THE COMPARATIVE PERFORMANCE OF LIQUIDITY- AND PROFITABILITY-BASED MODELS OF BUSINESS INVESTMENT

The failure of empirical interpretations of the neoclassical theory to provide consistent evidence on business investment behaviour suggests that another approach be considered. Utilizing a model in which the objective of the firm is to maximize its long run survival, the present study examines the explanatory power of various measures of liquidity and profitability. Analyzing time series data for each of twenty-five large corporations, the study finds that the liquidity variables indicated by the long run survival model explain at least as much of the variation in the data as the leading profitability-based approaches.

Introduction

Early studies of business investment described the relationship between investment and its explanatory variables as a technological phenomenon. However, for many years research on investment has been associated with the neoclassical assumption that the objective of the firm is to maximize its value and, in particular, with the view that it is almost a tautology “to say that investment is governed by profit expectations” (Tinbergen, 1939, p. 34). Leading models of investment are thus distinguished, not by their ideological differences, but by the way in which they attempt to measure expected profitability. Tinbergen argued that for most firms the distant future was of little concern, so that realized profit would ordinarily serve as an adequate substitute for expected profit.

Although the value maximization assumption is implicitly or explicitly assumed in most empirical research, various other characterizations of firm behaviour have been suggested as a basis for a theory of investment. Of particular interest are models that recognize what has variously been described as a “security motive” (Cunningham, 1958; Gordon, 1960) or the ability to “adapt to changing circumstances” (Meyer and Kuh, 1957). The subjective desire for flexibility or security was linked by its advocates to an objectively measurable variable believed to be capable of satisfying this desire, such as the composition of the firm’s balance sheet. However, the link was never firmly established on theoretical grounds, and a review of the investment literature since the late 1960's suggests that security-based models have been all but forgotten.

The role of security as manifested in liquidity variables was revisited by Chamberlain (1996), who, building on earlier work outlined in Chamberlain and Gordon (1989), described the investment decision that maximizes the probability of long run survival (PLRS) for a portfolio investor. Under the assumptions of the model this investment decision reduces to the allocation of wealth between risky and risk-free assets.

The PLRS is maximized by placing in the risky portfolio a fraction of wealth that varies directly with the excess of the expected rate of return on the risky portfolio over the risk-free rate of interest, inversely with the variance of the risky portfolio’s return and inversely with the investor’s wealth. A necessary condition for a high PLRS is a consumption-portfolio policy that
provides a high expected rate of growth in wealth. In fact, the PLRS is close to the probability that the rate of growth in wealth is positive.

For a corporation the liquidity stock variable that influences its PLRS is the debt-equity ratio rather than the fraction of net worth placed in risky assets. This difference, however, is only a matter of convention; the important difference between an investor and a corporation is in the nature of the risky assets held. A portfolio investor holds financial assets, which are readily traded in secondary markets and which offer rates of return that are independent of the quantity held. In contrast, a firm holds tangible productive assets, which have neither of these properties. Consequently, while an investor is able to move at will at the start of each period to any desired allocation of wealth, a corporation is only able to move toward its desired debt-equity ratio over the period. Thus, a corporation maximizes its PLRS by making the growth rate of its capital in each period equal to the expected rate of growth of its net worth plus some fraction of the difference between its actual and its desired debt-equity ratio.

The present study examines empirically the question of whether liquidity variables are important in explaining investment. In particular, the role of liquidity is studied through the estimation of the long run survival model using data for each of twenty-five large nonfinancial U.S. corporations. The performance of the model is then compared with results obtained for various interpretations of the value maximization theory frequently used in applied research. In the next section the long run survival model and the profitability-based models with which it is compared are described. This is followed by an outline of the methods to be adopted in implementing the various models, including the criteria to be applied in evaluating the estimation results. The following section describes the rules employed in the measurement of the variables, together with the nature of the data and the sources and methods used in their compilation. The estimation results are then presented and discussed. The study concludes with a brief summary.

**Model Description**

**The Long Run Survival Model**

The long run survival model of investment described in Chamberlain (1996) considers the behaviour of both individuals and firms. The important difference between the positions of the two groups relates to the nature of the risky assets in which each invests. The portfolio investor holds securities which are traded in secondary markets at modest cost and at prices which are independent of the quantity bought or sold. Similarly, the rate of return on a portfolio of risky securities is usually unrelated to the amount invested. In contrast, the firm’s return on its stock of real capital is not independent of the quantity held. Moreover, capital stock adjustments are constrained by the indivisible nature of real assets, their often unique characteristics and the absence or thinness of markets in which they may be traded. Hence, whereas the portfolio investor can rearrange his/her holdings to obtain the optimal allocation between risky and risk-free securities quickly and at little cost, a firm is obliged to adjust its capital stock over a period of time.

