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1 Interest Rate Spreads, Credit Constraints, and Investment Fluctuations: An Empirical Investigation

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Recent time-series work in macroeconomics has emphasized the role of the interest rate spread between risky and safe debt in forecasting real GNP. Stock and Watson (1989) and Friedman and Kuttner (1989) demonstrate that this interest differential has greater predictive power for output than money, interest rates, or any other financial variable. Increases in the spread are associated with subsequent downturns in GNP growth. While this analysis is limited to postwar data, similar results apply to the prewar period.[1]

Though the statistical relation between the spread and output appears robust, relatively little effort has been devoted to providing a sound structural interpretation of the evidence. It is clear that, under any story, movements in the spread reflect changes in "payoff" or "default" risk, broadly defined.[2] Nonetheless, the question emerges as to what are the sources of shifts in this payoff risk. In this paper, we argue that the countercyclical pattern in the spread may in part be symptomatic of a financial element in the business-cycle propagation mechanism. Our reasoning draws heavily on some recent theoretical work that links informational problems in capital markets at the micro level with fluctuations in aggregate economic activity. We also provide some

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supporting econometric evidence, extending methods used recently to test for the impact of credit-market imperfections on investment.

The theoretical literature to which we allude motivates a financial propagation mechanism by providing a rationale for why the agency costs of external finance may fluctuate countercyclically. Countercyclical movements in the wedge between external and internal finance, in turn, introduce a kind of "accelerator" effect on investment, ultimately magnifying investment and output fluctuations.[3] As Calomiris and Hubbard (1990) note, an associated implication of these theories is that the spread between risky and safe interest rates should move inversely with investment and output. The basic idea is that the widening of the spread is associated with, among other things, increased agency costs of external finance. In addition to being compatible with the time-series evidence, these theories also provide some formal underpinnings for the earlier work on financial crisis, which emphasized sharp increases in the spread as the precursors to financially induced disruptions in real activity.

An alternative to our story is that cyclical shifts in payoff risk are independent of financial factors. Defaults, for example, may be driven purely by technological factors. The spread is then useful as a "leading indicator" simply because it contains information about future technological disturbances, and not because there is any meaningful respect in which financial structure interacts with real activity. Indeed, this is a popular interpretation of the Stock-Watson results. While this explanation has some intuitive appeal, the underlying theory is incomplete. In the absence of any kind of imperfection in capital markets, the pattern of financial payoffs from borrowers to lenders is indeterminate (since the Modigliani-Miller theorem applies). In particular, since leverage ratios are indeterminate, there need be no particular connection between interest rate spreads and output fluctuations, as we demonstrate later.

In any event, a test of the competing theories is available. If the spread is simply an "information" variable and does not in any way reflect credit-market imperfections, then the data should not cause one to reject the neoclassical model of investment under perfect capital markets. If the story we offer is true—that is, movements in the spread reflect, at least in part, underlying movements in agency costs of external finance—then the null model should not hold. Further, an alternative model which relates firms' marginal cost of finance to agency factors should fit the data, where the movements in the interest rate spread can serve as a proxy for unobserved movements in agency costs.

We proceed in two steps. In section 1.1, we develop a simple model of investment and financial contracting under asymmetric information in which the link between interest differentials and the agency costs of external finance is made precise, and in which changes in the (endogenous) interest rate spread predict future movements in investment and output. We produce an example within the context of the Euler equation corresponding to firms' intertemporal decisions about investment. Situations are identified where, due to agency problems, the basic Euler equation for investment is violated. Shifts in interest rate differentials help predict investment in these periods. By necessity, the theoretical model is highly stylized and, therefore, cannot be matched directly to data. However, we estimate a model that loosely incorporates the key features of the simple stylized model. The estimation results are presented in section 1.2. Section 1.3 concludes.

1.1 Interest Differentials and Fluctuations Under Asymmetric Information

To illustrate how the empirical link between the spread and output fluctuations may, at least in part, reflect a financial mechanism, we present a simple model of investment finance under asymmetric information. We demonstrate first that in the benchmark case of symmetric information, there is no particular connection between financial variables (including the spread) and real variables; that is, the Modigliani-Miller theorem applies. A standard Euler equation for investment emerges. Under asymmetric information, however, a determinate pattern emerges. Firms' financial positions become relevant to the investment decision; investment moves inversely with firms' internal net worth. One manifestation of this relation is that changes in the spread help predict investment, even after controlling for changes in investment opportunities. In particular, an additional term emerges in the Euler equation, reflecting the impact of credit-market imperfections; this term covaries with the interest rate spread.

