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Acquisitions and Investment

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We derive a simple theoretical framework in which acquisitions are treated as an alternative way of obtaining capital goods. Our framework predicts that both investment and acquisitions are positively related to a firm's shadow value of capital. We transform our theoretical specification into an econometric model, which we then estimate using a long panel data-set spanning 503 US firms over 15 consecutive years. Our results indicate that an increase in the shadow value of capital has approximately the same proportionate effect on the level of acquisitions as it does on investment. This result proves to be robust to a variety of alternative specifications.

INTRODUCTION

Recent years have witnessed a dramatic increase in the number of corporate takeovers. This tide of activity raises a number of questions about the causes and consequences of acquisitions. What effects do takeovers have on research and development spending? Do takeovers reduce employment? How important are tax considerations in motivating acquisitions? Do management objectives and/or the availability of free cash flow play a role in acquisitions? Although these questions have been addressed in previous research, no specific optimizing model has been put forward to explain the fundamental nature of the acquisition decision.[1] In this paper we propose such a model.

When a firm makes an acquisition, it obtains assets. In this way acquisitions and investment are similar activities, which one might expect to be guided (at least to a substantial extent) by similar economic principles. In this paper we specify and estimate a simple model that explicitly links a firm's acquisition activities to its investment choices. The only unusual feature of this model is that these goods can be either purchased directly (investment) or obtained by taking over another firm (acquisitions). Our model is based on the firm's intertemporal optimization problem under what are, with this one exception, standard assumptions. Our specification yields a pair of equations in which a firm's choices regarding acquisitions and investment are jointly determined and are influenced by the shadow value of capital.

As in many models of investment, we assume that firms face convex costs of adjusting their capital stocks. Consequently, the shadow value of capital may exceed its replacement cost. Firms for which the shadow value of capital is high relative to its purchase price will have an incentive to make relatively large capital purchases in relation to their existing capital stock. Under standard assumptions, the shadow value of capital is reflected in the firm's stock market value.[2] Thus, one empirical prediction of our optimizing model is that acquisition spending, like investment spending, should be correlated positively with the q of the firm. This prediction is at the heart of our model, suggesting that an important step in understanding acquisitions is to recognize that they are an alternative means of obtaining capital goods. It contrasts sharply with undervaluation stories, according to which acquisitions should be associated with stock market troughs.[3]

Although our theoretical model is fairly simple and is based on standard assumptions, its estimation raises several important econometric issues. First, because acquisitions and investment are jointly determined, a simultaneous-equations framework is required. Second, many types of capital goods are finely divisible, so investment expenditure typically is modelled as a continuous variable. However, when capital is obtained through acquisitions, it is done by taking over one or more entire firms. As a result, one might expect acquisitions to be considerably lumpier than ordinary investment activities. In fact, more than one-quarter of the firms in our sample never engage in acquisitions. The level of acquisitions, therefore, must be modelled as a censored dependent variable. Third, there is likely to be substantial degree of unobserved heterogeneity among the firms in our sample, which may influence both their investment and acquisition choices. Unless this heterogeneity is properly accounted for, the resulting estimates will tend to be biased. We address each of these issues in our empirical analysis.

The data employed in our analysis have a number of appealing features. First, because they are drawn directly from the financial statements of individual firms, all acquisition spending by these firms is included, regardless of whether the target is large or small, public or private. Second, the cross-sectional dimension of the data is large; we have 503 US firms in our sample. Third, the time series dimension of our data also is fairly large, spanning the 15 consecutive years from 1971 to 1985. These latter two features not only add to the precision of our estimates, but also make it possible to control for firm-specific fixed effects.

The paper is organized as follows. A theoretical framework for acquisitions and investment is developed in Section I. In Section II a stochastic specification of firm-level adjustment costs is employed to transform our theoretical model of acquisitions and investment into a fixed effects econometric specification involving simultaneous equations and limited dependent variables. Section III provides a discussion of the panel data-set used in the analysis and the results for our main specification. Related sensitivity analyses are presented in Section IV. A summary and a brief conclusion are offered in Section V. Three appendices provide additional details relating to our estimation and sensitivity analysis.

I. Theoretical Framework

In this section a theoretical framework for investment and acquisitions is developed based on standard assumptions. Consider a perfectly competitive firm with an infinite time horizon. The firm has two channels for purchasing capital: investment and acquisitions.[4] The optimal time paths for investment and acquisitions are determined as the solution to the following dynamic optimization problem:

$$\text{(1)} \qquad \max_{I_t, A_t, G_t, V_t^N} V_0 = E_0\left\{ \sum_{t=0}^{\infty} \beta_t \left[\left(\frac{1-m_t}{1-c_t} \right) G_t - V_t^N \right] \right\}$$

subject to

$$(2) \qquad K_{t+1} = I_{t+1} + A_{t+1} + (1-\delta)K_t, \qquad [\lambda_t^K]$$

$$(3) \qquad (1-\tau_t)[R(K_t) - p_t^K C(I_t, A_t, K_t)] + \tilde{D}_{t+1} - [1 + i_t(1-\tau_t)]\tilde{D}_t + V_t^N + \tilde{B}_t$$
$$= G_t + (1 - k_t - \tau_t z_t)p_t^K I_t + (1 - \tau_t z_t)p_t^K A_t, \qquad [\lambda_t^G]$$

$$(4) \qquad G_t \geqslant 0,$$

$$(5) \qquad V_t^N \geqslant 0,$$

$$(6) \qquad A_t \geqslant 0.$$

where $V_0 \equiv$ market value of the firm's outstanding shares at time 0, $E_0 \equiv$ expectations operator conditional on information available at time 0, $\beta_t \equiv$ discount factor, $m_t \equiv$ dividend tax rate, $c_t \equiv$ effective capital gains tax rate, $G_t \equiv$ dividends, $V_t^N \equiv$ value of new share issues, $K_t \equiv$ capital stock, $\delta \equiv$ rate of capital depreciation, $\lambda_t^K \equiv$ costate variable for equation (2), $\tau_t \equiv$ corporate tax rate, $R_t(\bullet) \equiv$ revenue function, $p_t^K \equiv$ price per unit of capital, $C(\bullet, \bullet, \bullet) \equiv$ adjustment cost function, $\tilde{D}_t \equiv$ stock of (one-period) debt, $i_t \equiv$ nominal interest rate, $\tilde{B}_t \equiv$ value of depreciation allowances on past investments which can be claimed in period t, $k_t \equiv$ investment tax credit rate, $z_t \equiv$ present value of depreciation allowances for capital, $I_t \equiv$ additions to the capital stock through investment, $A_t \equiv$ additions to the capital stock through acquisitions and $\lambda_t^G \equiv$ Lagrange multiplier for equation (3).

Equation (1) indicates that the firm maximizes the present value of dividends, adjusted for taxes on shareholders and for new share issues.[5] Equation (2) describes the evolution of the capital stock, which depends on the time paths of investment and acquisitions as well as the rate of capital depreciation. Equation (3) is the cash flow identity. The terms on the left-hand side of this equation represent the sources of funds (revenue, *less* adjustment costs, *plus* net funds from debt issuance, the value of new share issues, and the value of depreciation allowances on past investments that can be claimed in period t). The terms on the right-hand side represent the uses of funds (dividends, investment and acquisitions). Notice that the price per unit of capital obtained through acquisitions is assumed to be the same as the price of capital obtained through investment. This assumption is based on the notion that competitive bidding on world capital markets will drive the price differential for these alternative sources of capital to zero.[6] An alternative assumption, proposed by King (1986), is explored in Appendix C and applied in our sensitivity analysis in Section IV. Equation (3) accounts for the investment tax credit, which applies only to investment, and for depreciation allowances, which apply to both investment and acquisitions.[7]

Equations (4) and (5) restrict dividends and new share issues to be non-negative.[8] Equation (6) explicitly accounts for the empirically relevant case of a corner solution for acquisitions. Over the 15-year period covered by our data sample, more than one-fourth of the firms never engaged in an acquisition.

