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An Empirical Investigation of the Dynamics of Qualitative Decisions of Firms*

by

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Abstract

This paper focuses on qualitative aspects of financing, investment and output decisions of firms. Such dimensions can be modeled econometrically by means of dynamic limited dependent variables models. We develop a partial equilibrium dynamic stochastic programming problem of investment, dividend and financing decisions for a typical firm.

We apply techniques involving limited dependent variable models to study the discrete decisions of whether or not firms pay dividends, use borrowing or issue equity to finance investment. We use panel data from COMPUSTAT for publicly traded U.S. manufacturing firms. We study the pattern of transitions over time across various regimes that represent alternative modes of finance while controlling for individual heterogeneity with a general stochastic structure for unobservables. Our dynamic limited dependent variable models show considerable success in explaining the dynamics of such decisions, with individual characteristics of firms, which include firm fundamentals and lagged values of past decisions, exhibiting a strong explanatory impact. The dynamics implied by the estimated models reveal high persistence in firms' qualitative decisions. Unobserved firm heterogeneity, which is modelled by means of random effects, plays a very significant explanatory role.

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1 Introduction

This paper explores dynamic aspects of qualitative decisions of firms by means of econometric techniques that utilize dynamic limited dependent variable models. One principal aspect of firms' behavior for which limited dependent variable models are indispensable modelling devices is that firms typically make qualitative decisions, such as whether or not to pay dividends to their shareholders, to repurchase outstanding shares, and to finance investment by borrowing (i.e., by means of issuing debt), or by issuing new shares. The prototype behavioral model for firms that we present below focuses on such decisions by integrating several pertinent strands in the literature. Noteworthy recent contributions to understanding modes of finance and investment behavior, such as Blundell *et al.* (1989), Bond and Meghir (1989), Carpenter (1991), Devereux and Sciantarelli (1989), Fazzari *et al.* (1988), Gertler *et al.* (1990), Gilchrist (1990), Hayashi and Inoue (1991), Himmelberg(1990), Sakellaris (1990), Hubbard and Kashyap (1990), Morck *et al.* (1990), and Whited (1988), have relied upon estimating Euler-type equations by identifying different subsamples describing investment behavior that may be qualitatively different. Many of these papers have employed careful comparisons of estimates derived from these subsamples and have drawn interesting conclusions about the investment behavior of firms. Nonetheless, many of these approaches have fallen short of delivering models of quantitative and qualitative decisions, such as investment behavior and choice of mode of finance, as *joint* decisions.

Section 2 below presents a partial equilibrium stochastic dynamic programming problem for a firm's financing and investment decisions. The necessary conditions for optimization under financing constraints are analyzed there. Section 3 discusses econometric aspects of the problem and models the qualitative decisions for the purpose of estimation. A discussion and preliminary observations on the data from COMPUSTAT that we utilize are presented in Section 4, while the empirical results appear in Section 5. Brief conclusions are found in Section 6. Descriptions of data construction, descriptive statistics and an extension on the model using taxes are given in Appendices.

We find that firm heterogeneity is always very significant when modeling discrete decisions of firms. Our results show that that there is always very significant persistence in the dynamics of discrete decisions. A large part of the variation of such decisions can be explained by individual firm characteristics. We feel that the present study of qualitative decisions of firms in dynamic settings is an important first step towards a more general theory that would combine quantitative and qualitative aspects of firms' investment and financing decisions.

2 A Prototype Model of Investment, Output and Financing Decisions of Firms

The analytical core of the modern literature on investment behavior may be traced back to models of firms' behavior introduced by Abel (1979; 1980) and Hayashi (1982). Those models assume a firm maximizes the expected value to its shareholders, that is the present value of dividend payments after tax, subject to a cash flow constraint and to stock accumulation constraints. These authors have provided a useful link with the earlier literature on Tobin's q. [Tobin(1969)]

2.1 The Standard Model

We follow a standard formulation of a firm's decision problem, such as Abel and Blanchard (1986), and adapt it to the case of uncertainty. First, we introduce notation to describe the model of firms' behavior. Let V_t be a firm's value, as of the beginning of time period t, defined in the standard fashion as the expected value of a firm's stream of net cash flows. Let K_t be its stock of the single capital good used in production in period t; I_t, its corresponding period t investment, which is assumed to augment capital in the following period. Let a_t be the firm's age, and let ω_t be a vector of parameters some of which may be deterministic or stochastic, whose evolution over time is determined exogenously by a family of distribution functions $P_\omega = \{P(\cdot \mid \omega), \omega \in \mathbf{\Omega}\}$. Let w_t be the vector of prices, with the price of the investment good being the numeraire; $\pi_t(K_t, a_t; \omega_t; w_t)$, the restricted profit function, which gives period t profits as a function of the vector of state variables and satisfies the usual properties [McFadden (1978)]; $c_t(I_t, K_t; w_t)$, the cost of current investment, assumed to be a convex increasing function of I_t and K_t. Finally, let β be the firm's discount factor, $0 < \beta < 1$.

A firm's problem may be treated analytically by means of the theory of dynamic programming. We can define the Bellman equation in terms of the value function, which in this case coincides with the value for an incumbent firm, formally defined as $V_t \equiv V_t(K_t, a_t; \omega_t; w_t, r_t \mid \mathcal{N}_t)$, where $\mathcal{N}_t$ is the information state at time t. The Bellman equation is:

$$V_t(K_t, a_t; \omega_t; w_t, r_t \mid \cdot) =$$
$$\max_{\{I_t, K_{t+1}\}} : \pi_t(K_t, a_t; \omega_t; w_t) - c_t(I_t, K_t; w_t) - I_t + \beta E_t \{V_{t+1}(K_{t+1}, a_{t+1}; \omega_{t+1}; w_{t+1}, r_{t+1} \mid \cdot)\}, \qquad (1)$$

where the maximization is subject to the equations of motion for aging,

$$a_{t+1} = a_t + 1, \qquad (2)$$

and for capital accumulation,

$$K_{t+1} = (1 - \delta)K_t + I_t, \qquad (3)$$

Existence and uniqueness of the optimal solution and thus of the value function may be established by means of standard conditions.[1] A key element of this theory is the assumed quasi-fixed nature of capital, with adjustment costs being a function of investment undertaken. In fact, this is the only way in which this model differs from the textbook case, where capital may be adjusted costlessly.

It is straightforward to show in this model that if the underlying production function is linearly homogeneous in K_t and all other variable inputs and the adjustment cost function for investment is linearly homogeneous in K_t and I_t, then the value of the firm, which is equal to the value function of problem (1), is proportional to K_t.[2] The factor of proportionality, which in view of the above may be written as equal to $V_t(K_t, \cdot)/K_t$, is known as the average q. Furthermore, this theory becomes operational under some additional assumptions that ensure that average q becomes equal to Tobin's q, defined as the market value of the firm

[1]See Bertsekas (1987) or Stokey, Lucas, and Prescott (1989), 112-114.

[2]See Hayashi (1982) for a proof of this important proposition under certainty and Hayashi and Inoue (1991) for its latest statement under uncertainty. The earliest statement of this proposition, though without proof, is attributed by them to Lucas and Prescott (1971).

over the replacement cost of its capital. These assumptions are that stock markets are efficient and managers rely upon the stock market to make investment decisions.

In a formal treatment of this problem, we would be adjoining the sequence of capital accumulation constraints (3) with Lagrange multipliers q_t, $t = 0, 1, \ldots$. According to the marginal interpretation of Lagrange multipliers, q_t, may be interpreted as the marginal value of an additional unit of investment, ("marginal" q,) and obeys the following necessary condition:

$$\frac{\partial V_t}{\partial K_t} = \frac{\partial \pi_t}{\partial K_t} - \frac{\partial c_t}{\partial K_t} + q_t(1-\delta) - \beta q_{t+1}.$$

We can see this more clearly by solving forward and taking expectations:

$$q_t = \frac{\partial V_t}{\partial K_t} = E_t \left\{ \sum_{\tau=1}^{\infty} (\beta(1-\delta))^\tau \left[\frac{\partial \pi_t}{\partial K_{t+\tau}} - \frac{\partial c_t}{\partial K_{t+\tau}} \right] \right\}. \tag{4}$$

Equation (4) says that the marginal value of capital equals the sum of expected discounted present value of future net cash flows of the firm.

The attractiveness of this theory, by now standard, lies in its ability to explain investment. To see this, note that the first order conditions for the firm's optimization problem imply:

$$\tilde{C}_t(\frac{I_t}{K_t}) = q_t, \tag{5}$$

where $\tilde{C}_t(\cdot)$ is defined in terms of the adjustment costs for investment as follows:

$$\tilde{C}_t(x) \equiv 1 + \bar{C}_t(x) + x\bar{C}'_t(x) \qquad c_t(I_t, K_t; W_t) \equiv I_t \bar{C}_t(\frac{I_t}{K_t})$$

The economic interpretation of this condition is straightforward. The firm computes the marginal value of an additional unit of capital and sets investment so as to equate the marginal cost of investment to it. If the adjustment costs for investment are assumed to be quadratic, then (5) implies that (I_t/K_t) is a linear function of q_t.[3]

The theory may be tested by means of equation (5). Under the above assumptions about production and cost conditions, average Tobin's q, which may be computed as the ratio of a firm's value over the value of its capital, is equal to marginal q, which appears in the RHS of (4). This implies that investment is determined only by a firm's costs for adjusting investment, as reflected in $\tilde{C}_t(.)$, and a firm's marginal value of investment, as reflected in q_t, which the market valuation of a firm's stock. By suitably parameterizing $\tilde{C}_t(.)$, which derives from the original adjustment cost function in (5), researchers have used it with both aggregate as well as micro (panel) data [Bond and Meghir(1989), Carpenter (1991), Devereux and Sciantarelli (1989), Gertler *et al.* (1990), Gilchrist (1990), Himmelberg(1990), and Whited (1988).