In particular, barring a significant issue or retirement of shares, both of which are unlikely, the firm will eliminate any difference between its actual and desired debt-equity ratios by retaining earnings at a rate that differs from the rate of its investment in real assets. This behaviour may be represented as follows:

\[
\kappa_t = \alpha_0 + \alpha_1 (\bar{r}_t - c_t) + \alpha_2 (z_t - \bar{z}_{t-1}) + \alpha_3 (a_t - a_t^*),
\]  

(1)
where, for period t, \( \kappa_t \) is the rate of investment in real assets and \( \bar{r_t} - c_t \) is the expected rate of growth in the firm’s equity. \( \bar{r_t} = \bar{x_t} + a_t (\bar{x_t} - i_t) \), in turn, is the expected rate of return on equity and \( c_t \) is the dividend rate during t. \( \bar{z_t} = \bar{x_t} - i_t \) is the excess of the expected return on real assets over the risk-free rate of interest, while \( \bar{a_t} - \bar{a}_t^* \) is the difference between the actual and desired ratios of debt to equity at the beginning of the period. The values of the parameters are \( \alpha_0 > 0 \), \( 0 < \alpha_1 < 1 \), \( \alpha_2 > 0 \) and, assuming that the firm is a net debtor, \(-1 < \alpha_3 < 0\).\(^1\)

When real assets and equity grow at the same rate, \( \kappa_t = \bar{r_t} - c_t \), and the debt-equity ratio remains unchanged. With \( \alpha_0 > 0 \) and \( 0 < \alpha_1 < 1 \), an increasing fraction of the firm’s liquidity flow is devoted to building up its liquidity stock as \( \bar{r_t} - c_t \) rises above \( \alpha_0 / (1 - \alpha_1) \). Conversely, as \( \bar{r_t} - c_t \) falls below \( \alpha_0 / (1 - \alpha_1) \), the liquidity stock is reduced in order to mitigate the decline in investment.\(^2\)

With regard to the second term, the firm’s movement toward its desired debt-equity ratio may be either advanced or moderated from period to period, depending upon the availability of acceptable investment opportunities. While it is difficult to measure explicitly the level of investment that would be acceptable, it seems reasonable to expect that this level will vary directly with the expected real asset return, \( \bar{x_t} \), or excess return, \( \bar{z_t} \), providing that the variance of the distribution of such returns remains unchanged. As between \( \bar{z_t} \) and \( \bar{x_t} \), the former appears to be the superior index. This is because the firm, in so far as it assesses its opportunities from the standpoint of their profitability, will do so with reference to the cost or saving associated with a complementary adjustment in its debt position. \( \bar{z_t} = \bar{z}_{t-1} \), in turn, is substituted for \( \bar{z_t} \) in order to allow for the possibility that the excess return variable experiences secular change.

Turning to \( \bar{a_t} - \bar{a}_t^* \), the firm will use its investment policy to shift \( \bar{a_t} \) towards \( \bar{a}_t^* \). \( \alpha_3 \) captures the effect on the investment rate of the difference between the actual and desired debt-equity ratios at the beginning of t. As noted above, the issuance or retirement of equity to bring the actual debt-equity ratio into line with the desired ratio is possible, but unlikely. However, this constraint need not be binding, and the opportunity to sell or repurchase stock may be treated as an empirical question. In order to accommodate such transactions, shareholders’ equity at the beginning of t -- that is, the denominator of \( \bar{a_t} \) in equation (1) -- can be adjusted by the quantity of funds obtained from (used for) the sale (repurchase) of shares during the period.

**Value Maximization Models**

\(^1\) a, will be less than zero if the firm is a net creditor; if so, \( 0 < \alpha_3 < 1 \).

\(^2\) Alternatively, one might expect \( \bar{a}_0 = 0 \) and \( \alpha_1 = 1 \) because, with \( \kappa_t = \bar{r_t} - c_t \), and the other two variables equal to zero, the existing allocation of wealth must be that which maximizes the probability of long run survival. However, this implies that \( \kappa_t \) tends to perpetuate a zero rate of growth in equity, notwithstanding the fact that the PLRS is very low when the mean rate of growth in equity is zero.
Value maximization models, particularly those focusing on profitability variables, have been discussed extensively in investment research. Hence, they will not be reviewed in detail here. (See Chirinko, 1993, Bond and Meghir, 1994). The particular models to be used as a basis for evaluating the long run survival model are the neoclassical, securities value (Tobin’s q) and accelerator models. These models enjoy broad acceptance among neoclassical economists and, in various forms, are the most frequently used in contemporary applied research. The particular distributed lag methodology to be employed in examining these models was introduced to the investment literature by Jorgenson and Siebert (1968) and has been commonly used ever since.