The maximum principle is employed to solve the above optimization problem. The first-order condition for investment may be expressed as

$$(7) \qquad E_{t-1}\left[\lambda_t^K - \lambda_t^G p_t^K\left((1-k_t-\tau_t z_t)+(1-\tau_t)\frac{\partial C_t}{\partial I_t}\right)\right]=0.$$

Equation (7) indicates that marginal expected net benefit of additional investment is equal to 0 at the optimum. The term λ_t^K represents the increase in the value of the firm from an additional unit of investment. The costs associated with this marginal investment include the tax-adjusted price of investment capital and the marginal adjustment costs.[9]

The first-order condition for acquisitions may be expressed as

$$(8) \qquad E_{t-1}\left[\lambda_t^K - \lambda_t^G p_t^K\left((1-\tau_t z_t)+(1-\tau_t)\frac{\partial C_t}{\partial A_t}\right)\right]\leqslant 0.$$

If the marginal net benefit for the first unit of acquisitions is negative, the optimal level of acquisitions is zero and the above equation is satisfied as an inequality. Otherwise, an interior solution for acquisitions exists with an interpretation analogous to that given above for investment.

The first-order conditions for dividends and new share issues are, respectively, as follows:

$$(9) \qquad \frac{1-m_t}{1-c_t} - E_{t-1}\{\lambda_t^G\} \leqslant 0$$

$$(10) \qquad -1 + E_{t-1}\{\lambda_t^G\} \leqslant 0.$$

Because c_t is not in general equal to m_t, it is not possible for both of the above equations simultaneously to be satisfied as equalities. If firms are always at an interior solution for dividends, equation (9) is always satisfied as an equality, which implies that the expected value of λ_t^G is equal to $(1-m_t)/(1-c_t)$ for all t. In the public finance literature this assumption is sometimes referred to as the 'tax capitalization view'. Conversely, if firms are always at an interior solution for new share issues, equation (10) is always satisfied as an equality, which implies that the expected value of λ_t^G is equal to 1 for all t. In the public finance literature this assumption is sometimes referred to as the 'traditional view'. Poterba and Summers (1983) provide empirical evidence in favour of the traditional view. Consequently, we focus on the case where the expected value of λ_t^G is equal to 1. However, an alternative specification based on the tax capitalization view is developed in Appendix C and applied in our sensitivity analysis in Section IV.

II. Econometric Model

In this section we derive an econometric specification from our theoretical model of Section I. This specification addresses three fundamental econometric issues: (1) the simultaneous determination of acquisitions and investments; (2) the lumpiness of acquisition activities; and (3) the panel nature of our data.

Model derivation

The costate variable λ_t^K, which represents the shadow value of capital in our theoretical model, is not directly observable. However, Hayashi (1982) has demonstrated that, if the production and adjustment cost functions are both linearly homogeneous, λ_t^K is linked to observable variables in the following way:

$$\frac{\lambda_t^K}{p_t^K} \equiv q_t \equiv \frac{V_t + D_t - B_t}{(1-\delta)p_t^K K_{t-1}}, \tag{11}$$

where

$$D_t = \sum_{j=0}^{\infty} \beta_j [i_{t+j}(1-\tau_{t+j})\tilde{D}_{t+j} - (\tilde{D}_{t+j+1} - \tilde{D}_{t+j})],$$

$$B_t = \sum_{j=0}^{\infty} \beta_j \tilde{B}_{t+j}.$$

The term D_t represents the expected present value of all cash flows associated with debt, including both interest payments and the additional resources generated through new debt issues; in empirical work, it is commonly captured by the stock of debt.[10] The depreciation bond B_t represents the expected present value of the tax savings resulting from depreciation allowances stemming from past investments. Equation (11) is the familiar condition representing the equality of marginal q and average q. The following adjustment cost function satisfies Hayashi's homogeneity condition, and permits an explicit solution for investment and acquisitions as functions of observable variables:

$$C(I_t, A_t, K_t) = K_t \left[\left(\frac{\gamma_I}{2}\right)\left(\frac{I_t}{K_t} - \alpha_I - u_{It}\right)^2 + \left(\frac{\gamma_A}{2}\right)\left(\frac{A_t}{K_t} - \alpha_A - u_{At}\right)^2 + \gamma_{IA}\left(\frac{A_t}{K_t}\right)\left(\frac{I_t}{K_t}\right) \right]. \tag{12}$$

The first term in the adjustment cost equation is a quadratic adjustment cost which depends on the rate of investment (I/K). Such a specification has been commonly used in the investment literature. The second term is a similar quadratic adjustment cost for acquisitions. The parameters α_I and α_A represent the rates of investment and acquisitions, respectively, at which adjustment costs associated with the two activities would (in the absence of shocks and interaction effects) reach their minima. In estimating our model, we allow for the possibility that these rates will differ across firms. The third term allows for two distinct possibilities. The first is that investment and acquisitions will interfere with each other. This might arise, for example, if substantial efforts are required from managers or professional staff to incorporate an acquired firm into the parent firm, thereby reducing the available time for handling other investment projects. The second possibility is that acquisitions and investment will help each other.

For example, human capital from the acquired firm may serve to lower the adjustment costs associated with investment.

The symbols γ_I, γ_A and γ_{IA} in equation (12) represent estimable parameters, and the terms u_{It} and u_{At} represent random shocks to the adjustment cost function. Applying the specifications given in equations (11) and (12) to the formulas provided in equations (7) and (8) yields the following simultaneous-equations specification for investment and acquisitions:

$$\frac{I_t}{K_t} = \alpha_I + \frac{1}{\gamma_I} Q_I - \frac{\gamma_{IA}}{\gamma_I}\left(\frac{A_t}{K_t}\right) + u_{It}, \tag{13}$$

$$\frac{A_t^*}{K_t} = \alpha_A + \frac{1}{\gamma_A} Q_A - \frac{\gamma_{IA}}{\gamma_A}\left(\frac{I_t}{K_t}\right) + u_{At}. \tag{14}$$

The term Q_I represents a tax-adjusted measure of q for investment, which accounts for both depreciation allowances and the investment tax credit:

$$Q_I = \frac{q_t - (1 - k_t - \tau_t z_t)}{1 - \tau_t}.$$

The term Q_A represents the corresponding tax-adjusted measure of q for an acquisition, which accounts only for depreciation allowances (an investment tax credit is not available in the case of an acquisition):

$$Q_A = \frac{q_t - (1 - \tau_t z_t)}{1 - \tau_t}.$$

As discussed later in Section III, we follow the standard practice of defining our tax-adjusted measures of q based on the beginning-of-period values. This helps to ensure that our measures will be contemporaneously uncorrelated with the disturbance terms of our model. The actual level of acquisitions A_t is related to the unobservable latent variable A_t^* as follows:

$$A_t = \begin{cases} A_t^* & \text{if } A_t^* > 0, \\ 0 & \text{otherwise.} \end{cases}$$

For the purpose of estimation, we assume that the disturbances u_{It} and u_{At} are bivariate normally distributed with zero means, variances σ_I^2 and σ_A^2, respectively, and correlation coefficient ρ.