At this level of generality, a key weakness of this theory is is that it says nothing specific about how a particular investment plan may be financed. Investment is determined so as to maximize the expected present value of a firm's cash flow over its lifetime. In general, when a firm's borrowing is unconstrained,

[3] It is for this reason that the assumption of quadratic adjustment costs is so popular in the literature [Bond and Meghir(1989), Carpenter (1991), Devereux and Sciantarelli (1989), Gertler *et al.* (1990), Gilchrist (1990), Himmelberg(1990), Hubbard and Kashyap (1990), and Whited (1988)].

one can demonstrate that the value of the firm at any point in time is equal to the value of its debt plus the expectation of the present value of its stream of dividend payments to its owners.[4]

2.2 Borrowing and Equity Issue Constraints

We have not so far concerned ourselves with how firms may finance their investments. Matters are not as straightforward, however, if a firm may be constrained in its borrowing behavior. Constraints on borrowing by a firm affect investment and cash flows. A firm's value may still be defined as above, by introducing borrowing constraints explicitly.

We proceed further by following Himmelberg, *op. cit.*, to describe a model of a firm's investment and dividend behavior under the assumption that internally generated funds enjoy a cost advantage over external sources of finance. Thus external finance is ignored and an external quantity constraint is imposed on the level of debt. This is done for two reasons. One is in order to express the existence of credit rationing. The second is as a device to disentangle the role of cash as liquidity from that of an input to the formation of expectations by the firm about its future profitability. Like Himmelberg, we impose two important restrictions on the firm's optimization problem. One is that dividends must be nonnegative, and the second is that debt may not exceed an exogenously given amount. Clearly, borrowing constraints would be irrelevant if firms could pay negative dividends, which would be tantamount to borrowing from stockholders.

In addition, following Fazzari *et al.* (1988), Gilchrist (1990) and Gilchrist and Himmelberg (1991), we introduce equity financing, subject to constraints. The value of the new shares should be deducted from the dividend payments assuming that current shareholders would have to buy additional shares in proportion to their current holdings in order to maintain their current claim on the firm's equity. By doing so we also account for the asymmetric information problem generated by the fact that new shareholders demand some risk premium payment when purchasing new shares in order to offset possible losses from funding "lemons," bad firms. Such an additional cost may be motivated in terms of a "lemons" problem in the stock market [Akerlof (1970)].

We now introduce additional notation and complete a description of the model of firms' behavior. Let V_t be the expected present value, as of the beginning of time period t, of the stream of dividend payments to the firm's owners. Let D_t denote the period t net dividend payment to the firm's shareholders; S_t the value of new shares the firm issues at time t; $\bar{S}_t$ the minimum amount of (negative) new stock the firm can issue at time t; Ψ_t a measure of the asymmetry of information, accounting for the risk premium or overvaluation of the new stock; X_t net borrowing by the firm during t; B_t the principal of the outstanding stock of debt as of the beginning of period t; $(1 + r_{t-1})B_t$, the principal plus interest due in the beginning of period t, assuming r_t to be independent of B_t; and $\bar{B}_t$ the maximum stock of debt the firm may hold as of the end of period t; [5] The quantities a_t, ω_t, $\pi_t(K_t, a_t; \omega_t; w_t)$, $c_t(I_t, K_t; w_t)$, and β are as defined earlier.

The Bellman equation for an incumbent firm can now be written analytically in terms of the firm's value function, $V_t \equiv V_t(K_t, B_t, a_t; \omega_t; w_t, r_t \mid \mathcal{N}_t)$, $\mathcal{N}_t$ being the information state at time t, as follows:

[4]This is a statement of the Modigliani-Miller(1959) theorem. One may easily demonstrate this by assuming an arbitrary financial plan, such as that adopted by Abel and Blanchard (1986).

[5]There exist several alternative specifications of a firm's borrowing constraints. It would be interesting to consider the case where the firm may borrow unlimited amounts at a borrowing rate that increases with the stock of debt outstanding.

$$V_t(K_t, B_t, a_t; \omega_t; w_t, r_t \mid \cdot) =$$

$$\sup_{\{I_t, X_t, K_{t+1}, B_{t+1}, S_t, D_t\}} : [D_t - (1+\Psi_t)S_t] + \beta E_t \{V_{t+1}(K_{t+1}, B_{t+1}, a_{t+1}; \omega_{t+1}, w_{t+1}; r_{t+1} \mid \cdot)\}, \quad (6)$$

subject to the following constraints. First, dividends, investment and borrowing in each period are related through the cash flow constraint:

$$D_t = \pi_t(K_t, a_t; \omega_t; w_t) - c_t(I_t, K_t; w_t) - I_t + X_t + S_t. \quad (7)$$

Second, dividends [6] are constrained to be nonnegative:

$$D_t \geq 0. \quad (8)$$

Third, borrowing in period t is constrained by:

$$X_t \leq \bar{B}_t - (1 + r_{t-1})B_t. \quad (9)$$

Fourth, the accumulation equation for debt, [7]

$$B_{t+1} = (1 + r_{t-1})B_t + X_t. \quad (10)$$

Finally, the new equity issue is exogenously restricted as follows:

$$S_t \geq \bar{S}_t; \quad (11)$$

that is, new shares issues are bounded below by some minimum (negative) level.

The accumulation equations for age and capital (2)-(3) above still hold. Some remarks are in order. The *supremum* operator inside the large brackets in the RHS of (6) defines the investment dividend and financing decisions. The following transversality condition ensures that the problem is well defined:

$$\Pr\left\{\lim_{t\to\infty} \beta^t B_t \leq 0\right\} = 1.$$

This requires that the firm should pay all its debts as time goes to infinity, or, in other words, that the accumulation of debt cannot increase faster than the discount factor.[8]

[6] Tax considerations are in practice extremely important and should be reflected in the definition of the dividend payments and of the various entries in the cash flow constraint. We derive the Bellman equation with tax considerations in Appendix B.

[7] Note that in effect the debt accumulation equation may also express accumulation of liquid assets which may earn the same rate of return as that paid on debt.

[8] Existence and uniqueness of an optimal solution in the presence of constraints is more complicated than the unconstrained case. However, we may extend the methods developed by Hajivassiliou and Ioannides (1992) in order to demonstrate existence and uniqueness.

2.3 The Extended Problem and Its Economic Interpretation

Let q_t, λ_t, d_t, b_t, μ_t and ς_t be the Lagrange multipliers corresponding to equations (3), (7), (8), (9), (10) and (11), respectively. The first order (necessary) conditions for the maximization of the firm's problem are the following:

Optimal investment, I_t, should equate the marginal value of investment, the marginal q, to the corresponding marginal cost, which is equal to the marginal resource cost, the shadow price of the net cash flow, plus the marginal adjustment cost:

$$q_t = \lambda_t \left(1 + \frac{\partial c_t(I_t, K_t)}{\partial I_t}\right) \tag{12}$$

This condition relates marginal q to the shadow price of the net cash flow, λ_t. The first order condition for optimality of capital, K_{t+1}, requires that:

$$q_t = E_t \left[\beta(1-\delta)q_{t+1} + \beta\lambda_{t+1}\left(\frac{\partial \pi_{t+1}(K_{t+1}, \omega_{t+1})}{\partial K_{t+1}} - \frac{\partial c_{t+1}(K_{t+1}, I_{t+1})}{\partial K_{t+1}}\right)\right]. \tag{13}$$

This may be interpreted as follows: The firm should be indifferent, on the margin, between investing today and tomorrow. The marginal value of an additional unit of capital today should equal to the expected discounted marginal value of an additional unit of capital tomorrow after accounting for depreciation and the marginal value of an additional dollar of cash flow.

The first order condition for the dividend payments, D_t, gives:

$$\lambda_t = 1 + d_t, \;\; d_t \geq 0. \tag{14}$$

It implies that when the firm pays positive dividends ($d_t = 0$) then the shadow value of an additional dollar of net cash flow equals 1, $\lambda_t = 1$. That is, an additional dollar of cash flow leads to an additional dollar of dividend payments. For a constrained firm that pays zero dividends, the shadow value of the net cash flow exceeds one by the marginal value of an additional dollar of dividends.

The necessary condition for new debt, X_t, is:

$$\lambda_t = \mu_t + b_t, \;\; b_t \geq 0. \tag{15}$$

This requires that the value of an additional unit of net cash flow equal the shadow value of the new debt, $\lambda_t = \mu_t$, when the firm is unconstrained with respect to debt, $b_t = 0$. If the firm is constrained, $\lambda_t > \mu_t$; and the firm would be better off by borrowing more, since the value of an additional dollar in net cash flow exceeds the value of an additional dollar of debt. Concerning the optimal stock of debt, we have:

$$\mu_t = \beta E_t \left\{(1+r_t)(\mu_{t+1} + b_{t+1})\right\}. \tag{16}$$

Note that for a firm which does not expect to be debt-constrained at time t+1, $b_{t+1} = 0$. This condition implies that the shadow value of the debt today should equal to the expected discounted value tomorrow including the interest payment. In other words, borrowing an additional dollar today is equivalent to borrowing $\beta(1+r_t)$ dollars tomorrow. It is interesting to observe that a debt-constrained firm for which the value of the debt is smaller than the value of the net cash flow, debt does not contribute to the net cash flow. In such a case a firm will never use debt to finance dividend payments. Given, however, that marginal q is always greater than λ_t (since $q_t = \lambda_t(1 + \partial c_t(.)/\partial I_t)$), the firm will demand as much debt as possible to finance investment.

An interesting result, implied by the above necessary conditions and obtained by Himmelberg, *op. cit.*, is that a constrained firm pays zero dividends until the probability of being debt-constrained in the future becomes zero. Once it starts paying positive dividends, it expects to continue doing so in all subsequent periods. For a debt-constrained firm the shadow price of investment is higher than the shadow value of the net cash flow, which is higher than the shadow value of debt. This implies that a debt-constrained firm will use funds from borrowing to finance investment projects rather than dividend payments.