The model is a variant of Gertler and Hubbard (1988) and Gertler and Rogoff (1990). There are two periods, zero and one. In period zero, an entrepreneur (i.e., the firm) has access to a production technology which yields a random quantity of output in period one, taking capital as input. Investment I is done in period zero and entails convex adjustment costs $A(I)$, where $A(\cdot)$ is twice continuously differentiable with $A(0) = 0, A' > 0$ and $A'' > 0$. Capital K available for use as input in period one is given by

$$K = I + (1 - \delta)K_0, \tag{1}$$

where δ is the depreciation rate and K_0 is the period zero capital stock, which we take as given.

The mean level of output increases at a diminishing rate in the level of capital used as input. In particular, output y obeys the following two-point distribution:[4]

$$y = \begin{cases} Y \text{ with probability } P(K) \\ 0 \text{ with probability } 1 - P(K) \end{cases} \tag{2}$$

where $P(K)$ is increasing, strictly concave, and twice continuously differentiable, with $P(0) = 0$ and $P(\infty) = 1$. That is, more capital raises the probability of obtaining a high level of output, and the marginal gain is diminishing.

The entrepreneur/firm has initial resources W_0 ("intemal net worth"). We interpret W_0 broadly here to include current cash, known collateralizable future resources, or valued relationships with lenders specializing in information gathering and monitoring (such as commercial banks). To invest more than W_0, the balance B must be borrowed using risky (noncollateralized) extemal finance.[5] To do so, the firm issues a state-contingent security which pays lenders L^g in the event of a good outcome and L^b in the event of a bad outcome. Given that R is the altemative gross riskless retum available to lenders, and given that lenders are risk-neutral, the payments on the security must satisfy

$$P(K)L^g + (1 - P(K))L^b \geqq RB, \tag{3}$$

with

$$B \geqq I - W_0. \tag{4}$$

The pattem of payments offered by the security must also satisfy the following feasibility conditions, corresponding to limited liability (given that W_0 is already invested):

$$L^g \leq Y, \quad L^b \leq 0. \tag{5}$$

The firm maximizes expected terminal wealth $E(W_1)$. Given that the entrepreneur may invest in his project or lend at the market rate R, $E(W_1)$ is given by

$$\begin{aligned} E(W_1) = {} & P(K)Y - [P(K)L^g + (1 - P(K))L^b] \\ & + R(W_0 + B - I) - A(I). \end{aligned} \tag{6}$$

The first two terms in equation (6) are expected net project eamings; the third is the retum from holding the safe asset; and the fourth is the adjustment cost of investing.

The outcome under symmetric information is simple to characterize. The firm invests in productive capital to the point at which expected marginal profitability of investment equals the gross riskless retum plus the marginal cost of investing. That is, the first-best value of investment I^* is given by

$$P'(K^*)Y = R + A'(I^*), \tag{7}$$

where $K^* = I^* + (1 - \delta)K_0$. Equation (7) is a conventional Euler equation for capital accumulation.

It is also important to note that the pattem of contractual payments is indeterminate in this case. Any set of payoffs which satisfies the expected-retum constraint (6) is acceptable. Because information is symmetric, there is no interdependence between financial structure and real economic decisions. As a consequence, there is no relation between the spread and investment in this case, after controlling for the variables that appear in equation (7).

To motivate a meaningful role for financial structure, we introduce a classic incentive problem, one described originally by Berle and Means (1932) as the basic motive for divergence of interests between ownership and management.[6] In particular, we assume lenders cannot observe the disposition of investment funds. That is, while outside lenders observe firms' initial resources W_0 and total borrowing B, the borrower has private information about how he allocates investment funds. For simplicity, we assume he can divert the funds to the safe asset and reap the benefits from this activity himself.

On the other hand, outside lenders may observe output. Under asymmetric information, therefore, contracts can be conditioned only on realized output y and not on investment I. Given the output-contingent payoffs (L^g, L^b) specified by the contract, the borrower will choose I to maximize expected final wealth, given by equation (6). This involves equating his expected marginal gain from investing with the opportunity cost of secretly diverting funds to a safe asset:

$$P'(K)[Y - (L^g - L^b)] = R + A'(I). \tag{8}$$

So long as L^g differs from L^b, investment I will differ from its first-best optimum value I^*, as may be seen by comparing (7) and (8). The problem is that the borrower's marginal gain from investing depends not only on the marginal gain in expected output but on the change in his expected obligation to lenders as well. In designing the contract, lenders take into account the borrower's decision rule, as given by (8).