Model identification

Our model is quite similar to the simultaneous Tobit specification considered by Lee (1976) and Sickles and Schmidt (1978). A key feature of this specification is that equation (13), which describes investment behaviour, has two separate first-order conditions corresponding to the cases where observed acquisition spending is zero and positive, respectively. As a consequence, the structural parameters of this equation are (over)identified even in the absence of any exclusion restrictions. In contrast, at least one identifying restriction is required to identify the structural parameters of the acquisition equation. The regressors Q_I and Q_A in equations (13) and (14) are similarly defined, but not perfectly correlated. By itself, the distinction between these variables provides only very weak identifying in formation. Fortunately, however, embedded within the model is also a cross-equation constraint. In particular, the ratio of the coefficient of A_t/K_t to the coefficient of Q_I in equation (13) is γ_{IA}, which may also be computed as the ratio of the coefficient of I_t/K_t to the coefficient of Q_A in equation (14). As discussed by Wegge (1965) and Kelly (1975), cross-equation restrictions frequently aid in model identification. In the context of our specification, this restriction alone is sufficient to identify the structural parameters of equation (14). Appendix A provides a detailed analysis of this issue.

Panel data estimation

We employ panel data to estimate our model, which allows us to control for possible unobserved time-invariant characteristics of firms that influence their investment and acquisition decisions. This is accomplished by specifying α_I and α_A in equations (13) and (14), respectively, as firm-specific fixed effects.[11] We also include a set of year dummies in our specification to account for any common period-specific effects across firms in our sample.

If the dependent variables in equations (13) and (14) were both observable, it would be possible to eliminate the fixed effects in the usual way by taking first differences. Unfortunately, in our case estimation involves the limited dependent variable A_t/K_t, which makes it necessary to estimate the fixed effects jointly with the other parameters of our model. Although the presence of these 'nuisance parameters' increases the computational burden, it remains feasible to estimate the model.

To exploit fully the identifying information in our data, we employ the method of maximum likelihood. In this subsection we derive the likelihood function for our model and discuss a parametric restriction that must be satisfied for internal consistency. As will be seen, this restriction has a natural economic interpretation and is implied by the second-order condition of the firm's optimization problem.

For a firm j that engages both in investment and acquisitions in period t, the likelihood expression takes the form

$$(15)\qquad L_1 = J\,\frac{1}{\sigma_I\sigma_A}\,\mathrm{pdfbvn}\left(\frac{u_{Ijt}}{\sigma_I}, \frac{u_{Ajt}}{\sigma_A}, \rho\right),$$

where

$$u_{Ijt} = \frac{I_{jt}}{K_{jt}} - \alpha_{Ij} - \frac{1}{\gamma_I}\,Q_{Ij} + \frac{\gamma_{IA}}{\gamma_I}\left(\frac{A_{jt}}{K_{jt}}\right),$$

$$u_{Ajt} = \frac{A_{jt}}{K_{jt}} - \alpha_{Aj} - \frac{1}{\gamma_A}\,Q_{Aj} + \frac{\gamma_{IA}}{\gamma_A}\left(\frac{I_{jt}}{K_{jt}}\right),$$

and pdfbvn(•, •, •) represents the standard bivariate normal probability density function. The symbol J represents the Jacobian term of the model. It is defined as $J = 1 - (\gamma_{IA}^2/\gamma_I\gamma_A)$. As pointed out by Amemiya (1974), this term must be positive in order for the model to be internally consistent, which imposes a restriction on the values that γ_I, γ_A and γ_{IA} may take. Appendix A provides the details of this argument. Some researchers (e.g. Maddala 1983, p. 211) have criticized specifications that require restrictions for internal consistency on the grounds that the restrictions often have no economic interpretation. In our model the condition required for internal consistency has a natural economic interpretation. It implies that the adjustment cost function must be convex, a requirement that also is imposed by the second-order condition associated with the firm's maximization problem.

For a firm j that engages only in investment during period t (i.e. $A_{jt}/K_{jt} = 0$), the likelihood expression takes the form

$$(16) \qquad L_2 = \frac{1}{\sigma_I}\,\phi\left(\frac{u_{Ijt}}{\sigma_I}\right)\Phi\left(\frac{u_{Ajt}/\sigma_A - \rho u_{Ijt}/\sigma_I}{\sqrt{(1-\rho^2)}}\right),$$

where $\phi(\bullet)$ and $\Phi(\bullet)$ represent the standard normal probability density and cumulative distribution functions, respectively.

Estimation issues

The maximum likelihood estimators of the parameters of our model are consistent only if the number of cross-sectional units and the number of observations per cross-sectional unit (time periods) are both permitted to increase. Often panel data researchers have access to only two or three observations per cross-sectional unit, in which case the maximum likelihood approach is unlikely to yield satisfactory results. Fortunately, in our data-set we have 15 observations per cross-sectional unit, a number that is sufficient to allay possible concerns about small sample bias. For example, a Monte Carlo experiment by Heckman (1981) has shown that a fixed-effects probit model performs satisfactorily with as few as eight observations per cross-sectional unit, which is the number employed in a fixed-effects Tobit specification by Heckman and MaCurdy (1980).

Our specification includes separate firm-specific fixed effects for the investment and acquisition equations. There are 503 firms in our data sample, which results in the estimation of a total of 1006 fixed effects. Owing to computer memory limitations, we chose to employ a stepwise maximization procedure. We divided our parameters into three sets: the investment equation fixed effects, the acquisition equation fixed effects, and the remaining parameters of the model. During each iteration, each set of parameters was estimated sequentially conditional on the most recent estimates of the remaining sets of parameters.[12] Convergence was fairly rapid.[13]

Over one-fourth of the firms in our data sample had never engaged in an acquisition during the 15-year period under investigation. For each of these firms, the maximum likelihood estimate of the fixed effect α_A negative infinity. Because negative infinity represents a boundary value of the parameter space, we are unable to estimate the standard error associated with such an estimate. This does not represent a serious problem for our analysis, however, because these are ‘nuisance parameters’; in any case, we are able to compute the standard error estimates for all of the remaining parameters of our model, conditional on the fixed-effects estimates for these particular firms.[14] Our standard error estimates were obtained from the estimated (BHHH) covariance matrix for the entire set of (non-boundary) parameters in our model.

III. Description of Data

The data-set employed in this study contains information on 503 US non-financial firms for the period from 1971 to 1985.[15] The primary data source from which the measure of the physical capital stock and q were constructed is the Compustat files, which are derived from the financial statements of publicly traded firms.[16] There are a variety of difficulties associated with the construction of economic variables from accounting information, especially with the construction of q. The approach taken in this paper is very similar to that employed by others. Like previous researchers, we have limited our sample to those firms for which there is sufficient information to compute q for each of the periods under consideration. This leaves us with a sample of firms that is broadly representative of all non-financial US firms whose shares have been traded throughout the 1970s and early 1980s. Because such firms account for a large proportion of all investment spending, we believe that their behaviour should provide a useful guide to overall investment and acquisition activity in the United States during this period.