It is also evident that the firm may not want to borrow up to its limit even though the shadow value of internally generated funds is positive. That is because the firm by keeping unused borrowing capacity, in effect liquidity, may be able to better handle future contingencies. In terms of the necessary conditions this can be explained as follows: The firm is assumed to be constrained in both periods t and $t+1$, that is $b_t \neq 0$ and $b_{t+1} \neq 0$. It may be the case, however, that each additional dollar of debt today is worth less than $\beta(1+r_{t-1})$ tomorrow, due to expected investment opportunities at these periods. In this case the firm will not exhaust its debt limit at the current period, transferring unused borrowing capacity to the next period.

Finally, the first order condition for the new stock issue should satisfy:

$$\lambda_t = (1 + \Omega_t) - \varsigma_t \tag{17}$$

This condition implies that the benefit of issuing new stock to raise more net cash flows, should equal its cost.

3 Empirical Analysis

In principle, both qualitative and quantitative aspects of the above theory for the behavior of firms may be tested econometrically. The literature to date has primarily emphasized quantitative aspects pertaining to investment decisions. Below we review first the work on quantitative aspects of investment decisions in greater detail than earlier in this paper. We then turn to qualitative aspects, and to our own work.

3.1 Brief Review of Empirical Studies of Investment

Theoretical predictions about the behavior of investment have been tested econometrically in the literature by means of Euler-type dynamic optimization conditions as in (12) and (13) of the above model. The estimated parameters obtained by Himmelberg, *op. cit.*, are plausible but Hansen's test of the overidentifying restrictions barely fails to reject the perfect capital market model at the one percent significance level. Himmelberg provides additional evidence in favor of borrowing constraints by assuming that an auxiliary function of the Lagrange multiplier corresponding to borrowing constraints is related to observables in some arbitrary fashion, such as being a function of lags of cash flow and sales to capital ratio.[9] The theory predicts that the cash flow coefficients of the reduced form equation are economically large and statistically significant. This implies that an increase in cash flow relaxes the borrowing constraint and an increase in sales tightens it by causing an increase in investment demand.

[9] This is similar to a procedure proposed first by Altonji *et al.*(1986).

Whited (1988)[10] and Gilchrist (1990),[11] who use COMPUSTAT data, and Bond and Meghir (1989), who use a company panel from the U.K., all employ models which are generally quite similar to Himmelberg's and obtain results clearly supporting the conclusion that borrowing constraints have an impact on investment. When these authors split their samples (by means of a variety of very different criteria), [12] they find the unconstrained Euler equation being violated for the sample of firms that are likely to be constrained. For constrained firms, cash flow does affect investment.[13]

Overall, the models employed by Gilchrist, by Himmelberg and by Whited are quite similar. Whited puts greater emphasis in her empirical work on the impact of a firm's access to the corporate debt market, rather than on implications of not paying dividends, which Himmelberg emphasizes.

An obvious extension of Himmelberg's framework is to estimate Euler equations while correcting for sample selection bias associated with restricting oneself to observations for firms which do or do not pay dividends. This estimation problem may be handled by a switching regression model with endogenous switching. [Hajivassiliou and Ioannides (1992)].

3.2 Qualitative Decisions of Firms

In general, we would expect that as market conditions vary over time a firm may switch from being constrained in its borrowing to being unconstrained, or it may decide to start paying positive dividends. Switching from one to another regime may depend on individual characteristics. Gilchrist (1990), Himmelberg (1990) and Whited (1988) are noteworthy in that they have articulated such qualitative aspects. Yet Himmelberg (1990) is the only paper that tests, though rather informally, his qualitative predictions about the dynamics of dividend payments. Models of qualitative decisions may be criticized on account of the fact that they appear to use less information relative to models involving quantitative decisions. Reliance on models of continuous decisions while ignoring inherently qualitative aspects, on the other hand, may introduce raise serious misspecification problems.

The role of the adjustment cost function is crucial here. Problems like the firm's model developed earlier often lead to corner solutions due to the linearity of the objective function and the (unknown) constraints

[10]Whited also provides an interesting defense of the use of the GMM method with panel data. She notes that the Garber-King criticism of the GMM method with aggregate data is mitigated when panel data are used. Using error components that account for individual effects as well as for time-effects removes possible sources of dependence between unobservable shocks and available instruments.

[11]Several authors emphasize that observing a strong correlation between cash flow and investment, both of which are endogenous variables, may simply capture the fact that firms with good investment opportunities tend to have high cash flows. Reduced-form investment equations (such as q-type models) are likely to be misspecified so that q is no longer a sufficient statistic for investment. This point is made particularly clearly by Blundell *et al.* (1989).

[12]The variables Whited uses to split the sample are noteworthy. One is the ratio of a firm's debt to the market value of its total assets. A second is the ratio of a firm's interest expenses to the sum of interest expense and cash flow. The former may be considered as a measure of a firm's effective discount rate. The latter may be considered as a measure of a firm's need to borrow. A third variable involves the availability of a rating for a firm's bond in the beginning of the sample. Whited argues that if a firm has undergone the extensive investigation that precedes the rating of its bonds, it would be less likely to suffer from the informational asymmetries that may restrict its access to borrowing.

[13]Such sample splits are reminiscent of what Zeldes (1989) and Runkle (1991) have done with data from the Panel Study of Income Dynamics. As Hajivassiliou and Ioannides (1991b) have argued, the endogeneity of the variables used to split the sample should be accounted for.

from borrowing and new equity limits the firm faces. Although most of the literature assumes that the adjustment cost function is convex, several authors have investigated mixed convex/concave adjustment costs [Jørgensen and Kort (1990), Söderström (1976)]. A convex adjustment cost function implies generally a smooth solution, the solution to the concave programming problem. A concave adjustment cost, however, leads to corner solutions which are characterized by "jumps" in a firm's behavior.

Our work takes a first step in a direction ignored by the literature to date. Below we explore econometric models of qualitative decisions which avoid misspecification problems at the cost of losing quantitative information. It should nonetheless be borne in mind that the necessary conditions for optimization do not provide specific guidance for formulating econometric models and thus may serve as a general framework for structuring estimation models.

We consider a number of different specifications with respect to discrete endogenous variables characterizing firms' behavior, especially as they pertain to financing behavior, and to dividend and investment behavior. The techniques we use allow us to account for the interdependence of the different discrete alternatives while accounting for the dynamic structure of such models. We note at the outset that an analysis of the data for firms' propensity to issue new debt, and new equity, as reported in Tables 3a and 3b,[14] provides strong evidence of a rich pattern of transitions and of a role for unobserved heterogeneity.

3.2.1 Qualitative decisions as univariate discrete events

Simple parameterization of the optimization problem yields expressions for the endogenous variables X_t, S_t, D_t and I_t. These depend, in general, upon the exogenous and endogenous state variables of the problem, that is, prices and other market variables and the capital stock. They also depend on characteristics of individual firms and the industries in which they operate. Unobservable and possibly persistent characteristics may also be important.

We may define, for the purpose of our empirical investigation, a number of discrete-valued endogenous variables that correspond to the above endogenous variables being positive. The discrete aspects of the financing decisions of the firms are captured by the following discrete events, that is, whether or not a firm issues new debt,

$$\mathcal{B}_t \equiv \mathbf{1}(X_t > 0), \tag{18}$$

and whether or not a firm issues new shares,

$$\mathcal{S}_t \equiv \mathbf{1}(S_t > 0), \tag{19}$$

where the indicator function $\mathbf{1}(\mathcal{A})$ is equal to 1, if $\mathcal{A}$ is true, and equal to 0, otherwise. We define, in addition, the discrete event $\mathcal{I}_t$ to express whether or not a firm undertakes net investment,

$$\mathcal{I}_t \equiv \mathbf{1}(I_t > 0), \tag{20}$$

and $\mathcal{D}_t$, for whether or not a firm pays positive dividends,

$$\mathcal{D}_t \equiv \mathbf{1}(D_t > 0). \tag{21}$$

[14] We discuss these results in full detail in Section 4.2.

These events are observable in the COMPUSTAT data. Furthermore, the above definitions are amenable to refinements, which would be needed, for example, to express the existence of several categories of dividends. We do not pursue further such refinements here.[15] The methods proposed by Hajivassiliou and Ioannides (1991) allow us to handle with panel data imperfect indicators for discrete events.[16]

We isolate the questions we focus on by considering *marginal* value functions associated with each of the discrete decisions in

$$\varpi_t = \{\mathcal{B}_t, \mathcal{S}_t, \mathcal{I}_t, \mathcal{D}_t\}\,.$$

These decisions are conditional on all observable information but are *marginal* with respect to one another. Such a formulation allows us to examine at a first pass the determinants and dynamics of each of these decisions on its own. Below we return to allow for interdependence between these decisions.

Let $\mathcal{A}_t \in \varpi_t$ denote a decision variable contained in ϖ_t. The marginal value function is defined as:

$$U_{\mathcal{A}_t} = \beta_{\mathcal{A}} Y_{it}^{\mathcal{A}} + \epsilon_{\mathcal{A}_t}, \tag{22}$$

where $\beta_{\mathcal{A}}$ is a vector of parameters to be estimated, $Y_{it}^{\mathcal{A}}$ a vector of observable variables which include a number of firm i's characteristics in period t, and $\epsilon_{\mathcal{A}_t}$ a stochastic (unobservable) part of the value function of the firm. The probability of choosing $\mathcal{A}_t = 1$, is thus given by:

$$Prob\,\{\mathcal{A}_t = 1\} = Prob\,\{\beta_1 Y_{it} - \beta_0 Y_{it} > \epsilon_{0,t} - \epsilon_{1,t}\}\,, \tag{23}$$

and thus depends on the difference in value levels between the best choice and the alternative choice.