The Jorgenson-Siebert framework involves two essential components: First, the determination of the firm’s desired capital stock; and second, an adjustment process according to which the firm’s investment (or disinvestment) activity moves the actual capital stock over time toward its (changing) desired level. Thus, if $K_i$ is the actual capital stock at the start of period $t$ and $K^*_i$ is the desired capital stock for the period, net investment during $t$ is

$$I_t = K_{t+1} - K_t + \delta K_t = (1 - \lambda)(K^*_t - K_t), \quad (2)$$

which can be rewritten as

$$I_t = \sum_{j=0}^{\infty} \mu_j (K^*_{t-j} - K^*_{t-j-1}) + \delta K_t, \quad (3)$$

where $\mu_j = (1 - \lambda)\lambda^j$.

In order to test a particular theory of investment, the desired capital stock terms in equation (3) are replaced with an affine function of a variable representing that theory. The model is then estimated, often for a variety of lag distributions, and its performance evaluated using goodness of fit criteria and/or tests of statistical significance.

Turning, first, to the neoclassical model, the present study follows Jorgenson and Siebert in setting the desired capital stock equal to

$$K^*_i = \gamma Q_i / h_i, \quad (4)$$

where $Q_i$ is the value of output and $h_i$, the cost of capital services, is defined as

$$h_i = \pi_i [(1 - \tau_i \omega_i)\delta + \rho_i] / (1 - \tau_i) \quad (5)$$

$\pi_i$ is the price index for investment goods, $\tau_i$, the tax rate on corporate income, $\omega_i$, the ratio of capital cost allowance to depreciation, $\delta$, the depreciation rate, and $\rho_i$, the cost of capital.

The next step is to place $K^*_i = \gamma Q_i / h_i$ in a distributed lag framework of the form represented by equation (3). Here Jorgenson and Siebert obtain an approximation using the ratio of two polynomials, $A(L)/B(L)$, in the lag operator $L$; that is,

$$I_t = \left[A(L) / B(L)\right](K_{t-\tau} - K^*_{t-\tau-1}) \quad (6)$$

They then choose from the set of combinations of the most recent three changes in desired capital and two lagged values of investment the one that minimizes the residual variance of the estimated regression equation for each firm in their sample. Here we shall use a variation of this strategy and include the current and two immediately past values for the change in desired capital as independent variables, with all prior values represented by $I_t / K_t$. The final form of the model is written as follows:
\[ \kappa_t = \beta + \sum_{r=0}^{2} \alpha_r \gamma(n_{t-r} - n_{t-r-1}) + \alpha_3 \kappa_{t-3}, \]  

where \( \kappa_t = I_t / K_t \), \( n_t = (Q_t / h_t) / K_t \), and \( \beta < 0 \). The presence of \( \beta \) allows the response of investment to changes in desired capital to be larger or smaller than a strict interpretation of the model would suggest.

With regard to the securities value model, the version popularized by Brainard and Tobin (1968)—and often referred to as Tobin’s q—will be utilized in this study. This model is based on the proposition that the firm will add to its stock of real assets whenever the marginal addition to the market value of the firm’s securities exceeds the replacement cost of its real assets. In the absence of information about the marginal effects of increased investment, q is usually measured by the average ratio of the market value of the capital stock to its replacement cost. (See Hayashi, 1982). Hence,

\[ I_t = -K_{t+1} - K_t = \lambda(q_t K_t - K_t) \]  

and

\[ I_t / K_t \equiv \gamma(q_t - 1), \]  

(9)

where \( 0 \leq \gamma \leq 1 \). If the response of investment to q extends over several periods, using the model form employed in equation (7) we obtain

\[ \kappa_t = \beta + \sum_{r=0}^{2} \alpha_r \gamma(t_{t-r} - t_{t-r-1}) + \alpha_3 \kappa_{t-3} \]  

(10)

The form used here differs to the extent that the level of q rather than the change in q is used to represent the desired level of capital.

The third value maximization model with which the survival model will be compared is a version of the accelerator model. Though first presented as a fixed relationship between investment and output or changes in output (Bickerdike (1914), Clark (1917)), the model has evolved into a general distributed lag relationship involving both current and past output-related variables. In addition, whereas early studies viewed the relationship between investment and output as a technological phenomenon, from the time of Tinbergen (1939) output variables have been treated as indicators of expected profit. The particular form of the accelerator model to be examined here parallels equation (7) and can be written as

\[ \kappa_t = \beta + \sum_{r=0}^{2} \alpha_r \gamma(u_{t-r} - u_{t-r-1}) + \alpha_3 \kappa_{t-3}, \]  

(11)

where \( u_t \) is the average rate of industry capacity utilization (actual output divided by practical capacity output) during t. The capacity utilization rate is used as the independent variable because the installation of new capital may result in an immediate increase in sales or output, thereby producing ambiguous results from a causality standpoint.