Note that the larger is the spread between L^g and L^b, the larger is the gap between I and the first-best level, I^*. One way to obtain the first best would be to make L^b large enough that the contract would be truly "sum certain," so that $L^g = L^b = R\,(I^* - W_0)$. This optimum is not feasible when $W_0 < I^*$, because of the limited liability condition in equation (5) (recall that the project yields nothing in the bad state).

Consider the case for which borrowing is required ($W_0 < I^*$). The solution to the contracting problem is fairly intuitive. The contract pays lenders nothing in the bad state, so that the limited liability condition (5) is binding for L^b. (More generally, the contract always pays lenders the maximum feasible amount in the bad state.) This arrangement minimizes the spread between L^g and L^b, thereby minimizing the gap between I^* and I. Similarly, equation (4) is binding; under the incentive-compatible arrangement, the firm borrows only to finance investment and does not allocate funds to the riskless asset. Borrowing more than is required to finance investment I would raise the gap between L^g and L^b.

Given that $L^b = 0$ and $B = I - W_0$, the following two relations jointly determine I and L^g:

$$YP'(K) = R + A'(I) + L^g P'(K) \tag{9}$$

$$L^g = R\,(I - W_0)/P(K), \tag{10}$$

where $K = I + (1 - \delta)K_0$ from equation (1).

Equation (9) is obtained from the incentive condition (8) and is a downward-sloping locus in (I, L^g) space. The curve slopes downward since higher values of L^g lower the firm's expected marginal gain from investment and therefore must be offset by reduced investment. Equation (10) is obtained from the condition that the security must offer a competitive return (from eq. [3]) and is upward sloping in (I,L^g). The positive relation emerges because higher investment requires greater borrowing and because L^b cannot adjust, since the limited liability constraint is binding.

Whenever $W_0 < I^*$, investment I will be less than the first-best level, I^*. Increases in internal net worth raise investment by lowering L^g, thereby relaxing the impact of the incentive constraint on investment.

The spread S between the firm's marginal cost of finance and the riskless rate is given by

$$
\begin{aligned}
S &= \frac{L^g}{B} - R \\
&= \frac{L^g}{I - W_0} - R \qquad (11) \\
&= R\left(\frac{1}{P(K)} - 1\right)
\end{aligned}
$$

When the incentive constraint is binding, the spread is always positive. Further, a rise in W_0 increases K, and therefore reduces S. That is, $\partial K/\partial W_0 > 0$, implying $\partial S/\partial W_0 < 0$.

If the only shocks in the economy were to firms' net worth (W_0), then there will be an inverse relation between *changes* in the spread (ΔS) and the level of investment ($\Delta K = I$). In this case, movements in the spread contain information about movements in net worth.[7] Of course, in actual data, this relation is a correlation. Shocks to the level or distribution of the marginal product of capital will also shift the spread (given some level of net worth). To carry the simple Euler equation in (8) to data, it will be necessary in the estimation procedure to control for such shifts, as we describe in section 1.2.2 below.

It is worth emphasizing that shocks to internal net worth W_0 can be broadly interpreted here—for example, reductions in collateralizable resources (Gertler and Hubbard 1988), increases in debt-service burdens (Calomiris, Hubbard, and Stock 1986; Gertler and Hubbard 1991), or disruptions in ("bank") credit markets in which problems of asymmetric information are less severe (Bernanke 1983; Calomiris and Hubbard 1989). In each case the transmission mechanism is that movements in the "spread" correspond to shocks to internal net worth, owing to the impact of movements in net worth on the agency costs of external finance.

1.2 Empirical Evidence of U.S. GNP Growth and Investment

1.2.1 Interest Rate Spreads, GNP growth, and Investment: Reduced-Form Evidence

For our empirical work, we examine short-term spreads. One reason for preferring short-term measures to the alternative long-term Baa–Treasury bond spread is that the Baa-Treasury spread data are not stationary over our period (with a significant increase in the average value of the spread during the 1980s, relative to the 1950s, 1960s, and 1970s). We focus on the short-term interest rate differential corresponding to the spread between six-month commercial paper and Treasury bill rates. The spread is plotted in figure 1.1. The short-term spread is positive in all periods, of course, averaging 61 basis points. Following the intuition noted in the previous section, we will focus our attention on changes in the spread, which can be pronounced (as in 1970, 1974, and 1982, for example).