We allow for persistent heterogeneity by means of individual effects in the form of random effects. That is, we assume that the stochastic error $\epsilon_{\mathcal{A}_t}$ consists of a random individual effect for each firm i, $\eta_{i,\mathcal{A}}$, and an unobserved value component for firm i at period t, $\nu_{i,\mathcal{A}_t}$:

$$\epsilon_{\mathcal{A}_t} = \eta_{i,\mathcal{A}} + \nu_{i,\mathcal{A}_t}. \tag{24}$$

The two error components are assumed to be independent and normally distributed. Failure to account for individual effects may result in serious bias in the estimation.

In estimating models of this type we are bound by available econometric techniques. For the case of univariate discrete events we can use univariate probit estimation methods for non-balanced panel data with random effects. For the estimation we use a numerical quadrature method (with and without random effects) based on an algorithm presented in Butler an Moffitt (1982) and Hajivassiliou (1984).

3.2.2 Multivariate discrete events

We extend the above models to account for possible interdependence among the discrete financing decisions. Our assumptions about the marginal value functions allow us to consider multivariate events by means of

[15] Additional discrete events corresponding to other qualitative aspects of firms' behavior may also be defined. Whether or not they are observable depends very much on the data.

[16] The availability of data in COMPUSTAT on bond ratings, ingeniously used by Whited (1988), is a classic example of an imperfect indicator of $\mathcal{S}(t)$. The event of whether a firm is constrained in its borrowing may be defined as follows:

$$\mathcal{C}(t) \equiv \mathbf{1}[X_t < \bar{B}_t - (1 + r_{t-1})B_t].$$

multinomial probit models. That is, an observation for which financing is in the form of new debt only, $\{\mathcal{B}_t = 1\} \cap \{\mathcal{S}_t = 0\}$, which occurs with probability

$$\text{Prob}\left\{(\beta_{1,\mathcal{B}} - \beta_{0,\mathcal{B}})Y_{it} \geq \epsilon_{0,\mathcal{B}_t} - \epsilon_{1,\mathcal{B}_t}, (\beta_{0,\mathcal{S}} - \beta_{1,\mathcal{S}})Y_{it} \geq \epsilon_{1,\mathcal{S}_t} - \epsilon_{0,\mathcal{S}_t}\right\}. \tag{25}$$

In a similar fashion, we can define the event that the firm uses new equity financing only, $\{\mathcal{B}_t = 0\} \cap \{\mathcal{S}_t = 1\}$, which occurs with probability

$$\text{Prob}\left\{(\beta_{0,\mathcal{B}} - \beta_{1,\mathcal{B}})Y_{it} \geq \epsilon_{1,\mathcal{B}_t} - \epsilon_{0,\mathcal{B}_t}, (\beta_{1,\mathcal{S}} - \beta_{0,\mathcal{S}})Y_{it} \geq \epsilon_{0,\mathcal{S}_t} - \epsilon_{1,\mathcal{S}_t}\right\}; \tag{26}$$

or, a mix of new debt and new equity financing, $\{\mathcal{B}_t = 1\} \cap \{\mathcal{S}_t = 1\}$, whose probability is given by:

$$\text{Prob}\left\{(\beta_{1,\mathcal{B}} - \beta_{0,\mathcal{B}})Y_{it} \geq \epsilon_{0,\mathcal{B}_t} - \epsilon_{1,\mathcal{B}_t}, (\beta_{1,\mathcal{S}} - \beta_{0,\mathcal{S}})Y_{it} \geq \epsilon_{0,\mathcal{S}_t} - \epsilon_{1,\mathcal{S}_t}\right\}, \tag{27}$$

or, no external financing at all, $\{\mathcal{B}_t = 0\} \cap \{\mathcal{S}_t = 0\}$, whose probability is given by

$$\text{Prob}\left\{(\beta_{0,\mathcal{B}} - \beta_{1,\mathcal{B}})Y_{it} \geq \epsilon_{1,\mathcal{B}_t} - \epsilon_{0,\mathcal{B}_t}, (\beta_{0,\mathcal{S}} - \beta_{1,\mathcal{S}})Y_{it} \geq \epsilon_{1,\mathcal{S}_t} - \epsilon_{0,\mathcal{S}_t}\right\}. \tag{28}$$

We propose to explain the probability of the observable financing event in terms of the differences of the unobserved value components. Regressions for the estimation of (25) – (28) involve error components, defined by:

$$w_{\mathcal{A}_t} = \epsilon_{j,\mathcal{A}_t} - \epsilon_{i,\mathcal{A}_t}, i, j \in \{0, 1\}; i \neq j, \mathcal{A}_t \in \varpi_t. \tag{29}$$

Our assumptions on the stochastic structure of the ϵ' s, implies a well defined stochastic structure for (29) which may be obtained from (24) by means of tedious but elementary manipulations. Our estimation methods allow for interdependence of the alternative choices. The smooth simulated maximum likelihood algorithm we use produces unbiased estimates of the choice probabilities of the above models. Our estimation according to the Simulated Maximum Likelihood Algorithm follows the approach proposed by Börsch- Supan and Hajivassiliou (1991), and Börsch-Supan et. al (1992) which allows for random effects for panel data models as described in (24).

4 Description of the COMPUSTAT Data

The data used in this work are based on the "Manufacturing Sector Master File: 1959–1987," created initially by Bronwyn H. Hall [Hall (1988)] under the auspices of a National Bureau of Economic Research project. The Manufacturing Sector Master File consists of a non-balanced panel of 2726 publicly traded firms with 90 variables during the period 1959–1987. There are 49,225 firm-year observations in all. The original data are obtained from the Annual COMPUSTAT Industrial and Over-the-Counter Files for 1978 through 1987. Data items come from a variety of sources such as income statements, balance sheets, flow of funds statements, etc. A detailed description of the construction of the data is presented in Hall (1990), 26–30.

The COMPUSTAT panel data set contains all firms traded on the New York and American Stock Exchanges and a number of firms traded on over–the–counter markets. Minimum requirement for the inclusion of a firm in the current panel is existence of data for at least three consecutive years between 1976 and 1985.

The following variables from the COMPUSTAT data measure important characteristics of firms and are included in our study: investment, operating income, net and gross cash flow, sales, dividends, dividends and common stock repurchases, and total debt. All of these variables have been normalized by dividing by the net capital stock. In addition, we use Tobin's q[17] and a number of ratios used in standard corporate finance theory.[18] These include: profitability ratios, such as the ratio of cash flow to sales, measuring the operating efficiency and the rate of internal cash generation; the ratio of cash flow to total tangible assets, which accounts for the ability of the firm to generate cash flows from resources; and the ratio of operating income to total tangible assets, which measures the management's ability to generate operating income from the firm's assets. The liquidity ratio was defined as cash flow over total liabilities and measures the cash generation out of total liabilities. Ratios intended to measure leverage include total debt to total tangible assets, which measures the degree to which the firm's assets are financed by debt, and retained earnings to total tangible assets, which indicates long term profitability, i.e., the degree to which existing assets have been financed by reinvested profits. A list of variable definitions is given in Table 1. Descriptive statistics of all variables and ratios are given in Tables 2a and 2b and in Appendix C.

4.1 Analysis of the Data

Tables A and B of the Appendix give descriptive statistics for the whole panel. All variables have been made comparable by using an adjustment factor for the common stock splits and have been deflated to 1970 as the base year.

We illuminate qualitative aspects of the data by defining a number of distinct regimes for firm behavior. In particular, firms may stay in a specific regime for a number of periods, or they may switch between regimes. We examine some basic characteristics of these regimes towards obtaining a better understanding of the dynamics of the process of regime switching.

We distinguish six regimes defined in terms of the discrete events of positive versus zero dividends, $\mathcal{D}_t \in \{0, 1\}$, of positive versus negative net debt (if the firm pays back debt), $\mathcal{B}_t \in \{0, 1\}$, and of positive or negative new shares issues (if the firms buys back its own shares), $\mathcal{S}_t \in \{0, 1\}$. A picture of the average pattern of transitions is given in Tables 3a and 3b. We have left out the investment decision primarily because it exhibits, according to Tables 2a and 2b, relatively very little variation, at least when compared to the other variables. Tables C to R in the Appendix provide further detail by means of descriptive statistics for each of the sixteen distinct subsamples that are obtained after the inclusion of the discrete event $\mathcal{I}_t \in \{0, 1\}$, that is whether or not net investment is positive or negative.

Referring to Tables 2a and 2b, we note that Table 2a pertains to the full sample, whereas Table 2b pertains to the balanced panel we use in estimation. Regime 1 includes firms which at a specific time utilize all kinds of external finance, that is, they borrow, issue new shares, and pay dividends. Firms which belong to this regime are younger and stronger with high leverage and high profits; 28.7% of all firm observations belong to Regime 1. Regime 2 is similarly defined except that dividend payments are zero. This is 13.06% of the sample and consists of younger small firms with low debt and profits. Regime 3 consists of observations from the sample where firms use debt for finance purposes and they do not issue new shares or buy back shares from the market. The descriptive statistics show that such firms comprise 11.8% of the sample and are mostly larger than average, with high debt and high earnings, and such observations come mostly from recent years. Regime 4 is defined similarly but with zero dividend payments. It includes small firms with

[17]For a detailed description of the construction of Tobin's q, see Appendix A.

[18]For example, see Brealey and Myers (1991).

low debt and earnings, especially the latest years of the sample. [19] Regime 5 is a rather "abnormal" but nonetheless includes a substantial number of firms (17.5 %) which pay dividends and issue new equity but do not issue new debt. [20] Regime 6 comprises a small portion of the sample (5.5%), and is similar to regime 5, except that dividend payments are zero. Small firms with low leverage and profits is the case here. Regime 7 consists of firms using internal finance only to pay dividends. This group comprises 9.8% of the panel and include average firms typically with low debt and high income for dividends. Finally, regime 8 pertains to a relatively infrequent occurrence (5.5%) of smaller firms with low debt and no income to distribute, which do not use any external finance and do not pay dividends. Descriptive statistics on the whole sample and on these regimes are given in Tables A–R of the Appendix.