The firm’s capacity utilization rate might also be used to address the causality issue. However, the decision to utilize existing assets will only require that variable costs be covered, whereas the profitability of investment involves the consideration of fixed costs as well. Hence, unless the industry is already operating at full capacity, small changes in its utilization rate are not likely to have a material impact on product prices. Even though some firms may experience significant increases in capital usage, they will not necessarily have an incentive to undertake new
investment. Conversely, an abundance of profitable opportunities will affect all firms familiar with the industry’s markets and production technology. While an individual firm’s capacity utilization rate may still differ from that of the industry, changes in their respective levels should be strongly and positively correlated.

Methodology and Data

The models examined in this study were estimated using ordinary least squares with time series data for each of twenty-five large nonfinancial corporations over the period 1955-1999. Parallel tests were conducted using (estimated) replacement cost and historical cost data to measure the independent variables, as well as for alternative assumptions about the measurement of flow variables that are unknown at the time the firm’s investment decision is made. The motivation for considering both historical cost and replacement cost data is Booth’s (1981) observation that while replacement cost measures are more likely to approximate the economic concepts of value, income and cost, managers may not fully appreciate the impact of changing price levels on the firm. If this view is correct, variables measured using historical cost data may be more relevant than their replacement cost counterparts in attempting to explain firm investment behaviour. In addition, as explained below, whereas all of the historical cost data is information produced by the firms themselves, much of the replacement cost information comprises estimates generated by the author using aggregate price indices.

Firm data were obtained from the Value Line tapes, successive editions of Moody’s Industrial Manual and company annual reports. The Survey of Current Business and its National Income and Product Accounts Supplement provided the data required to compute price indices, while interest rate information was obtained from Moody’s Industrial Manual. In order to compile the capacity utilization series, the results of a study by Klein and Summers (1966) for the pre-1966 period were combined with more recent information published in the Survey of Current Business.

Annual data were used to measure the variables. Although quarterly or monthly observations are sometimes employed to estimate models of investment, they were not available in the detail that the measurement rules applied here required. In any event, the use of annual data avoided seasonal variations in the values of certain variables.

The details of the measurement rules used in his study are presented in Table 1. In keeping with the origins of the bulk of the data—that is, reports to stockholders and to the Securities and Exchange Commission—the variables are defined in customary accounting terms unless otherwise indicated. In addition, as noted above, flow variables are estimated using both current data and one period lagged data. The use of lagged data is related to the fact that the firm’s investment expenditure plans will be largely, if not completely, determined at the beginning of the period in which the expenditure is to be made. Current flow variables, in contrast, will not be known with certainty and, as such, may have little effect on the rate of investment.

Table 1

<table>
<thead>
<tr>
<th>Detailed Measurement Rules</th>
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<tbody>
<tr>
<td>$\kappa_t$ = $I_t/K_t$ = the rate of growth in real capital during period t</td>
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<tr>
<td>$I_t$ = net investment in capital during t</td>
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</tbody>
</table>
\( K_t \) = net capital (permanent inventory plus net fixed assets) at the beginning of \( t \)

\[ z_t = \bar{x}_t - i_t \left[ 1 + \Delta_t \right] \] = the excess of the expected return on capital over the interest rate during \( t \)

\( \bar{x}_t = \bar{x}_t / K_t \) = the expected return on capital during \( t \)

\( \bar{x}_t \) = earnings before interest, taxes and extraordinary items during \( t \)

\( i_t \) = the nominal interest rate on debt at the beginning of period \( t \)

\( \bar{x}_t \) = the yield on Moody’s Aa-rated bonds

\( \Delta_t = P_{Q,t}/P_{Q,t-1} - 1 \) = the expected rate of inflation during \( t \)

\( P_{Q,t} \) = the deflator for the gross domestic product of nonfinancial corporate business for \( t \)

\( u_t \) = the average rate of industry capacity utilization during \( t \)

\( q_t = (B_t^m + S_t) / K_t \) = the ratio of the market value of capital to its cost at the beginning of \( t \)

\( B_t^m \) = the estimated market value of debt at the beginning of \( t \)

\( S_t \) = the market value of equity at the beginning of \( t \)

\( n_t = (Q_t/h_t) / K_t \) = the ratio of the value of output to the cost of capital services during \( t \), deflated by actual capital at the beginning of the period

\( Q_t \) = the value of output (sales plus the change in inventory) during \( t \)

\( h_t = \pi_t(1 - \tau_t)\delta_t + \rho_t \) / (1 - \tau_t) = the implicit rental cost of capital services during \( t \)

\( \pi_t = \) the implicit price deflator for gross private nonresidential fixed investment

\( \delta_t = D_p/K_t = \) the capital depreciation rate during \( t \)

\( D_p = \) depreciation during \( t \)