We begin our empirical analysis by corroborating the predictive power of the interest rate spread for output growth (measured by the growth rate of real GNP). As a simple reduced-form test, we regressed the quarterly GNP growth rate on a constant, on four lags of the GNP growth rate, and on four lagged values of the spread or changes in the spread. Given lags and consideration of the thickness of the market, the quarterly data cover the period from 1964 to 1989. We can reject at the 1.9×10^{-6} level the hypothesis that the spread coefficients are zero; approximately the same level of rejection holds for the change in the interest rate spread. The coefficient estimates suggest a negative effect of the spread on GNP growth.

Following the model in the previous section, our primary interest lies in

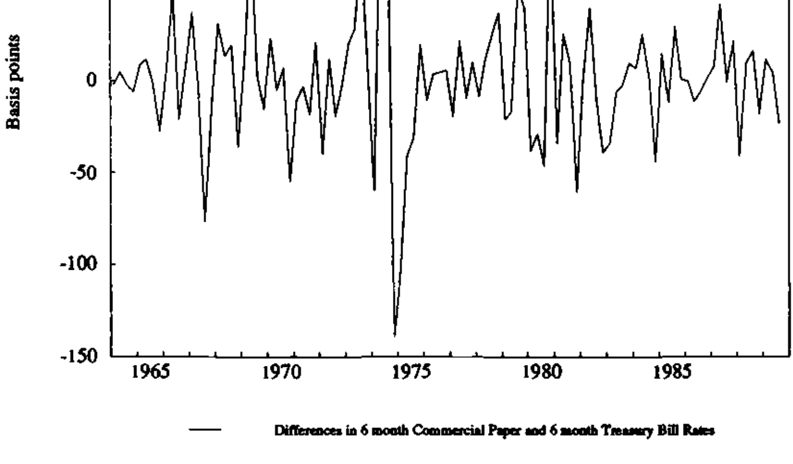

Fig. 1.1 Short-term commercial paper–Treasury bill interest rate differentials

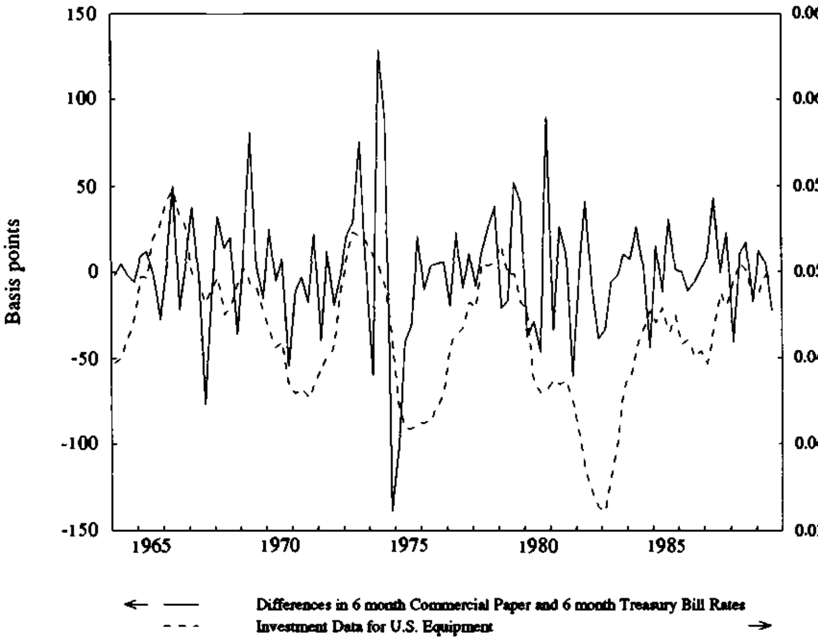

Fig. 1.2 Investment rate and the short-term interest rate differential

examining the effects of movements in the spread on investment. Data on real gross private domestic investment in fixed. nonresidential producers' durable equipment are plotted in figure 1.2. We selected equipment investment because of the greater variation in the series (relative to structures investment) during our sample period. and because of the negative trend in the investment-to-capital ratio for structures over the period. Repeating the simple time-series tests done for GNP growth for investment. we can reject at the 0.0014 level the hypothesis that the spread coefficients are zero (or at the 0.10 level for the change in the spread). As with GNP growth. there is a negative effect of the spread on the rate of investment. These results are consistent with the findings in Stock and Watson (1989) of the predictive power of the interest rate differential for real activity. To investigate these correlations more formally. we outline below an econometric approach to modeling investment in the spirit of the model of section 1.1.