4.2 Analysis of Patterns of Transitions across Regimes.

Tables 3a and 3b consider cross tabulations on transitions across 8 regimes concerning dividend payments, borrowing and equity issue behavior. Table 3a refers to the whole sample (46,513 observations) while Table 3b refers to the balance panel of 301 firms for the years 1959-1987. Comparison between those two tables prompts the following observations.

Most firms in Regime 1 (positive dividend payments and positive borrowing and new shares issue), which is the most frequent regime in both samples (60%), remain in the same regime from period to period. Another 20% of the firms change their behavior towards not issuing more debt and 13% do not issue new equity in the next period.

Most firms in Regime 2 (same as Regime 1 but no dividend payments) remain in the same regime for the next period (50% and 40% for the full and the balanced samples, respectively) where the only other interesting move is to a regime where no new debt is issued.

Most firms in Regime 3 (firms which do not issue new shares, but they increase net borrowing while paying positive dividends) remain in the same regime. However, we have relatively more moves to regimes where the financing pattern changes, either by starting issuing shares or (fewer) by stopping borrowing. Similar is the case for Regime 4 (same as 3, but with zero dividends).

In regimes 5 and 6 (no debt issue, positive share issue and positive and zero dividends respectively) most firms remain in the same regime from one period to the next, some start issuing debt and a smaller number of them stop issuing shares. For the firms which do not use any kind of financing the most common switch (if any) is starting issuing new shares, while starting issuing new debt is less frequent.

A most interesting conclusion obtained by comparing Tables 3a and 3b is that the transitions across regimes in the unbalanced panel of the full sample of 46,513 observations are very similar to the transitions for the smaller balanced panel of 301 firms for the years 1959–1987 (8,428 observations). This encourages us to rely on the balanced (and smaller) panel for multinomial probit estimations, described on Section 3.2.2, rather than the full sample, since the smooth simulated probit algorithm requires a balanced panel.

Summarizing the above discussion we can see that there is a fair amount of switching across regimes over time (around 50 % of the firms decide to remain in the same regime). Whenever firms do switch from one regime to another, it is hardly ever the case that firms change their dividend behavior. When firms change

[19] This is possibly a case of constrained firms with high risk premia which explain the fact that they do not issue new equity.

[20] This behavior of mostly average firms with high profits is questionable: They seem to worry mostly about their signals for bankruptcy risks (debt–equity ratio) and less about the cost of financing.

their financing mode, it is more likely that they do so by issuing new shares. If they did not issue new shares in the last period, it is possible to start issuing in the current period. A similar but weaker result holds for issuing new debt. The above results are reversed when firms use a specific type of financing and then they stop using it. They also seem to be more likely to stop borrowing than to stop issuing new shares.

5 Estimation Results

Tables 4, 5, 6 and 7 summarize the results of the probit estimations for the discrete events of issuing new debt, issuing new shares, positive dividend payments and positive net investment respectively for the unbalanced panel of 1875 firms between the years 1958 and 1987, totaling 46,498 observations. In all those tables the first column of results reports to estimations for a homogeneous probit model (no individual heterogeneity is assumed), while the second column contains the probit results for the same model with individual heterogeneity modeled by means of a random effect.

5.1 New Debt

Estimation results for the discrete event of issuing new (net) debt as described on equation (18) and modeled in terms of the specification in (23) and (24) are given on Table 4. By comparing the two columns of results we can observe that allowing for a random effect significantly increases the explanatory power of the model. This follows from the fact that the likelihood ratio test gives strong support for the hypothesis that the model in the second column (which includes a random effect) significantly improves the performance of the homogeneous model. In support to this argument comes the significance of the variance of the random effect, $\log(\sigma_\eta)$. It is clear then that the unobserved "value" component includes a time- invariant random term. Yet, the estimated coefficients show considerable stability after the introduction of the random effect.

Most of the explanatory variables used for modelling this discrete event are significant and their signs are consistent with simple economic intuition. The lagged dependent variable has a positive estimated coefficient, which implies that firms exhibit strong persistence when it comes to the decisions about issuing new debt. In other words, given that the firm was issuing new debt last period, it is very possible that it will continue issuing debt the current period. Switching is rather rare. The effect of investment is positive. Firms which invest with higher rates are more likely to issue debt in order to finance investment. On the other hand, firms which are not involved in major investment projects are expected to pay back their debt.

Firms with high operating income prefer to pay back their debt while firms with low operating income decide to issue more debt. This result is also consistent with the theory. There is a significant negative coefficient for the gross rate of return. Firms with high rates of return from their investment seem to issue more debt. Also, firms with high net cash flows and large sales pay back their debt or do not issue more. Tobin's q has a significant and positive estimated coefficient, which implies that firms with higher market value to replacement cost of capital decide to borrow more often. This is a direct implication of the first order conditions for borrowing, discussed in section 3.2, that lead to equations (12) and (15). When the shadow value of investment, the marginal q, which is approximated here by Tobin's q, is high enough to exceed the shadow value of borrowing, a firm is more willing to borrow.

The ratio of net cash flow to tangible assets, which provides a measure of a firm's ability to generate funds from its own resources, has a significant positive effect to the firm's decision to issue new debt. Higher long term profitability, measured by the ratio of retained earnings to tangible assets, also has a positive impact on the firm's decision to issue debt.

5.2 New Stock Issues

The probit estimations on Table 5 for the discrete event of issuing new stock are very interesting. The first noteworthy observation is that the panel structure is strongly significant. By comparing the models on the two columns of Table 5, which represent estimations without and with random effects respectively, and by using a likelihood ratio test, it follows that the model with the random effects significantly improves the explanatory power of the model. The estimate of the variance of the random effect is very significant.

Many of the explanatory variables are very significant and provide useful insights on the firm's decision to issue new stock. First, the lagged endogenous variable implies very significant dynamics. Its positive sign implies high persistence in the firm's propensity to issue new shares. Firms that invest more are more likely to issue new stock, and so do firms with high operating income. On the other hand, firms with higher net cash flows and higher sales seem to be less likely to issue new stock. One explanation may be that they do not need cash as much and are thus unwilling to assume risks associated with issuing new shares. Surprisingly, dividend payments seem to be completely irrelevant to the decision of issuing new stock.

5.3 Dividends

The discrete event of whether or not to pay dividends is very interesting since modelling dividend payments is one of the most contentious issues in the applied finance literature. Our estimations, reported on Table 6, show a number of interesting aspects of the dividend decision. Here, again, individual heterogeneity seems to be important since the variance of the random effects turns out to be significant and the likelihood ratio test for the homogeneous versus the random effects model supports the explanatory power of the panel structure.

With respect to the dynamics, the previous year's decision has a significantly positive coefficient, which implies that there is high persistence in the propensity to pay dividends. This result accords with predictions obtained by Himmelberg *op. cit.*, namely that conditional on the event that positive dividends are paid in a given year, the probability that no dividends are paid in the following year is small. Similarly, the probability that no dividends are paid in a subsequent year is very high, conditional on the event that no dividends are paid in a given year. Our own results provide strong support for Himmelberg's predictions with respect to the discrete event of whether or not positive dividends are paid, even after we have accounted for individual effects (which he does not).

A number of other explanatory variables show a significant effect on the decision to pay dividends. We find that firms which invest a lot are less likely to pay dividends, as is also the case for firms with high gross rate of return. The intuition is rather simple. Given firms' cash flow, funds for investment projects compete with funds for dividends. This may well be the case for young firms, while it seems natural to observe that firms with no new investment opportunities use their cash flows to finance dividend payments to shareholders. This agrees quite nicely with another of our findings, that firms with higher operating income are more willing to pay dividends. Debt is negatively related to dividend payments: Firms with high debt to capital ratio are less likely to pay dividends. Under the assumption that firms with higher debt levels are more likely to be debt-constrained, this finding provides partial support for Himmelberg (1990) and White's (1988) argument that constrained firms do pay zero dividends. Finally, the result that long-term profitability, as approximated by the retained earnings to tangibles ratio, is positively associated with paying positive dividends, accords with simple economic intuition.

5.4 Net Investment

Table 7 provides probit results for the model of equation (23) applied to the case of the discrete event defined in terms of net investment being positive. Appendix A provides details on the construction of net investment and the endogenous variables. Our findings here give interesting insights on the investment behavior of firms. Again, the explanatory power of the model increases with the inclusion of a random effect. Both the variance of the random effect, $\log(\sigma_\eta)$, and the likelihood ratio test between the models in columns I and II of Table 7 show that the model with the random effect is significantly better than the homogeneous model.

We now refer to the second column of Table 7 and we make a number of interesting observations concerning the determinants of the event that net investment is positive. The lagged dependent variable, $\mathcal{I}_{t-1}$, has a positive and significant coefficient, which implies that firms' propensity to invest exhibits strong persistence. That is, when a firm decided to increase net investment in the last period, then the probability that it will continue this behavior is very high, while so is the case for firms which disinvest.

The coefficient of Tobin's q is positive and significant, implying that the higher a firm's valuation of investment (as measured by Tobin's q) the more attractive is new investment. This result accords with the theoretical prediction developed in Section 2, and with previous work in the investment literature.

Additional significant coefficients include the debt to capital ratio (DEBT2K) which has a positive effect on the likelihood of new investment. This implies that firms with higher debt are the ones which invest in new projects. This finding provides additional support to a borrowing–investment link established by our results on the determinant of the likelihood that a firm issues new debt.

5.5 Interdependence of Modes of Financing

Table 8 reports multinomial probit results for three of the four events defined in (25) – (28) as dependent variables. We use the following three events as joint dependent variables. These events, which represent alternative modes of finance, are: whether or not only borrowing is used (with respective variables bearing subscript 1 in Table 8); whether or not only new equity is used (with respective variables bearing subscript 2 in Table 8); and, whether or not both new debt and new equity is used (with respective variables bearing subscript 3 in Table 8).[21]

The results reported in Table 8 pertain to jointly estimated reduced forms. The estimation uses a balanced panel of firms, which appear in the sample during the period 1959–1987. The reliance on a balanced panel is problematic, in principle, but is dictated by the availability of software for the Simulated Maximum Likelihood Algorithm. As we discussed in Section 4.2, the pattern of transitions among the various modes for this sample and the full sample are very similar. It is for this reason that we are not too concerned about using the smaller but balanced panel. The random effects estimation failed to converge. The results reported in Table 8 are without random effects.