In equation (11), q is defined as the ratio of the value of the firm’s equity and debt (less the depreciation bond) to the replacement value of the capital stock. Our measure of corporate equity V_t takes into account both common and preferred shares. The market value of common equity is simply the price of a share multiplied by the number of shares outstanding. Both the number of shares and the share price are taken at the end of the previous year, so that the resulting measure captures the value of q at the beginning of the period. Because preferred shares are infrequently traded, their valuation is somewhat more difficult than the valuation of common shares. We employ the approach used by Summers (1981) for valuing all equity: namely, we capitalize the value of preferred dividends. The debt term D_t is measured by the book value of debt. We follow Hayashi and Inoue (1991) in deducting all non-depreciable assets, such as intangibles, that appear in the firm’s accounts from the numerator of q. The depreciation bond and the present value of depreciation allowances (our measure of $\tau_t z_t$ in equations (13) and (14)) were constructed using a method proposed by Salinger and Summers (1983).

The denominator of q is the replacement value of the capital stock. Firm-specific depreciation rates were used in these calculations, which were obtained by applying a procedure developed by Salinger and Summers (1983) to the firm’s reported depreciation values. The recursive formula, $K_t = K_{t-1}(P_t^K / P_{t-1}^K)(1-\delta) + I_t$, was used to compute the capital stock, where the implicit price deflator for gross private fixed domestic investment was used as our measure of the price of capital.

TABLE 1
SUMMARY STATISTICS

	Full sample		Subsample with positive acquisitions	
Variable	Mean (1)	Median (2)	Mean (3)	Median (4)
Q_I	2.6456	0.5098	3.5503	0.9899
I/K	0.2044	0.1525	0.2996	0.2141
A/K	0.0387	0.0000	0.1875	0.0507
Sample size	7545		1558	

Table 1 presents some summary statistics for the variables used in the analysis. Columns (1) and (2) present the mean and median values, respectively, for the entire sample, while columns (3) and (4) present the corresponding information for the subsample of cases with positive acquisitions. The variable Q_I is the tax-adjusted value of q, which is defined as $[q-(1-k-\tau z\ )/(1-\tau)$, where the terms k, τ and z represent the investment tax credit, the corporate tax rate, and the present value of capital depreciation allowances, respectively. The mean and median values of Q_I and I/K for the overall sample are comparable with those presented in other studies (e.g. Fazzari *et al.* 1988; Schaller 1990; and Whited 1991).

It is noteworthy that the tax-adjusted value of q is higher when the sample is restricted to cases with positive acquisitions. This is consistent with the main thrust of our model; namely, that acquisitions (like investment) should be higher when the shadow value of capital for a given firm is high relative to the purchase price of capital goods. In this vein it is also interesting to note that investment spending is higher for the subsample with positive acquisitions, again suggesting that acquisitions and investment are motivated by similar factors. In the next section we pursue the links among investment, acquisitions, and tax-adjusted q more formally.

Table 1 indicates that acquisition expenditures, on average, are just under 20% of the amount expended on direct investment.[17] For those firms that participate in acquisitions in a given year, spending on acquisitions is over 60% of the amount expended on direct investment. Thus, acquisition spending certainly is not trivial. Its distribution is quite skewed, however. The majority of firms do not make any acquisitions in a given year. In fact, A/K is positive for only 20.6% of all observations, which underscores the importance of accounting for the censored nature of acquisitions in both theory and empirical work.

IV. RESULTS

Table 2 presents our results from estimating of the model described in Section II. Columns (1) and (2) present the results for versions of our model without and with firm-specific fixed effects and year dummies, respectively. The results for these two specifications are similar, although the estimated

TABLE 2
RESULTS FOR FULL SAMPLE

Parameters	Model with no fixed effects or year dummies (1)	Model with fixed effects and year dummies* (2)
γ_I	177.9	257.4
	(86.1)	(33.4)
γ_{IA}	−59.5	−84.8
	(−29.0)	(−18.2)
γ_A	217.1	318.2
	(8.6)	(2.4)
σ_I	0.1883	0.1611
	(324.1)	(195.3)
σ_A	0.6960	0.6247
	(72.7)	(21.9)
ρ	0.0499	0.0649
	(1.5)	(1.1)
α_I	0.1766	—
	(58.3)	
α^A	−0.7286	—
	(−54.1)	
Log-likelihood	−1875.1	243.5
Sample size	7545 (503 firms)	7545 (503 firms)

*Fixed-effects and year dummy coefficient estimates are not presented; *t*-statistics are in parentheses.

adjustment cost parameters (γ_I, γ_{IA} and γ_A) are somewhat larger in absolute value for the specification that includes fixed effects and year dummies. A comparison of the likelihood values for the two cases indicates that the specification containing fixed effects and year dummies provides a dramatic improvement in the fit of the model. A likelihood ratio test confirms that the fixed effects and time dummies are statistically significant at all conventional significance levels.

For both specifications, the estimated values of the adjustment cost parameters, γ_A and γ_I, are of the same order of magnitude. A Wald test fails to reject the null hypothesis that γ_A and γ_I are equal at all conventional significance levels.

Appendix B provides formulae for computing the marginal impact of a one-unit increase in q (adjusted for corporate taxes) on investment and acquisitions.[18] Simulating over all of the observations in our sample, the mean estimated change in I/K from a one-unit increase in q is 0.0038. Other researchers have obtained similar estimates; for example, Salinger and Summers (1983), Fazzari *et al.* (1988) and Schaller (1990) present estimates ranging from 0.004 to 0.007.[19] When taken as a proportion of the average level of I/K, the predicted increase in I/K for the overall sample is 1.86%.

Again simulating over all of the observations in our sample, the mean impact of a one-unit change in q on A/K is estimated to equal 0.00072. When the estimated impact is taken as a proportion of the average level of A/K, this translates into a 1.85% increase, which is extremely similar to the corresponding statistic for investment. The magnitude of the effect of an increase in q on the level of acquisitions is influenced by two factors: the change in the probability that a firm will engage in acquisitions, and the change in the expected level of acquisitions for a firm that already is engaging in acquisitions.[20] The average estimated size of each of these changes in response to an increase in q is about 0.0013, which indicates that q has important effects on both the intensive and extensive margins of acquisition behaviour.

Our parameter estimates may be used to interpret the magnitude of the adjustment costs associated with acquisitions and investment. At the mean values of the variables in our model, total adjustment costs in equation (12) represent about 7.1% of total capital purchases (i.e. investment plus acquisitions).

Our results indicate that investment and acquisitions are both responsive to changes in q. However, like most q studies of investment, the degree of responsiveness is rather sluggish. In one of the sensitivity analyses presented below, we have re-estimated our specification after eliminating outlier values of q from our sample. The results from that analysis indicate a much higher degree of responsiveness for both investment and acquisitions.

Sensitivity analyses

In this subsection we subject our model to a number of forms of sensitivity analysis to determine how robust our findings are. First, we investigate the importance of the estimated correlation between the adjustment cost disturbances for our conclusions. Second, we explore the sensitivity of our results to outlier values of q. Third, we examine whether our findings are influenced by the presence of intangible assets. Fourth, we investigate how replacing the traditional view of investment with the tax capitalization view influences our estimates. Fifth, we examine the performance of a specification that incorporates both the tax capitalization view and an alternative assumption about the price of capital obtained through acquisitions.