\( \omega_t = \) TD/Dp = the fraction of capital depreciation deducted for tax purposes during \( t \)

\( TD_t = \) accelerated depreciation taken during \( t \)

\( \tau_t = \) CTL_t/PBT_t = the current tax rate for \( t \)

\( CTL_t = \) the current tax liability for \( t \)

\( PBT_t = \) profits before taxes and extraordinary items during \( t \)

\( \rho_t = i_t (1 - \tau_t) \left[ 1 - \Delta_t \right] \left[ (B_t^m + S_t) / (B_t^m + S_t) \right] + (D_t / S_t + (\bar{r}_t - d_t))(S_t / (B_t^m + S_t)) \)

\( D_t = \) dividends paid during \( t \)

\( \bar{r}_t = (1 - \tau_t)(\bar{x}_t + (\bar{x}_t - i_t)(B_t / E_t) \left[ 1 + D_t(B_t / E_t) \right] ^t \) = the expected rate of return on equity during \( t \)

\( d_t = D_t/E_t = \) the dividend rate during \( t \)

\( B_t = \) the book value of debt at the beginning of \( t \)

\( E_t = \) the book value of equity at the beginning of \( t \)

\( \bar{\Delta}_t(B_t / E_t) = \) the Modigliani-Cohn (1979) inflation adjustment, to recognize that the firm can borrow \( \bar{\Delta}_t(B_t/E_t) \) times its total capital and pay the proceeds in dividends without increasing its debt-equity ratio

* the terms in square brackets represent adjustments made to flow variables when replacement cost balance sheet data were used to estimate the models.

** Noninterest-bearing liabilities were measured at book value; the market values of interest-bearing liabilities not publicly traded were estimated by adjusting book values using Taggart’s (1977) algorithm, according to which debt is treated as a perpetuity and interest expense is capitalized at the market rate of interest.
Finally, the liquidity stock variable in the long run survival model requires, in conjunction with the actual ratio of debt to equity, a measure of the desired ratio. Here we use the average debt-equity ratio of the four years preceding the year for which the desired ratio is required.

Estimation Results

For each of the twenty-five firms in our sample, a number of estimates of each model were obtained, representing the various (either two or four) possible combinations of historical or replacement cost accounting data and current or one period lagged values of the flow variables. Each of Tables 2 through 5 summarizes the various combinations of results for, in turn, the long run survival, neoclassical, securities value and accelerator models.

The Long Run Survival Model

Referring, first, to Table 2, one finds that the long run survival model performs reasonably well. The constant term has the expected positive sign most of the time and, in the two cases utilizing replacement cost data, is generally significant at the five percent level. Likewise, the results for the liquidity flow variable are quite good. Most of the estimated values of $\alpha_i$ fall within the expected range of zero to one, and approximately one-half are significant at five percent.

Table 2

\[
\kappa_t + \alpha_0 + \alpha_1 (\bar{r}_t - c_t) + \alpha_2 (\bar{z}_t - \bar{z}_{t-1}) + \alpha_3 (a_t - a_t^*)
\]

<table>
<thead>
<tr>
<th>Historical cost, current values of flow variables</th>
<th>Historical cost, lagged values of flow variables</th>
<th>Replacement cost, current values of flow variables</th>
<th>Replacement cost, lagged values of flow variables</th>
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<tbody>
<tr>
<td>No. Firms</td>
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<td>$\alpha_3 &gt;0$</td>
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<td>$\alpha_0&gt;0$</td>
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<td>$t&gt;t_{95}$</td>
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<tr>
<td>$0&lt;\alpha_1&lt;1$</td>
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<td>14</td>
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<tr>
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<tr>
<td>$t&gt;t_{95}$</td>
<td>2</td>
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</table>
The results for the liquidity stock variable, in contrast, are quite disappointing. Barely one-half of the estimated coefficients have the correct sign, and almost none are statistically significant. These results may be due, in part, to the fact that the desired debt-equity ratio is not measured directly and, in particular, to the tendency for the estimates of the desired ratio to follow the actual ratio. Unless the actual and estimated desired debt-equity ratios are perfectly correlated, in which case the liquidity stock will not have any explanatory power, the tendency of the estimated desired ratio to follow the actual ratio probably overstates the extent to which $a_t$ and $a^*_t$ move together. If so, the effect of $a_t - a^*_t$ on $\kappa_t$ will not be fully reflected in our results for equation (1).

As for the profitability index in equation (1), the choice of the change in expected excess return, as opposed to, for example, the expected excess return itself, was motivated by a concern that the latter might change over time. However, in those cases in which $z_{t-1}$ is measured using current data, the estimated coefficient hardly ever has the expected positive sign.