Similarly to the results for the univariate models for new debt and new equity, the estimated coefficients of the respective lagged dependent variables (LDB1 and LDB2) are positive and very significant, implying strong

[21]Unfortunately, software limitations do not allow us to include the fourth variable defined in Section 3.2.2 above, that is, $\{\mathcal{B}_t = 0\} \cap \{\mathcal{S}_t = 0\}$.

persistence when it comes to such financing decisions. This is not the case however with the combination of the two types of external financing, that is issue new debt and new equity at the same time. It is hardly significant and has a negative sign. Firms seem to avoid using both types of external finance when they used both of them in the last period. This is consistent with an earlier observation in the cross-tabulations reported on Table 3b.

For the remainder of the results we observe that the sales to capital ratio (SALES2K) has a negative coefficient, implying the negative relationship of high sales to external financing generally. The positive signs of the Tobin's q coefficients are supportive of the same argument as in Section 5.1, which relates the marginal q (approximated here by the Tobin's q) to the shadow price of external financing. Long term profitability, as measured by the ratio retained earnings to tangible assets, has a positive effect on external financing.

Another interesting feature of these results is an improvement due to the inclusion of an autoregressive error in the stochastic structure of the form:

$$\epsilon_{i,t} = \rho_i \epsilon_{i,t-1} + \nu_{i,t},$$

with $\nu_{i,t}$ being an i.i.d. process. Such a specification implies a block diagonal structure of the variance–covariance matrix with each block having an *AR(1)* process structure.[22] Our model strongly supports the autoregressive error structure and imply rich dynamics in the unobserved components determining financing decisions.

6 Concluding Remarks

Models of qualitative aspects of the firm's investment and finance decisions give a new perspective on some of the classic problems in the theory of the firm. Our results exhibit interesting patterns in explaining firms' behavior, which have not been investigated before. Such qualitative decisions as whether or not to pay dividends, to issue new debt, to issue new equity, and to undertake net investment are significantly affected by unobserved firm heterogeneity. Also, persistence appears to be an important factor in firms' propensity to choose among alternative modes of finance. Our results should be seen as a first pass towards a more general theory which would combine quantitative and qualitative aspects of firms' behavior as joint decisions. This task still lies ahead.

[22] See Börsch-Supan *et al.* (1992), p.83.

TABLE 1

VARIABLES and RATIOS USED
as FIRM CHARACTERISTICS

I2K	Investment to capital
OPY2K	Operating Income to Capital
GRATE	Gross Cash Flow to Capital
NCF2K	Net Cash Flow to Capital
SALES2K	Sales to Capital
q	Tobin's q
DIV2K	Dividends to Capital
DIVR2K	Dividends plus Repurchases to Capital
DEBT2K	Total Debt Stock to Capital
NCF2SALE	Net Cash Flow to Sales
NCF2TANG	Net Cash Flow to Total Tangible Assets
OPY2TANG	Operating Income to Total Tangible Assets
NCF2LIAB	Net Cash Flow to Total Liabilities
B2TANG	Total Debt to Total Tangible Assets
RE2TANG	Retained Earnings to Total Tangible Assets

Table 2a

Descriptive Statistics
Full Sample

Variable	# of Observ.	Mean	Std Dev	Minimum	Maximum
$\mathbf{1}(NEWDEBT > 0)$	46471	0.4222418	0.4939220	0	1.0000000
$\mathbf{1}(NEWSHARES > 0)$	46471	0.6059048	0.4886607	0	1.0000000
$\mathbf{1}(DIVIDENDS > 0)$	46471	0.6697725	0.4702999	0	1.0000000
$\mathbf{1}(NETINVEST > 0)$	46471	0.9437499	0.2304066	0	1.0000000
I2K	42891	0.1777658	0.1676876	0	2.3346705
OPY2K	44560	0.4159968	0.5116916	-7.4400785	18.7017073
GRATE	44568	1.2768296	18.7769207	-12.6138391	1523.73
NCF2K	44568	0.7727858	9.5685606	-94.0005768	946.5344990
SALES2K	44544	3.9405346	4.8034437	0.000220911	255.3450015
q	37296	5.1457523	65.0279018	-15.9063216	3075.82
DIV2K	44198	0.2767623	4.8942466	0	283.5819304
DEBT2K	44561	0.4120752	0.5941614	0	71.4891029
NCF2SALE	44544	0.2274687	22.9523600	-4161.38	2059.34
NCF2TANG	44567	0.2726277	3.4667908	-24.5216356	355.6228661
OPY2TANG	45817	0.1542847	0.1235678	-3.6675017	3.2533328
NCF2LIAB	44520	1.4290837	18.5477593	-177.5181725	1762.64
B2TANG	45999	0.1779327	0.1547900	0	3.9889552
RE2TANG	42122	0.2770584	0.5237479	-24.0047616	2.7933324

Table 2b

Descriptive Statistics
Balanced Panel Subsample 1959–1987

Variable	# of Observ.	Mean	Std Dev	Minimum	Maximum
$\mathbf{1}(NEWDEBT > 0)$	8439	0.3732670	0.4837008	0	1.0000000
$\mathbf{1}(NEWSHARES > 0)$	8439	0.7068373	0.4552394	0	1.0000000
$\mathbf{1}(DIVIDENDS > 0)$	8439	0.9082830	0.2886432	0	1.0000000
$\mathbf{1}(NETINVEST > 0)$	8439	0.9840028	0.1254716	0	1.0000000
I2K	8179	0.1936675	0.1595023	0	1.5947460
OPY2K	8298	0.4795413	0.4572764	-1.7762903	4.6764499
GRATE	8299	0.2222445	1.5598848	-0.7198718	70.4608917
NCF2K	8299	0.2084666	0.9332855	-1.3067890	36.1275845
SALES2K	8290	3.6780945	3.1262598	0.0427295	44.5979670
q	7321	0.7906973	0.7364028	-0.3894575	15.4823851
DIV2K	8287	0.0842973	0.1241639	0	1.7739578
DEBT2K	8299	0.4041610	0.4294232	0	9.1535827
NCF2SALE	8290	0.0740164	0.2984768	-0.9288598	19.7768275
NCF2TANG	8299	0.0858174	0.2774273	-0.7643613	16.6228396
OPY2TANG	8413	0.1708566	0.0862727	-0.4176803	0.6712404
NCF2LIAB	8288	0.4448659	2.2826108	-3.4419560	163.0225741
B2TANG	8436	0.1692053	0.1227820	0	1.4936618
RE2TANG	7114	0.3671882	0.1926993	-1.6795466	1.1030691

TABLE 3a

CROSS TAB ON THE TRANSITIONS OF 8 REGIMES
BASED ON DIVIDEND AND FINANCING PATTERNS

(full sample)

t / $t+1$	Regime 1 $\Delta B > 0$ $\Delta S > 0$ $D > 0$	Regime 2 $\Delta B > 0$ $\Delta S > 0$ $D = 0$	Regime 3 $\Delta B > 0$ $\Delta S \leq 0$ $D > 0$	Regime 4 $\Delta B > 0$ $\Delta S \leq 0$ $D = 0$	Regime 5 $\Delta B \leq 0$ $\Delta S > 0$ $D > 0$	Regime 6 $\Delta B \leq 0$ $\Delta S > 0$ $D = 0$	Regime 7 $\Delta B \leq 0$ $\Delta S \leq 0$ $D > 0$	Regime 8 $\Delta B \leq 0$ $\Delta S \leq 0$ $D = 0$	Total
Regime 1 $\Delta B > 0$ $\Delta S > 0$ $D > 0$	6000 (58.07)	166 (3.31)	1407 (29.04)	66 (2.11)	2392 (25.09)	80 (2.06)	667 (11.07)	62 (1.65)	10840
Regime 2 $\Delta B > 0$ $\Delta S > 0$ $D = 0$	127 (1.23)	2625 (52.41)	48 (0.99)	744 (23.84)	50 (0.52)	1139 (29.33)	28 (0.46)	564 (15.00)	5325
Regime 3 $\Delta B > 0$ $\Delta S \leq 0$ $D > 0$	1443 (13.96)	47 (0.94)	1785 (36.84)	107 (3.43)	645 (6.76)	29 (0.75)	961 (15.95)	105 (2.79)	5122
Regime 4 $\Delta B > 0$ $\Delta S \leq 0$ $D = 0$	70 (0.68)	689 (13.76)	108 (2.23)	1183 (37.9)	22 (0.23)	348 (8.96)	41 (0.68)	764 (20.32)	3225
Regime 5 $\Delta B \leq 0$ $\Delta S > 0$ $D > 0$	2040 (19.74)	62 (1.24)	571 (11.79)	40 (1.28)	5002 (52.46)	149 (3.84)	1788 (29.67)	99 (2.63)	9751
Regime 6 $\Delta B \leq 0$ $\Delta S > 0$ $D = 0$	81 (0.78)	1071 (21.38)	30 (0.62)	319 (10.22)	78 (0.82)	1632 (42.02)	43 (0.71)	817 (21.73)	4071
Regime 7 $\Delta B \leq 0$ $\Delta S \leq 0$ $D > 0$	539 (5.22)	26 (0.52)	828 (17.09)	59 (1.89)	1294 (13.57)	63 (1.62)	2402 (39.86)	217 (5.77)	5428
Regime 8 $\Delta B \leq 0$ $\Delta S \leq 0$ $D = 0$	33 (0.32)	323 (6.45)	68 (1.4)	603 (19.32)	52 (0.55)	444 (11.43)	96 (1.59)	1132 (30.11)	2751
Total	10333	5009	4845	3121	9535	3884	6026	3760	46513