The findings of our sensitivity analyses of our specification containing fixed effects and year dummies are summarized in Table 3. In our previous analysis the estimated correlation (ρ) between the adjustment cost disturbances (u_I and u_A) was fairly small and statistically insignificant, which indicates that these disturbances may be stochastically independent. In column (2) we examine how imposing a zero correlation (independence) between these disturbances influences our results; if this over-identifying restriction is valid, it will generate relatively more efficient parameter estimates. The parameter estimates for this restricted specification are qualitatively quite similar to our original findings, which are reproduced in the first column of Table 3 for convenience. However, the t-statistics are larger under the restricted specification, reflecting the gain in relative efficiency.

Column (3) of the table presents the results for our outlier analysis. All observations for which q was below 0.05 or above 5 were deleted for this analysis. This entailed eliminating all 15 observations for three of the 503 firms in our sample as well as a subset of the observations for many of the remaining firms. The effect of removing these outliers is to reduce substantially the estimated values for the adjustment cost parameters, γ_I, γ_A and γ_{IA}, which implies a much larger estimated marginal impact of q on both investment and

Table 3
Sensitivity Analyses of Fixed Effects Specification*

Parameter	Original specification (1)	Model with independent structural disturbances (2)	Model with outliers removed (3)	Results for high R&D–high advertising subsample (4)	Model based on tax capitalization view (5)	Model based on King (1986) (6)
γ_I	257.4	264.9	33.2	235.3	362.1	318.8
	(33.4)	(33.2)	(20.6)	(10.4)	(3.6)	(26.1)
γ_{IA}	−84.8	−89.5	−16.1	−98.5	−119.4	−21.0
	(−18.2)	(−35.9)	(−12.6)	(−7.3)	(−18.3)	(−3.4)
γ_A	318.2	231.2	86.7	264.1	460.6	1262.7
	(2.4)	(5.3)	(3.2)	(2.6)	(2.3)	(0.16)
σ_I	0.1611	0.1609	0.1313	0.1463	0.1611	0.1909
	(195.3)	(230.8)	(221.4)	(109.7)	(195.4)	(161.5)
σ_A	0.6247	0.5946	0.2811	0.3660	0.6265	0.5360
	(21.9)	(33.6)	(32.8)	(13.0)	(21.5)	(57.5)
ρ	0.0623	—	−0.0190	−0.0325	0.0668	0.1535
	(1.1)		(−0.30)	(−0.28)	(1.1)	(2.9)
Log-likelihood	243.5	241.2	2635.4	483.0	242.2	−625.2
Sample size	7545	7545	6715	2610	7545	7545
No. of firms	503	503	500	174	503	503

*t-statistics are in parentheses.

acquisitions. Adjusting for corporate taxes, the predicted change in investment from a one-unit increase in q (0.0271) is about seven times as large as our previous estimate, and the predicted change in acquisitions (0.0032) is over four times as large as our previous result.[21] Thus, the presence of firms with extreme q values in our sample appears to promote relatively conservative estimates of the role of q in investment and acquisition decisions. The parameter estimate for γ_A is much larger than the estimate for γ_I when the outliers are removed. A Wald test for the equivalence of these parameters is rejected at the 5% level of significance.[22] A comparison of the log-likelihood values for the original sample and outlier cases also indicates that the fit of the model is substantially improved when firms with extreme q values are excluded from the analysis.

The fourth column of Table 3 reports the findings from estimating our specification using a subsample of firms from industries that are either R&D-intensive or subject to substantial advertising expenses.[23] Intangible assets are likely to make up a significant share of the overall capital stock for such firms. If our specification is sensitive to the presence of intangible assets, therefore, we would expect that our parameter estimates in columns (1) and (4) would be quite different. In fact, however, they are quite similar, suggesting that intangible assets do not pose a significant problem for our analysis.

A comparison of the columns (1) and (5) of the table reveals the consequence of replacing the traditional view of investment with the tax capitalization view. As is detailed in Appendix C, incorporation of the tax capitalization view involves replacing q_t in equations (13) and (14) with $q_t[(1-c_t)/(1-m_t)]$. The consequence of this modification is simply an increase in the size of the estimated values of γ_I, γ_A and γ_{IA} by a factor of about 1.4, or the approximate value of $(1-c_t)/(1-m_t)$. Thus, the estimated impact of a marginal change in q on investment and acquisitions is nearly identical to our earlier results.

The last column of Table 3 presents the results of a specification incorporating both the tax capitalization view and an alternative assumption about the price of capital obtained through acquisitions. Previously we have assumed that the price of capital obtained through acquisitions (P^A) is equal to the price of capital obtained through investment (P^K). As discussed in Section I, this assumption is based on the notion that competitive bidding on world capital markets will tend to equalize these prices. However, under the tax capitalization view of investment behaviour, corporate equity tends to be valued at less than the replacement value of capital. As discussed in Appendix C, this observation leads King (1986) to propose that the relative price of capital obtained through acquisitions (P^A/P^K) should be equal to the q of the acquiring firm. Although this alternative specification is not nested within our original model, it is still possible formally to compare the adequacy of these two specifications using Vuong's (1989) generalized likelihood ratio test. This test involves comparing a modified likelihood ratio statistic to a pair of critical values from the standard normal distribution. If this statistic falls into the rejection region defined by the lower critical value, one concludes that the alternative specification is superior. Alternatively, if the test statistic falls into the rejection region defined by the upper critical value, one concludes that the original specification is superior. If the statistic does not fall into either rejection region, then one is unable to discriminate between the two specifications given the available data. For our data sample, the value of the modified likelihood ratio statistic is 2.29, which falls into the upper tail of the standard normal distribution. For a 5% level of significance, the relevant critical value is 1.96. Thus, we conclude that our original specification provides a superior explanation of the data.

V. Conclusion

Using standard assumptions, we have developed a theoretical framework which predicts that both investment and acquisitions are positively related to a firm's shadow value of capital. Our empirical results, which are based on a specification that controls for a number of relevant econometric issues, show that both acquisitions and investment are increasing in q, the shadow value of capital. The estimated parameters indicate that a one unit increase in q has about the same proportionate effect on acquisitions as it does on investment.

Traditionally, the focus of the q model has been on explaining investment behaviour. However, our results suggest that it can also be used to explain acquisition activity. A q model of acquisitions may serve as a useful starting point for examining issues such as the importance of management objectives, free cash flow and tax changes in driving takeover activity and the impact of takeovers on research and development, labour demand and investment.[24]

In future research, it would be interesting to extend our framework to allow for capital market imperfections. Researchers have typically expanded the q model of investment to address capital market imperfections in one of two ways: either by including a balance sheet variable as an additional regressor for investment (e.g. Fazzari *et al.* 1988) or by estimating investment Euler equations which allow for the possibility of finance constraints (e.g. Hubbard and Kashyap 1992; Whited 1992). One could extend either of these approaches to account for the effects of capital market imperfections on acquisitions as well as investment.

APPENDIX A: MODEL IDENTIFICATION AND INTERNAL CONSISTENCY

In this appendix, we provide a detailed analysis of model identification as well as the condition required for our model to be internally consistent. To focus on the key issues, we ignore the slight difference between Q_A and Q_I in our specification (which provides only very weak identifying information), treating them both as the same variable Q. For simplicity, we ignore the fixed effects and time dummies, which are not germane to the questions of model identification and internal consistency.