In retrospect the poor performance of the current change in excess return might have been anticipated. For most firms it appears that the periods in which the largest declines in excess return took place were among those in which the highest values for $z_t$ were achieved. Hence, if, in fact, investment varies directly with the excess return on real assets, a large number of incorrect signs for $\alpha_2$ is not precluded.

Alternatively, a negative relationship between $z_t - z_{t-1}$ and $\kappa_t$ may be due to a lag in the response of investment to changes in profitability. The results for $z_t - z_{t-1}$ when $z_t$ is equal to $z_{t-1}$, are better than when $z_t$ is measured using $z_{t-1}$. What this suggests is that a decline in excess return during $t$ is often preceded by a positive change during $t-1$, which induces a high rate of investment in the subsequent period.

A further possible interpretation of our results is that when profits are declining, the firm attempts to strengthen its position in its markets through investment in new modes of production. This “market share” explanation of the relationship between $\kappa_t$ and $z_t - z_{t-1}$ is consistent with the results for the accelerator model reported in Table 5. These results indicate that the frequency of positive signs for the coefficient of the current value of $u_{t-1} - u_{t-\tau-1}$ is much smaller than it is for any of the coefficients of the lagged values of this variable.

With regard to the choice between historical cost and replacement cost data, one might expect better results from the latter in so far as they embrace the effects of inflation and changes in technology. However, the question of how best to capture the information utilized by the firm in arriving at its investment decision is an empirical one. In the case of equation (1) no clear
pattern emerges, though, assuming the model is correct, the replacement cost results appear to be slightly better.

Turning to the measurement of expectations, the results reported in Table 2 do not favour the use of either current or lagged data. The one pattern that does appear is the one noted above; that is, the coefficient for $z_t - z_{t-1}$ is much more likely to have the expected positive sign when $z_t$ is set equal to $z_{t-1}$ than when it is measured with $z_t$.

**Present Value Maximization Models**

The estimation results for the neoclassical, securities value and accelerator models are summarized in Tables 3, 4, and 5. The neoclassical and securities value models, equations (7) and (10) respectively, incorporate accounting data in the measurement of the independent variables. For these models results were obtained using both historical cost and replacement cost data. The independent variable in the accelerator model, equation (11), in contrast, is based on $u_t$, the rate of physical capacity utilization. Hence, for this model, there is only one set of independent variables to consider.

As explained earlier, the main reason for examining equations (7), (10) and (11) is that they are profitability-based investment models widely used by neoclassical economists. For this reason, their collective performance is being used as a benchmark for assessing the performance of the long run survival model.

If, before proceeding to this comparison, one looks only at the distributed lag results, one finds that none of the models works particularly well. The performance of the neoclassical model is, perhaps, the least compelling, with median $R^2$ values that range from 0.128 to 0.208. As for the distributed lag coefficients, depending upon the response of investment to the change in desired capital, not all of the regressors will necessarily affect investment in a material way. Indeed, even one positively signed and significant coefficient could be interpreted as evidence in support of the model in question.
The results summarized in Table 3 indicate that only the coefficients for the current value of $n_{t-\tau} - n_{t-\tau-1}$ are generally positive in sign. However, at the five percent level, very few of these coefficients are statistically significant. At the same time, by focussing on a single variable, we ignore the possibility that the lag in the adjustment of $\kappa_t$ to $n_{t-\tau} - n_{t-\tau-1}$ varies across firms. For this reason, the F test is used to assess the coefficients’ statistical significance.

The F statistic will be significantly different from zero if any of the coefficients in the equation under consideration is significant according to the t test. In addition, even if none of the individual coefficients are significant, but, jointly, they have a marked effect on investment, the F test will allow rejection of the hypothesis that all of the coefficients are equal to zero. However,
referring to Table 3, one finds that no combination of measurement rules produces more than four, of a possible twenty-five, significant F statistics.

Finally, the poor results for the neoclassical model may be due, in part, to the complexity of \( n_{t-\tau} \). The rules employed in the measurement of this term were as sympathetic as the data would permit. Nonetheless, the combinations of the underlying data required to compute \( n_{t-\tau} \) often caused the independent variables to behave in an erratic fashion.

\[
\kappa = \beta + \sum_{r=0}^{2} \alpha_r \gamma (q_{t-\tau} - q_{t-\tau-1}) + \alpha_3 \kappa_{t-3}
\]