TABLE 3b

CROSS TAB ON THE TRANSITIONS OF 8 REGIMES
BASED ON DIVIDEND AND FINANCING PATTERNS
(balanced panel subsample 1959-1987)

t $t+1$	Regime 1 $\Delta B > 0$ $\Delta S > 0$ $D > 0$	Regime 2 $\Delta B > 0$ $\Delta S > 0$ $D = 0$	Regime 3 $\Delta B > 0$ $\Delta S \leq 0$ $D > 0$	Regime 4 $\Delta B > 0$ $\Delta S \leq 0$ $D = 0$	Regime 5 $\Delta B \leq 0$ $\Delta S > 0$ $D > 0$	Regime 6 $\Delta B \leq 0$ $\Delta S > 0$ $D = 0$	Regime 7 $\Delta B \leq 0$ $\Delta S \leq 0$ $D > 0$	Regime 8 $\Delta B \leq 0$ $\Delta S \leq 0$ $D = 0$	Total
Regime 1 $\Delta B > 0$ $\Delta S > 0$ $D > 0$	1546 (60.49)	5 (2.67)	308 (32.32)	6 (5.66)	641 (22.59)	5 (1.71)	119 (9.06)	2 (1.10)	2632
Regime 2 $\Delta B > 0$ $\Delta S > 0$ $D = 0$	13 (0.51)	76 (40.46)	4 (0.42)	21 (19.81)	5 (0.18)	66 (22.60)	1 (0.08)	18 (9.89)	204
Regime 3 $\Delta B > 0$ $\Delta S \leq 0$ $D > 0$	329 (12.87)	3 (1.60)	363 (38.09)	5 (4.72)	143 (5.04)	0 (0.00)	174 (13.24)	5 (2.75)	1022
Regime 4 $\Delta B > 0$ $\Delta S \leq 0$ $D = 0$	5 (0.20)	27 (14.44)	5 (0.52)	33 (31.13)	0 (0.00)	11 (3.77)	2 (0.15)	30 (16.48)	113
Regime 5 $\Delta B \leq 0$ $\Delta S > 0$ $D > 0$	516 (20.19)	11 (5.88)	121 (12.70)	3 (2.83)	1673 (58.95)	14 (4.79)	475 (36.15)	6 (3.30)	2819
Regime 6 $\Delta B \leq 0$ $\Delta S > 0$ $D = 0$	10 (0.39)	49 (26.20)	3 (0.31)	14 (13.21)	13 (0.46)	161 (55.14)	7 (0.53)	47 (25.82)	304
Regime 7 $\Delta B \leq 0$ $\Delta S \leq 0$ $D > 0$	134 (5.24)	1 (0.53)	139 (14.59)	1 (0.94)	361 (12.72)	4 (1.37)	530 (40.33)	14 (7.69)	1184
Regime 8 $\Delta B \leq 0$ $\Delta S \leq 0$ $D = 0$	3 (0.12)	15 (8.02)	10 (1.05)	23 (21.70)	2 (0.07)	31 (10.62)	6 (0.46)	60 (32.97)	150
Total	2556	187	953	106	2838	292	1314	182	8428

TABLE 4

Probit Estimation of $\mathcal{B}_t = \mathbf{1}(B_t > 0)$

Variable	no random effects	with random effects
constant	0.051177661524	0.051598856421
	(7.291795089)*	(5.602160669)
$\mathcal{B}_{t-1}$	0.1404642540	0.1396823645
	(19.72138031)	(18.05188470)
i2k	0.2925936145	0.2915183118
	(34.11189535)	(31.62560213)
opy2k	-0.2074047072	-0.2130227674
	(-15.96345411)	(-9.422087795)
grate	0.4255806876	0.4213081325
	(15.56835510)	(10.52524399)
ncf2k	-0.3277625940	-0.3323055648
	(-8.981876191)	(-7.513923678)
sales2k	-0.090368605164	-0.091780629273
	(-9.085427874)	(-7.878287575)
div2k	-0.050428812021	-0.0051541492345
	(-5.511638309)	(-0.6065213973)
debt2k	-0.1338497766	-0.1323983999
	(-9.759506184)	(-9.176919985)
Tobin's q	0.016353233108	0.015876451992
	(2.066601774)	(1.906655018)
ncf2tang	0.070738192351	0.065405101290
	(11.35671524)	(3.053341070)
opy2tang	-0.3550239145	-0.036288373716
	(-28.92878310)	(-1.825731522)
b2tang	0.2258989043	0.2279822190
	(19.14812081)	(17.73524285)
re2tang	0.023866628434	0.020536572430
	(2.608798114)	(2.242048585)
$\log(\sigma_\eta)$	———————	-1.320290336
	———————	(-28.06508570)
L.L.F.	-2329.6026910	-2217.7232472

* Numbers in parentheses are t-statistics.

TABLE 5

Probit Estimation of $\mathcal{S}_t = \mathbf{1}(S_t > 0)$

Variable	no random effects	with random effects
constant	0.3833186696	0.3981954140
	(52.14258015)*	(33.24419311)
$\mathcal{S}_{t-1}$	0.4854837918	0.3728896112
	(67.50765732)	(44.28430597)
i2k	0.1451993090	0.1565073657
	(16.36020501)	(15.69911507)
opy2k	0.1330031803	0.1353364464
	(6.247619230)	(5.754972785)
grate	0.1765292194	0.1567543046
	(5.149400057)	(4.048809876)
ncf2k	-0.2450572971	-0.2217132124
	(-5.794234693)	(-4.712597777)
sales2k	-7.0799832069E-02	-8.0519842259E-02
	(-7.651185331)	(-6.649846292)
div2k	-1.1798536425E-02	-2.6938297404E-04
	(-1.526666375)	(-0.0305295294)
debt2k	8.1555735054E-05	-3.8642229164E-03
	(0.0055953874)	(-0.2432618922)
q	-4.9852006557E-03	4.4968819518E-03
	(-0.6390940272)	(0.5119232348)
ncf2tang	0.1134909879	0.1197253449
	(5.674907054)	(5.494983697)
opy2tang	-2.5801936557E-02	-2.2548772246E-02
	(-1.324762517)	(-1.041853242)
b2tang	1.0308992525E-02	3.4253218493E-03
	(0.8519754720)	(0.2477371750)
re2tang	-7.4728039932E-02	-7.8716378159E-02
	(-8.698213302)	(-7.841615927)
$\log(\sigma_\eta)$	————————	-0.8263214828
	————————	(-25.10367050)
L.L.F.	-1.9670439298D+04	-1.9315966474D+04

* Numbers in parentheses are t-statistics.

TABLE 6

Probit Estimation of $\mathcal{D}_t = \mathbf{1}(D_t > 0)$

Variable	no random effects	with random effects
constant	0.7994247496	0.8056634842
	(73.15715194)	(65.53016328)
$\mathcal{D}_{t-1}$	1.515477034	1.501845380
	(153.9623001)	(122.3912806)
i2k	-4.1190478530E-02	-4.0257072110E-02
	(-3.850320142)	(-3.280756859)
opy2k	5.685600435	5.692269404
	(17.74384413)	(46.26416417)
grate	-6.6041037854E-02	-6.6908020185E-02
	(-1.712081825)	(-5.422400867)
ncf2k	1.7612743749E-02	1.8430891632E-02
	(0.5295027640)	(0.1495686169)
sales2k	-1.9826639760E-02	-1.9557155208E-02
	(-2.063538961)	(-1.594669569)
div2k	-3.2358594915E-03	-4.7356126045E-03
	(-0.3654256635)	(-0.3870750158)
debt2k	-2.733657160	-2.834054136
	(-7.806287345)	(-23.16904549)
ncf2tang	5.9885398377E-03	5.4037233942E-03
	(0.1447442320)	(0.4373594905)
opy2tang	-6.024323936	-6.031389099
	(-17.73795937)	(-48.99077062)
b2tang	2.912690327	3.019891867
	(7.786046540)	(24.65363684)
re2tang	4.6535635210E-02	4.5725761972E-02
	(3.697454754)	(3.717848122)
$\log(\sigma_\eta)$	———	-1.754709787
	———	(-14.18506128)
L.L.F.	-8.3187723871D+03	-8.3165390224D+03

* Numbers in parentheses are t-statistics.

TABLE 7

Probit Estimation of $\mathcal{I}_t = \mathbf{1}(I_t > 0)$

Variable	no random effects	with random effects
constant	2.479130561	31.70863165
	(0.8611163950)	(8.795519929)
$\mathcal{I}_{t-1}$	0.2158909964	0.2377648373
	(4.995935286)	(6.600528150)
i2k	-11.99697020	-14.76964820
	(-0.5583352981)	(-4.096408900)
opy2k	-1.092260451	-11.07817900
	(-0.2057329500)	(-0.3072641429)
grate	3.9363142281E-02	1.9347140721E-02
	(0.3175033701)	(0.5372711692)
ncf2k	2.6610430029E-02	0.3874883517
	(0.1928676170)	(1.075630516)
sales2k	-5.3218822766E-02	-0.8801223154
	(-0.2231723927)	(-0.2441085439)
div2k	2.896136246	1.598612830
	(0.2235333248)	(0.4433794264)
debt2k	-0.1076390121	1.0603530681E-02
	(-2.012399883)	(2.942274832)
q	9.998865656	2.945115629
	(1.029824824)	(8.168345822)
ncf2tang	1.7270057160E-02	-3.3266857440E-02
	(0.2358526308)	(-0.9231399999)
opy2tang	1.888741814	11.37923206
	(0.3074783043)	(0.3156141923)
b2tang	-6.9128026282E-02	-0.3169213799
	(-0.8618907150)	(-0.8792765982)
re2tang	5.7964036537E-03	-9.0414391816E-02
	(0.7101148667E-01)	(-0.2508528400)
$\log(\sigma_\eta)$	———	2.404633295
	———	(7.659328572)
L.L.F.	-7.4883862193D+01	-6.8086936178D+01

* Numbers in parentheses are t-statistics.