Identification

The reduced-form equations for our model are as follows:

$$\text{(A1)}\qquad \frac{I}{K} = \begin{cases} \pi_{11} + \pi_{12}Q + w_I & \text{if } A^* > 0, \\ \alpha_I + \dfrac{1}{\gamma_I}Q + u_I & \text{otherwise,} \end{cases}$$

$$\text{(A2)}\qquad \frac{A}{K} = \begin{cases} \pi_{21} + \pi_{22}Q + w_A & \text{if } A^* > 0, \\ 0 & \text{otherwise,} \end{cases}$$

where

$$\pi_{11} = \frac{\alpha_I - (\gamma_{IA}/\gamma_I)\alpha_A}{1 - (\gamma_{IA}^2/\gamma_I\gamma_A)}; \qquad \pi_{12} = \frac{(1/\gamma_I) - (\gamma_{IA}/\gamma_I\gamma_A)}{1 - (\gamma_{IA}^2/\gamma_I\gamma_A)};$$

$$w_I = \frac{u_I - (\gamma_{IA}/\gamma_I)u_A}{1 - (\gamma_{IA}^2/\gamma_I\gamma_A)};$$

$$\pi_{21} = \frac{\alpha_A - (\gamma_{IA}/\gamma_A)\alpha_I}{1 - (\gamma_{IA}^2/\gamma_I\gamma_A)}; \qquad \pi_{22} = \frac{(1/\gamma_A) - (\gamma_{IA}/\gamma_I\gamma_A)}{1 - (\gamma_{IA}^2/\gamma_I\gamma_A)};$$

$$w_A = \frac{\alpha_I - (\gamma_{IA}/\gamma_A)u_I}{1 - (\gamma_{IA}^2/\gamma_I\gamma_A)}.$$

Notice that the investment equation takes two forms, depending on whether A^* is positive or non-positive. As a consequence, α_I and γ_I can be estimated as well as the reduced-form parameters π_{11}, π_{12}, π_{21} and π_{22}. (Sickles and Schmidt (1978) provide the full details on this issue.) Let us now verify that the remaining structural parameters α_A, γ_A and γ_{IA} are also identified. Observe the following relationships:

(A3) $\quad \pi_{12} + \gamma_{IA}\pi_{22}/\gamma_I = 1/\gamma_I,$

(A4) $\quad \pi_{11} + \gamma_{IA}\pi_{21}/\gamma_I = \alpha_I,$

(A5) $\quad \pi_{22} + \gamma_{IA}\pi_{12}/\gamma_A = 1/\gamma_A,$

(A6) $\quad \pi_{21} + \gamma_{IA}\pi_{11}/\gamma_A = \alpha_A.$

From (A3), the structural parameter γ_{IA} can be obtained by substituting in the values for γ_I and the reduced-form parameters π_{12} and π_{22}. Alternatively, γ_{IA} can be obtained from (A4) by substituting in the values for α_I, γ_I and the reduced-form parameters π_{11} and π_{21}. Thus, the structural parameters of the investment equation are (over)-identified. After solving for γ_{IA}, we now can obtain γ_A from (A5) by substituting in the values for γ_{IA} and the reduced-form parameters π_{22} and π_{12}. Finally, using γ_A, γ_{IA} and the reduced-form parameters π_{21} and π_{11}, we can solve for α_A. Thus, all of the parameters of the acquisition equation are identified as well.

Internal consistency

Certain parameters in our model must satisfy an inequality constraint in order for the model to be internally consistent. To see this, consider the following reduced-form expression for A^*/K:

$$\text{(A7)} \qquad \frac{A^*}{K} = \begin{cases} \alpha_A + \dfrac{1}{\gamma_A}Q_A - \dfrac{\gamma_{IA}}{\gamma_I\gamma_A}Q_I + \left(u_A - \dfrac{\gamma_{IA}}{\gamma_A}u_I\right) & \text{if } A^* \leqslant 0, \\ \dfrac{1}{J}\left[\alpha_A + \dfrac{1}{\gamma_A}Q_A - \dfrac{\gamma_{IA}}{\gamma_I\gamma_A}Q_I + \left(u_A - \dfrac{\gamma_{IA}}{\gamma_A}u_I\right)\right] & \text{if } A^* > 0, \end{cases}$$

where $J = 1 - (\gamma_{IA}^2/\gamma_I\gamma_A)$. Observe that J must be positive if the above two conditions are to be mutually exclusive. This is precisely the condition presented in the text for internal consistency.

APPENDIX B: SIMULATION FORMULAE

Formulae relating the responsiveness of acquisitions and investment to changes in q can be derived from the reduced-form equations of our model. The reduced-form expression for acquisitions may be written as

$$\text{(B1)}\quad \frac{A}{K}= \begin{cases} \dfrac{1}{J}\left[\left(\alpha_A-\dfrac{\gamma_{1A}}{\gamma_A}\alpha_I\right)+\dfrac{1}{\gamma_A}Q_A-\dfrac{\gamma_{IA}}{\gamma_I\gamma_A}Q_I+\left(u_A-\dfrac{\gamma_{IA}}{\gamma_A}u_I\right)\right] & \text{if } A^*>0,\\ 0 & \text{otherwise,}\end{cases}$$

where $Q_I=[q-(1-k-\tau z)]/(1-\tau)$, $Q_A=[q-(1-\tau z)]/(1-\tau)$, and $J=1-(\gamma_{IA}^2/\gamma_I\gamma_A)$. The expected value of A/K can be computed from (B1) by multiplying the probability that A^* is greater than zero by the expected value of A/K, given that A^* is greater than zero. Based on our assumption that the disturbances u_I and u_A are bivariate normally distributed with zero means, variances σ_I^2 and σ_A^2, respectively, and correlation coefficient ρ, we may deduce from (B1) that

$$\text{(B2)}\quad E\left\{\frac{A}{K}\right\}=\frac{\Phi\left(\dfrac{\widehat{A/K}}{\sigma_{\nu_A}}\right)\dfrac{\hat{A}}{K}+\sigma_{\nu_A}\phi\left(\dfrac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}{1-(\gamma_{IA}^2/\gamma_I\gamma_A)},$$

where

$$\frac{\widehat{A}}{K}=\left(\alpha_A-\frac{\gamma_{IA}}{\gamma_A}\alpha_I\right)+\frac{1}{\gamma_A}Q_A-\frac{\gamma_{IA}}{\gamma_I\gamma_A}Q_I$$

and

$$\sigma_{\nu_A}=\sqrt{\sigma_A^2-2\rho\sigma_I\sigma_A\left(\frac{\gamma_{IA}}{\gamma_A}\right)+\sigma_I^2\left(\frac{\gamma_{IA}^2}{\gamma_A^2}\right)}.$$

From (B2), it follows that the expected change in A/K resulting from a one-unit increase in q (adjusted for corporate taxes) is equal to

$$\text{(B3)}\quad \frac{\left(\dfrac{1}{\gamma_A}-\dfrac{\gamma_{IA}}{\gamma_I\gamma_A}\right)\Phi\left(\dfrac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}{1-(\gamma_{IA}^2/\gamma_I\gamma_A)}.$$