<table>
<thead>
<tr>
<th>Historical cost</th>
<th>Replacement cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Firms</td>
<td>25</td>
</tr>
<tr>
<td>( \alpha_1 \geq 0 )</td>
<td>17</td>
</tr>
<tr>
<td>( \alpha_2 \geq 0 )</td>
<td>15</td>
</tr>
<tr>
<td>( \alpha_3 \geq 0 )</td>
<td>10</td>
</tr>
<tr>
<td>( \alpha_4 \geq 0 )</td>
<td>5</td>
</tr>
<tr>
<td>( \alpha_1 \geq 0 ), ( t &gt; t_{.95} )</td>
<td>2</td>
</tr>
<tr>
<td>( \alpha_2 \geq 0 ), ( t &gt; t_{.95} )</td>
<td>0</td>
</tr>
<tr>
<td>( \alpha_3 \geq 0 ), ( t &gt; t_{.95} )</td>
<td>0</td>
</tr>
<tr>
<td>( \alpha_4 \geq 0 ), ( t &gt; t_{.95} )</td>
<td>0</td>
</tr>
<tr>
<td>Median ( R^2 )</td>
<td>0.255</td>
</tr>
<tr>
<td>Median SER</td>
<td>0.0479</td>
</tr>
<tr>
<td>( F &gt; F_{.95} )</td>
<td>7</td>
</tr>
<tr>
<td>( D-W_{.95} )</td>
<td>5</td>
</tr>
</tbody>
</table>

The goodness of fit of the securities value model is, on average, somewhat better than that of the neoclassical model. As for the estimated coefficients, they are as often negative as they are positive. At the same time, about two thirds of the coefficients for both \( q_t \) and \( q_{t-1} \) have the expected positive sign. This suggests that for the securities value model a relatively short lag may be most appropriate. In addition, the proportion of significant F statistics is
somewhat higher for equation (10) than it was for equation (7). However, though not reported in Table 4, most of the individual coefficients that are significant according to a t test have a negative sign.

Referring to Table 5, with generally higher $R^2$ values and positively-signed coefficient estimates, the overall performance of the accelerator model is also somewhat better than that of the neoclassical model. The coefficients for the current change in the capacity utilization rate do not have the expected signs, however, as all but six of twenty-five signs are negative. Inasmuch as the firm cannot adjust its capital stock at will, this result is, perhaps, to be expected. Nonetheless, it is difficult to reconcile with the finding that the coefficients for the current value of the neoclassical term, alone among the parameter estimates for equation (7), are almost always positive. Finally, application of either the F or t test indicates that, at five percent, only a small number of the coefficients for the accelerator model are statistically significant.

\[
\kappa = \beta + \sum_{t=0}^{2} \alpha_t \gamma(u_{t-\tau} - u_{t-\tau-1}) + \alpha_3 \kappa_{t-3}
\]

<table>
<thead>
<tr>
<th>Current values of flow variables</th>
<th>Lagged values of flow variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Firms</td>
<td>25</td>
</tr>
<tr>
<td>$\alpha_1 &gt; 0$</td>
<td>6</td>
</tr>
<tr>
<td>$\alpha_2 &gt; 0$</td>
<td>16</td>
</tr>
<tr>
<td>$\alpha_3 &gt; 0$</td>
<td>16</td>
</tr>
<tr>
<td>$\alpha_4 &gt; 0$</td>
<td>10</td>
</tr>
<tr>
<td>$\alpha_1 &gt; 0$ $t &gt; t_{.95}$</td>
<td>0</td>
</tr>
<tr>
<td>$\alpha_2 &gt; 0$ $t &gt; t_{.95}$</td>
<td>3</td>
</tr>
<tr>
<td>$\alpha_3 &gt; 0$ $t &gt; t_{.95}$</td>
<td>1</td>
</tr>
<tr>
<td>$\alpha_4 &gt; 0$ $t &gt; t_{.95}$</td>
<td>0</td>
</tr>
<tr>
<td>Median $R^2$</td>
<td>0.252</td>
</tr>
<tr>
<td>Median SER</td>
<td>0.0541</td>
</tr>
<tr>
<td>$F &gt; F_{.95}$</td>
<td>2</td>
</tr>
<tr>
<td>$D-W_{.95}$</td>
<td>9</td>
</tr>
</tbody>
</table>
Turning to the question of how the independent variable in each model should be measured, we recall that the neoclassical model did not perform very well generally, with neither historical cost nor replacement cost data indicating strong results. Likewise, the performance of the securities value model does not appear to depend on how the independent variable is quantified. Though not reported in Table 4, a firm by firm comparison of both \(R^2\) statistics and coefficient signs indicated very little variation between the two sets of data. What this suggests is that most of the periodic change in \(q_{t-t}\) is accounted for by its market value component, which is common to both the historical cost and replacement cost estimates.

The presence of lagged variables in equations (7), (10), and (11) may be justified on the grounds that investment decisions take time to make and implement. An alternative, albeit complementary, view is that current and past values of the independent variables are being used to predict their future levels which, in turn, are the basis for investment.