Table 8
Probit Estimation of Alternative Modes of Finance
as Multivariate Joint Discrete Events

Variable	Coefficient	T-Statistic
LDB1	0.128286092	(2.836947959)
LDB2	0.313903830	(6.827176134)
LDB3	-0.047227624	(-1.357966516)
I2K1	0.315487018	(0.246542313)
I2K2	0.147851508	(0.166527140)
I2K3	1.066935235	(1.482681564)
OPY2K1	-0.238055391	(-0.142123950)
OPY2K2	0.087370562	(0.062373304)
OPY2K3	-0.978118287	(-0.928016614)
GRATE1	0.427811112	(0.059142894)
GRATE2	0.153074050	(0.032549171)
GRATE3	1.175227594	(0.272235954)
NCF2K1	-0.326746472	(-0.052812662)
NCF2K2	-0.228279970	(-0.057620946)
NCF2K3	-1.233417248	(-0.366428181)
SALES2K1	-0.566632208	(-3.495552956)
SALES2K2	-0.589700180	(-5.004866234)
SALES2K3	-0.374827282	(-4.890583230)
Q1	0.186829988	(0.863945000)
Q2	0.046282410	(0.316170403)
Q3	0.548461844	(4.913115150)
DIV2K1	-0.004381436	(-0.000974578)
DIV2K2	-0.005465970	(-0.001525633)
DIV2K3	0.998056274	(0.368027149)
DEBT2K1	-0.103760724	(-0.095359470)
DEBT2K2	-0.019546739	(-0.026678628)
DEBT2K3	0.950764966	(1.718956510)
NCF2TAN1	0.081820079	(0.024189243)
NCF2TAN2	0.123587973	(0.039988785)
NCF2TAN3	1.009348851	(0.328981931)
OPY2TAN1	-0.030588882	(-0.011837792)
OPY2TAN2	-0.034161229	(-0.016955919)
OPY2TAN3	-1.057137570	(-0.537545563)
B2TANG1	0.279276175	(0.138215227)
B2TANG2	0.011313111	(0.009433276)
B2TANG3	0.939036513	(1.041133251)
RE2TANG1	0.042369802	(0.067259576)
RE2TANG2	0.072758037	(0.179797328)
RE2TANG3	0.882573619	(1.998593031)
one1	0.138380052	(0.251369761)
one2	0.342277491	(0.962450531)
one3	0.705534933	(2.275519702)
σ_1	1.877559974	(127.401166323)
σ_2	1.672989452	(1664.494839423)
$\sigma_1 2$	0.057680908	(68.183902082)
$\sigma_1 3$	-0.134186104	(-133.964100089)
$\sigma_2 3$	-0.024339196	(-62.887993886)
ρ_1	0.534541995	(522.699342666)
ρ_2	0.549608136	(5357.787495835)
ρ_3	0.482587295	(851.140138408)
L.L.F.	-4603.1173	

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APPENDIX

A Definitions and Constructions of Variables

We describe here the variables used from the COMPUSTAT data, from the R&D Master File and the new variables we created.

A.1 Net Investment

We measure investment by using the variable INVEST, which accounts for capital expenditures (gross investment). GRATE is the gross rate of return to capital defined as the ratio of gross cash flows to gross capital stock adjusted for inflation (GROCAP). The market value of the firm (VAL) is defined as the sum of common and preferred stock (VCOMS, PREFST), the long term debt adjusted for its age structure (LTDEBT), and the short term debt (STDEBT), less the net short term assets (ADJ). We use this definition of the value of the firm to calculate Tobin's q, which is defined as the ratio of the value of the firm divided by the replacement value of capital. For the replacement value of capital we use the inflation adjusted net capital stock (NETCAP).

To examine the discrete event of whether or not a firm invests we need to model net (new) investment. In the literature there is a distinction between replacement investment[23] and net investment, defined as the difference between gross investment and replacement investment. There are no data that separates the two. We construct net investment implicitly from other information of the data and by making some additional assumptions.

The data provide information on the gross capital stock, K^G, and the net capital stock, K^N, which is similar but depreciated, assuming straight line depreciation. So, it must be the case:

$$K_t^N = K_t^G - \sum_{i=0}^{t} DE_{t-i},$$

where DE_t is the total depreciation at time t. We also have that gross investment at time t, I_t, is

$$I_t = I_t^N + I_t^R,$$

where I_t^N is net investment and I_t^R replacement investment. It is pretty obvious that replacement investment is at most equal to depreciation, but here we assume that equality holds, that is replacement investment is always equal to depreciated capital. This assumption allows net investment to become negative which is an implication of disinvesting by the firm. Substituting for

$$DE_t = I_t^R = I_t - I_t^N$$

in the first equation and taking differences with its lagged we get an explicit form for net investment at t:

$$I_t^N = I_t - K_t^N + K_{t-1}^N + K_t^G - K_{t-1}^G$$

A.2 New Debt – New Shares

The data distinguish between long term debt (due after one year), BKDEBT, and debt due in one year from now, DEBT1YR. We derive a NEWDEBT variable with a simple transformation of the two above variables as follows:

$$\text{NEWDEBT}_t = \text{BKDEBT}_t - \text{BKDEBT}_{t-1} + \text{DEBT1YR}_t$$

Similar is the case for new shares. We define the issue of new shares as:

[23] For an interesting review see Feldstein and Rothschild (1974)

$$\text{NEWSHARES}_t = \text{NOSHARES}_t - \text{NOSHARES}_{t-1}$$

where NOSHARES_t is the number of common shares outstanding at time t. We have corrected this variable on account of common stock splits etc.

A.3 Dividends

We consider the variable DIV, dividends per share, which we multiplied by the number of shares outstanding in order to find the amount of dividends the firm paid out at a specific year.

A.4 Other Variables

All macroeconomic variables, including deflators for nonresidential investment and the consumer price index, as well as the growth rate of GNP and the Treasury Bill rates are taken from the 1992 *Economic Report of the President.*

B Derivation of the Bellman Equation with Tax Considerations

Let V_t be the value of the firm at time t. Then, the following equation describes the evolution of the value of the firm:

$$E_t\ V_{t+1} = E_t\ {}_tV_{t+1} + (1 + \Psi_t)S_t, \tag{1}$$

where V_{t+1} is the value at time $t+1$ of shares outstanding at the same period $t+1$, ${}_tV_{t+1}$ is the value at time $t+1$ of shares outstanding at time t, S_t is the value of new shares issued in the end of period t, and Ψ_t a measure of the asymmetry of information, accounting for the risk premium of new stock.

Let R_t be the equilibrium after tax rate of return for the current equity holders. Then the standard finance arbitrage condition in the stock market is:[24]

$$R(t) = \frac{(1-\theta)D_t + (1-c)\left[E_t\ {}_tV_{t+1} - V_t\right]}{V_t}, \tag{2}$$

where θ is the tax rate on dividends and c is the tax rate on capital gains. It is generally the case, under the U.S. Tax Code that the tax rate on dividends exceeds the tax rate on capital gains, or

$$\theta > c$$

Now, by substituting (1) into (2) and rewriting we get

$$R_tV_t = (1-\theta)D_t + (1-c)\left(E_t\ V_{t+1} + (1+\Psi_t)S_t - V_t\right)$$

which implies that:

$$V_t = \frac{1}{1+\frac{R}{1-c}}\left[E_tV_{t+1} + \frac{1-\theta}{1-c}D_t + (1+\Psi_t)S_t\right]$$

Solving forward after normalizing for the initial period $t = 0$ and considering uncertainty for random variables as assumed in Section 2.2 we get:

$$V_0 = E_0\sum_{t=0}^{\infty}\prod_{j=0}^{t}\beta_j\left[\frac{1-\theta}{1-c}D_t + (1+\Psi_t)S_t\right]$$

where

$$\beta_j = \left(1 + \frac{R_j}{1-c}\right)^{-1}$$

The term $1/(1+\frac{R_t}{1-c})$ is thus the discount factor, β_t, and so the *value of the firm* turns out to be the discounted present value of all future earnings in the form of dividends corrected for the tax rates and the new shares valuation. Notice also that the value of an additional unit of capital – i.e. the marginal q – is $(1-\theta)/(1-c)$ because shareholders at this point are indifferent between reinvesting one dollar in the firm taxed at rate c and a dollar of dividends taxed at rate θ.

It seems interesting to consider the relationship between the value of the firm over time with the dividend payments D_t. From the value of the firm equation (3) it follows that:

$$V_t = E_t\ \sum_{i=t}^{\infty}[\prod_{j=t}^{i-t}\beta(j)]\left(\frac{1-\theta}{1-c}D_i + (1+\Psi_i)S_i\right)$$

[24]See for example Fama, Eugene, R. and Merton H. Miller, *The Theory of Finance*, 1972.

or

$$V_t = \frac{1-\theta}{1-c} D_t + (1+\Psi_t) S_t + E_t \sum_{i=t+1}^{\infty} [\prod_{j=t+1}^{i-(t+1)} \beta(j)] \left(\frac{1-\theta}{1-c} D_i - (1+\Psi_t) S_i \right)$$

or

$$V_t = \left(\frac{1-\theta}{1-c} D_t + (1+\Psi_t) S_t \right) + E_t V_{t+1}$$

which, after rewritten as

$$E_t V_{t+1} - V_t = -(1+\Psi_t) S_t - \frac{1-\theta}{1-c} D_t$$

implies that the *increase* in the firm value equals to the market value of its new shares after dividends are subtracted. Also, using equation (1) we get the condition

$$E_t \left[{}_t V_{t+1} \right] = V_t - \frac{1-\theta}{1-c} D_t$$

that is, the expected value of the currently existing stock tomorrow equals to their value today after the dividend payments.