Observe that (B2) can be respecified as

$$\text{(B2}'\text{)}\quad E\left\{\frac{A}{K}\right\}=\Phi\left(\frac{\widehat{A/K}}{\sigma_{\nu_A}}\right)\left(\frac{\dfrac{\widehat{A}}{K}+\sigma_{\nu_A}\dfrac{\phi\left(\dfrac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}{\Phi\left(\dfrac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}}{1-(\gamma_{IA}^2/\gamma_I\gamma_A)}\right),$$

where the first term represents the probability of a positive acquisition and the second represents the expected level of acquisitions given that acquisitions are positive. An increase in q influences both of these terms. On the extensive margin, it affects the likelihood of a positive acquisition. The change in probability of a positive acquisition associated with a one unit increase in q is equal to

$$\text{(B4)}\qquad \left(\frac{1}{\gamma_A}-\frac{\gamma_{IA}}{\gamma_I\gamma_A}\right)\phi\left(\frac{\widehat{A/K}}{\sigma_{\nu_A}}\right).$$

The change in the expected value of acquisitions given that acquisitions are positive is equal to

$$\text{(B5)}\qquad \left(\frac{1}{\gamma_A}-\frac{\gamma_{IA}}{\gamma_I\gamma_A}\right)\left[1-\frac{\phi\left(\frac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}{\Phi\left(\frac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}\left(A/K-\sigma_{\nu_A}\frac{\phi\left(\frac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}{\Phi\left(\frac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}\right)\right].$$

The responsiveness of investment to changes in q can be derived from the reduced-form expression for I/K:

(B6)

$$\frac{I}{K}=\begin{cases}\dfrac{[\alpha_1-(\gamma_{IA}/\gamma_1)\alpha_A]+(1/\gamma_1)Q_1-(\gamma_{IA}/\gamma_1\gamma_A)Q_A+[u_1-(\gamma_{IA}/\gamma_1)u_A]}{1-(\gamma_{1A}^2/\gamma_1\gamma_A)} & \text{if } A^*>0,\\[2ex] \alpha_1+(1/\gamma_1)Q_1+u_1 & \text{otherwise.}\end{cases}$$

From (B6), it follows that the expected change in I/K resulting from a one-unit increase in q (adjusted for corporate taxes) is equal to

$$\text{(B7)}\qquad \frac{1}{1-(\gamma_{1A}^2/\gamma_1\gamma_A)}\left[\frac{1}{\gamma_I}-\frac{\gamma_{IA}}{\gamma_I\gamma_A}+\frac{\partial E\{(u_I-(\gamma_{IA}/\gamma_I)/u_A)\mid A^*>0\}}{\partial q}\right]$$

when acquisitions are positive and to

$$\text{(B8)}\qquad \frac{1}{\gamma_I}+\frac{\partial E\{u_I\mid A^*<0\}}{\partial q}$$

when acquisitions are zero. Substitution of the appropriate expressions for the derivatives in (B7) and (B8) yields the following formulae for the marginal effect of q on investment:

$$\text{(B9)}\qquad \frac{\partial E\left\{\frac{I}{K}\,\middle|\, A^*>0\right\}}{\partial q}=\frac{\frac{1}{\gamma_I}-\frac{\gamma_{IA}}{\gamma_I\gamma_A}}{1-\frac{\gamma_{IA}^2}{\gamma_I\gamma_A}}-\frac{\frac{1}{\gamma_A}-\frac{\gamma_{IA}}{\gamma_I\gamma_A}}{\sigma_{\nu_A}^2\left(1-\frac{\gamma_{IA}^2}{\gamma_I\gamma_A}\right)}\left[\sigma_{IA}\left(1-\frac{\gamma_{IA}^2}{\gamma_I\gamma_A}\right)-\frac{\gamma_{IA}}{\gamma_I}\sigma_A^2-\frac{\gamma_{IA}}{\gamma_A}\sigma_I^2\right]$$
$$\times\left(\frac{\frac{\widehat{A/K}}{\sigma_{\nu_A}}\phi\left(\frac{\widehat{A/K}}{\sigma_{\nu_A}}\right)\Phi\left(\frac{\widehat{A/K}}{\sigma_{\nu_A}}\right)+\phi^2\left(\frac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}{\Phi^2\left(\frac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}\right)$$

$$\text{(B10)}\qquad \frac{\partial E\left\{\dfrac{I}{K}\,\middle|\, A^*<0\right\}}{\partial q}=\frac{1}{\gamma_I}+\frac{1}{\sigma^2_{\nu_A}}\left(\frac{1}{\gamma_A}-\frac{\gamma_{IA}}{\gamma_I\gamma_A}\right)\left(\sigma_{IA}-\frac{\gamma_{IA}}{\gamma_A}\sigma_I^2\right)$$
$$\times\left(\frac{\dfrac{\widehat{A/K}}{\sigma_{\nu_A}}\phi\left(\dfrac{\widehat{A/K}}{\sigma_{\nu_A}}\right)\Phi\left(-\dfrac{\widehat{A/K}}{\sigma_{\nu_A}}\right)+\phi^2\left(\dfrac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}{\Phi^2\left(-\dfrac{\widehat{A/K}}{\sigma_{\nu_A}}\right)}\right)$$

where σ_{IA} represents the covariance between u_I and u_A.

APPENDIX C: ALTERNATIVE SPECIFICATIONS

In this appendix we derive two alternative specifications of investment and acquisitions, which we employ in the sensitivity analysis discussed in Section IV.

In our first alternative specification, we replace the assumption that λ_t^G is equal to 1 for all t (the traditional view) with the assumption that λ_t^G is equal to $(1-m_t)/(1-c_t)$ for all t (the tax capitalization view). As a consequence of this change, the measures of tax-adjusted q employed in equations (13) and (14) must be modified. The amended equations are as follows:

$$\text{(C1)}\qquad \frac{I_t}{K_t}=\alpha_I+\frac{1}{\gamma_I}\left(\frac{q_t\left(\dfrac{1-c_t}{1-m_t}\right)-(1-k_t-\tau_t z_t)}{1-\tau_t}\right)-\frac{\gamma_{IA}}{\gamma_I}\left(\frac{A_t}{K_t}\right)+u_{It}$$

$$\text{(C2)}\qquad \frac{A_t^*}{K_t}=\alpha_A+\frac{1}{\gamma_A}\left(\frac{q_t\left(\dfrac{1-c_t}{1-m_t}\right)-(1-\tau_t z_t)}{1-\tau_t}\right)-\frac{\gamma_{IA}}{\gamma_A}\left(\frac{I_t}{K_t}\right)+u_{At}.$$

Our second alternative specification is quite similar to King's (1986) model of acquisitions. This specification, like the one above, is based on the tax capitalization view of investment. However, the distinguishing feature of this specification is the assumption concerning the price of capital obtained through acquisitions. Previously, we have assumed that the price of capital obtained through acquisitions (P^A) is the same as the price of capital obtained through investment (P^K) However, because corporate equity tends to be valued at less than the replacement value of a firm's capital stock under the tax capitalization view, it is possible that acquisition capital may be purchased at a relatively favourable price in this case. King assumes that the acquiring firm is able to purchase its target for an amount equal to the anticipated increase in its equity value resulting from the acquisition of the target firm's capital stock. In the context of our model, King's assumption implies that the relative price of capital obtained through acquisitions (P^A/P^K) is equal to the q of the acquiring firm.[25] Under this assumption, the first-order condition for acquisitions takes the form

$$\text{(C3)}\qquad E_{t-1}\left[\lambda_t^K-\lambda_t^G\left(P_t^A(1-\tau_t z_t)+p_t^K(1-\tau_t)\frac{\partial C_t}{\partial A_t}\right)\right]\leqslant 0,$$

where, under the tax capitalization view, $E_{t-1}(\lambda_t^G) = (1 - m_t)/(1 - c_t)$ for the US tax system. Employing the result that

$$\frac{\lambda_t^K}{p_t^K} \equiv q_t \equiv \frac{P_t^A}{P_t^K}$$

and substituting for the term $\partial C_t/\partial A_t$ in the above expression yields the following amended version of equation (14):

$$\text{(C4)} \qquad \frac{A_t^*}{K_t} = \alpha_A + \frac{1}{\gamma_A}\left(\frac{\dfrac{1-c_t}{1-m_t} - (1-\tau_t z_t)}{1-\tau_t}\right) q_t - \frac{\gamma_{IA}}{\gamma_A}\left(\frac{I_t}{K_t}\right) + u_{At}.$$

