of 6%.

The present value of future depreciation deductions on investment at time t was calculated as:

$$Z_i = \frac{\tau_d}{\delta + \frac{\rho+\pi}{1-\tau_c}}$$

where τ_d is the dividend tax rate, δ is the depreciation rate of capital, $(\rho + \pi)$ is the real rate of return expected by investors on equity adjusted for the capital gains tax rate τ_c.

B_t is the present value of depreciation allowances on existing capital. This was calculated as :

$$B_t = \frac{\tau_d}{\delta + \frac{\rho+\pi}{1-\tau_c}} \left(\frac{1 - \tau_d}{1 - \tau_c}\right) P_t K_t$$

where τ_d is the dividend tax rate, τ_c is the capital gains tax rate, P_t is the price level, and K_t is capital stock.

Tax Variables

The reported investment tax credit for each firm represents the accumulated tax deferrals of investment tax credits generated by new capital investments. All tax rates from 1970 to 1978 were taken directly from Summers (1981). Tax rates from 1979 to 1989 were derived as follows: the corporate tax rate τ_f which represents the statutory tax rate on corporate income is derived from Henderson (1989). The tax rates on dividends τ_d is the average marginal tax rates on dividend income estimated from an unpublished manuscript by Gary Biddle, University of Washington School of Business Administration. The capital gains tax τ_c is the average marginal tax rate on capital gains income taken from Henderson (1989).

Appendix C

TOBIN'S Q AND TAX ADJUSTED Q_2 FOR 17 FIRMS: 1978 AND 1988

Tobin's q and Tax Adjusted Q_2
1978 and 1988

Firm	Summers (1978)		Estimates (1988)	
	q : 1978	Q_2 : 1978	q : 1988	Q_2 : 1988
ACA	0.658	0.296	1.164	0.8521
American Brands	0.989	1.543	1.956	2.678
American T and T	0.765	0.4852	1.301	1.001
Bethlehem Steel	0.303	-0.807	1.227	1.029
Eastman Kodak	1.607	3.906	1.089	0.667
Exxon	0.744	0.674	1.644	2.003
General Electric	1.444	3.501	1.355	1.065
Goodyear Tire	0.554	-0.181	2.774	5.158
IBM	3.083	9.85	1.30	1.321
International Paper	0.854	0.992	1.716	1.770
Merck	3.026	8.83	1.298	1.052
3M	2.129	5.85	4.058	5.360
Proctor and Gamble	1.703	4.63	1.956	2.014
Sears	2.01	4.26	1.730	1.844
Texaco	0.67	0.177	1.254	0.978
Union Carbide	0.534	0.036	1.277	1.163
United Technologies	1.17	2.198	1.260	1.090

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