Whereas \(q_t\) in equation (10) is measured at the beginning of \(t\), \(n_t - n_{t-1}\) in equation (7) and \(u_t - u_{t-1}\) in equation (11) only became known during \(t\) and after the firm’s capital expenditure for the period had been established. Hence, we might expect \(n_t - n_{t-1}\) and \(u_t - u_{t-1}\) to be of little importance in determining \(\kappa_t\). Indeed, as we have already indicated, the coefficients for \(u_t - u_{t-1}\) seldom had the expected positive sign. At the same time, the coefficients for \(n_t - n_{t-1}\), alone among the parameter estimates for equation (7), were almost always correct. In addition, in terms of goodness of fit, the performance of equations (7) and (11) was not generally improved when current data were excluded from the distributed lags.

Comparison of the Long Survival Model with the Value Maximization Models

In measuring the performance of the long run survival model against those of the three value maximization models, we first recall how the latter differ given the objective of our research. That is, because we are concerned with distinguishing the contribution of liquidity to explaining investment from that of profitability, we view the neoclassical, securities value and accelerator models as empirically useful interpretations of the neoclassical model. By choosing the distributed lag equation that provides the best explanation of the data for comparison with the long run survival model we give the profitability theory the most sympathetic interpretation possible.

As explained earlier, we use both performance measures that adjust and do not adjust for the number of degrees of freedom. The adjusted measure, the standard error of the regression, accommodates the fact that the survival model comprises three regressors, as opposed to four in each of the other equations. The unadjusted measure, \(R^2\), is used because the use of the same distributed lag model for all estimates of equations (7), (10) and (11) may sometimes allow a longer lag than is actually needed.

The summarized \(R^2\) coefficients suggest that overall the securities value model works best, followed by the survival, accelerator and neoclassical models. Though not presented here, firm by firm comparisons indicate the same ranking.

When the standard error statistic is used as the basis for comparison, not surprisingly the relative performance of equation (1) is enhanced. The summarized results for the survival model indicate a median standard error that in all cases is lower than those of the other models. At the
same time, firm by firm comparisons, not presented here, suggest that the securities value model is the best performer as often as is the survival model.

These results must be interpreted with some caution however. The validity of comparisons based on standard error or $R^2$ measures of performance depends on the serial independence of the error terms. An indication of whether the independence assumption is met can be obtained by examining Durbin-Watson test statistics. The results of this test, which are included in Table 2, offer little evidence suggesting that the error terms for the long run survival model are not, in general, randomly distributed. In contrast, the test statistics for the distributed lag models in Tables 3 through 5—and the accelerator model, in particular—frequently indicate the presence of serial correlation. This is in spite of the fact that for these models, the Durbin-Watson statistic is biased toward randomness because of the presence of $\kappa_{t-3}$ among the regressors.

Finally, the regression coefficients for each of the models have already been discussed in some detail. To reiterate briefly, we found that whereas the coefficients for the survival and accelerator models generally had the expected signs, those obtained for the neoclassical and securities value models were as often incorrect as they were correct. However, it was also suggested that the three distributed lag models should not be judged on the basis of individual coefficients. Because of the range of possible responses of investment to each determining variable, even one correctly signed and significant coefficient could be interpreted as evidence in support of a particular model. For this reason the F test is used to assess the coefficients’ statistical significance.

The above notwithstanding, application of the F test still favours acceptance of the survival model over the three profitability-based models. Irrespective of how the independent variables are quantified, the number of significant F statistics for equation (1) is always higher than it is for either equation (7) or (11) and generally higher than it is for equation (10).

Summary

The objective of the present study was to examine the role of liquidity variables in explaining the firm’s investment behaviour. For this purpose a model in which the firm’s goal is to maximize the probability of long run survival was compared with three interpretations of the value maximization theory, which focuses on profitability as the basis for investment. Wherever possible, the models were estimated using both historical cost and replacement cost accounting data to measure the independent variables, to obtain some evidence on how the relationships that govern firm behaviour should be quantified.

No single model can reasonably be expected to encompass all of the factors that might influence a firm’s investment decisions. Indeed, capturing such diversity may not be a particularly useful objective. The more important question is whether the model reflects a wide range of observed behaviour among nonfinancial firms.

The findings summarized in the preceding section suggest that the long run survival model is at least as compatible with firm behaviour as any of the leading profitability-based approaches. Indeed, the liquidity flow variable in the survival model appears to be the most effective measure considered.
At the same time, the results are, in some respects, disappointing. The explanatory power of the survival model, based on goodness of fit criteria, is respectable, but not compelling. In addition, the magnitudes and significance of the estimated coefficients often fail to confirm expectations. In the case of the liquidity stock term, this may be because of a tendency for the estimates of the desired debt-equity ratio to follow the actual ratio.

Finally, the results obtained using historical cost information differed in some respects from those utilizing replacement cost measures. However, the study’s conclusions concerning the role of liquidity variables and the effectiveness of the survival model hold irrespective of which type of accounting data is utilized.

References