In practice, we observe $P_t^A A_t / P_t^K K_t$ rather than A_t/K_t. In our previous specifications P_t^A was assumed to equal P_t^K, which had the effect of making these two expressions equal. However, the assumption for this case is that $P_t^A / P_t^K = q_t$, which implies that

$$\frac{A_t}{K_t} = \frac{1}{q_t}\left(\frac{P_t^A A_t}{P_t^K K_t}\right).$$

Thus, our second alternative econometric specification of acquisitions may be expressed as

$$\text{(C5)} \qquad \frac{1}{q_t}\left(\frac{P_t^A A_t^*}{P_t^K K_t}\right) = \alpha_A + \frac{1}{\gamma_A}\left(\frac{\dfrac{1-c_t}{1-m_t} - (1-\tau_t z_t)}{1-\tau_t}\right) q_t - \frac{\gamma_{IA}}{\gamma_A}\left(\frac{I_t}{K_t}\right) + u_{At}.$$

A similar exercise results in the following econometric specification of investment:

$$\text{(C6)} \qquad \frac{I_t}{K_t} = \alpha_I + \frac{1}{\gamma_I}\left(\frac{q_t\left(\dfrac{1-c_t}{1-m_t}\right) - (1-k_t-\tau_t z_t)}{1-\tau_t}\right) - \frac{\gamma_{IA}}{\gamma_I}\left[\frac{1}{q_t}\left(\frac{P_t^A A_t}{P_t^K K_t}\right)\right] + u_{It}.$$

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NOTES

1. See e.g. Morek *et al.* (1990), Jensen (1986), Auerbach and Reishus (1988), Hall (1988) and Shleifer and Summers (1988).

2. See Hayashi (1982).
3. See e.g. Golbe and White (1988).
4. Chirinko (1993) and Wildasin (1984) have also examined situations with 'multiple capital goods'. Like these authors, we specify that alternative capital-purchasing activities enter the adjustment cost function as separate terms. However, unlike the purchasing activities considered by them, the activities in our model (investment and acquisitions) involve the same type of capital good. For example, while Chirinko specifies numerous μ_j Lagrange multipliers in his equation (6a), corresponding to different capital goods, our model contains only a single multiplier (λ^K), corresponding to a single capital good. Our model is also unique in that it explicitly allows for interactive effects among the alternative means of obtaining capital goods in the adjustment cost function.
5. This formula for the value of the firm can be motivated by solving the capital market equilibrium condition (i.e. the period-to-period arbitrage condition for an investor) subject to a transversality condition. See e.g. Poterba and Summers (1983).
6. Consider a potential investor who is close to his optimal capital stock, so that adjustment costs are negligible. Because investment capital and acquisition capital are assumed to be perfect substitutes, the marginal benefit from a unit of capital from investment is equal to the marginal benefit of a unit of capital from acquisitions. If the prices of capital from these two alternative sources were to differ, the investor would choose to purchase capital from the less expensive source, which would tend to bid up its price. (We are ignoring the investment tax credit, which may not be relevant to a marginal investor from another country).
7. Acquisitions are sometimes associated with additional tax complications, which we abstract from in our analysis. For a thorough treatment of the tax consequences of acquisition activities, refer to Auerbach and Reishus (1988).
8. For simplicity, we have ruled out the possibility of share repurchases. Allowing for repurchaes would not alter the qualitative features of our results.
9. The term λ_t^G in equation (7) is discussed below.
10. See e.g. Blundell *et al.* (1992, pp. 239–40).
11. In principle, it would be possible to specify a random-effects model for our panel data-set. However, as emphasized by Heckman and MaCurdy (1980), a random-effects specification generates inconsistent estimates whenever the random effects are correlated with any of the explanatory variables (in our case, with tax-adjusted q). In contrast, our fixed-effects specification continues to generate consistent estimates in this case. Since $q_t = C_{I,t+1}$ (the first derivative of adjustment costs with respect to investment in period $t+1$), the measured level of q in our model will in fact tend to be correlated with the firm-specific effects α_I in the adjustment cost function. (See equation (12); a similar correlation problem would be present in the acquisitions equation.) Therefore, a random effects specification would be inappropriate.
12. Cramer (1986, pp. 57–9) provides a detailed discussion of stepwise maximization procedures. The standard errors of our parameter estimates were obtained by computing and inverting the estimated Hessian of the likelihood function based on the final estimates for all of the model's parameters. For the analysis of the subsample of firms in research and development, or advertising intensive industries, discussed in Section IV, the number of parameters was sufficiently small that it was possible to estimate all parameters jointly.
13. Alternative sets of starting values were employed with equivalent results.
14. Heckman and MaCurdy (1980) propose an alternative to our unconditional maximization approach, which in the context of our model would involve eliminating the problematic firms from our sample and maximizing a conditional likelihood function. We chose not to employ this approach, because the elimination of these firms from our sample would entail a loss of valuable information concerning their investment behaviour.
15. Financial firms such as banks were excluded because standard investment models may be less applicable to their activities.
16. Although all of the acquiring firms in our sample are publicly traded, the information on targets takes into account both public and private firms.
17. The variable A/K was computed on the assumption that the gross acquisition price per unit of capital is equivalent to the gross investment price per unit of capital.
18. These formulae determine the change in investment and acquisitions resulting from a one-unit change in $q/(1-\tau)$.
19. Estimates from Japanese panel data exhibit wider variation. For example, the mean of the coefficients presented in Table III by Hayashi and Inoue (1991) is 0.011, whereas the first row of Table II of Hoshi and Kashyap (1990) reports a coefficient of 0.0015.
20. The formulae for these calculations are presented in Appendix B.
21. When taken as a proportion of the mean values for I/K and A/K, these results imply a 14.6% increase in I/K and an 11.7% increase in A/K.
22. The test statistic is equal to 4.04, which exceeds the critical value for a chi-square random variable with 1 degree of freedom.

23. This subsample includes firms from the following industries: chemicals and allied products, electrical products, machinery, scientific equipment, transportation equipment, food and kindred products, and hotels. For a detailed analysis of intangible assets by industry category, refer to Fullerton and Lyon (1988).
24. As noted previously, past studies of these issues have not been based on an optimizing model of acquisitions.
25. An undesirable feature of this assumption is that it implies that those firms with q values in excess of unity (firms that one may expect would be particularly likely to engage in acquisitions) would actually pay more for capital obtained through acquisitions than they would for capital obtained through investment.

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