1.2.2 Econometric Approach for Investment

There are serious difficulties in econometric implementation of investment models. even without considerations of capital market imperfections. One conventional approach stresses the role of "marginal q," the increase in firm value from additions to the capital stock. It is well known that by specifying a functional form for adjustment costs, one can solve for an investment function relating the rate of investment to q (see, for example, Hayashi 1982 and Summers 1981). The problems with this approach are three. First, its empirical success in explaining the variation in investment (in aggregate data or micro data) has not been overwhelming. Second, empirical proxies for "marginal q"—typically "average q"—are likely to be inadequate, owing to imperfect competition in the product market, non-constant returns to scale in production, or imperfect capital markets. Finally, the q model may be an inappropriate vehicle given our interest in asymmetric information, as expectations reflected in prices quoted on centralized securities markets will not in general reflect insiders' valuations of future investment projects.[8]

Our stylized model of section 1.1 suggests an Euler equation for investment with adjustment costs, modified to include a term that reflects credit-market imperfections (see eq. [8]). Since this model is not directly estimable, we follow the approach outlined in Hubbard and Kashyap (1990) to examine the effects on investment of proxies for movements in internal net worth. Specifically, we develop an empirical Euler equation for investment that incorporates the possibility that financial constraints are important. As in section 1.1, violations of a null ("perfect capital markets") Euler equation should be in the direction of an alternative model in which variations in net worth affect the marginal cost of outside finance, holding constant investment opportunities. We argue, expanding upon the model in section 1.1, that movements in the interest rate differential are good proxies for these shifts in net worth. This approach builds upon the related approach of Zeldes (1988) in testing for liquidity constraints on consumption.

While the discussion in section 1.1 applies to "investment" broadly, we present evidence below for effects of interest differentials (as proxies for internal net worth) on fixed investment using annual time-series data for producers' durable equipment investment in the United States. The specific framework within which we operate is derived under the assumption that risk-neutral firms maximize the present discounted value (V) of profits (Π) from investment, where

$$V_0 = E_0 \sum_{t=1}^{\infty} \beta_t \Pi_t, \tag{12}$$

where β_t is the discount factor at time t. The maximization takes place subject to the following constraints:

1. *Capital Accumulation:* $K_t = (1 - \delta)K_{t-1} + I_t$, where I and K represent investment and the end-of-period capital stock, respectively, and where δ is the (assumed constant) rate of depreciation.

2. *Profits:* Profits are the residual after taxes, payments to variable factors,

investment (and adjustment costs), and debt service. Finance is composed of internal equity and debt.[9]

Let:

N = vector of variable factors of production;
w = vector of variable factor prices;
B = value of net debt outstanding (one-period loans);
i = interest rate on loans;
p^I = effective price of capital goods at time t (incorporating tax considerations);
$F(K_{t-1},N_t)$ = revenue function ($F'_K > 0$, $F''_K < 0$); and
$A(K_{t-1},I_t)$ = costs of adjusting the capital stock.

Then,

$$\text{(13)} \qquad \Pi_t = F(K_{t-1},N_t) - w_t N_t - A(I_t,K_{t-1}) - i_{t-1}B_{t-1} + B_t - B_{t-1} - p_t^I I_t.$$

All prices and values are expressed relative to the general output price deflator (i.e., so that real profits are maximized).

3. *Transversality Condition:* So that firms cannot borrow an infinite amount to distribute, we require that

$$\lim_{T\to\infty} \sum_{t=0}^{T-1} \beta_t B_T = 0, \quad \forall_t.$$

The recent tradition in the q-theory literature is to assume that marginal and average q are equal, and to obtain an estimating equation. Instead of following this route, we choose to eliminate the shadow value of capital from the first-order condition for the choice of the capital stock, and work with the dynamic equation for investment, as in Hubbard and Kashyap (1990). That is, the first-order condition for the choice of the capital stock (from maximizing [12], subject to the constraints mentioned above) is given by

$$\text{(14)} \qquad \beta_{t+1}E_t\{F_{Kt} - A_K(K_t,I_{t+1}) + (1 - \delta)\,[A_I(K_t,I_{t+1}) + p^I{}_{t+1}]\} - A_I(K_{t-1},I_t) - p^I{}_t = 0.$$

To obtain an equation for investment, it is necessary to parameterize the adjustment cost function A. We let[10]

$$\text{(15)} \qquad A(K_{t-1},I_t) = [\alpha_0((I_t / K_{t-1}) - \mu) + (\alpha_1 / 2)((I_t / K_{t-1}) - \mu)^2]K_{t-1},$$

where μ is the average (normal) investment rate. Now,

$$\text{(16)} \qquad A_{It} = \alpha_0 + \alpha_1\,(I_t / K_{t-1} - \mu),$$

and

$$\text{(17)} \qquad A_{Kt} = -(\alpha_1 / 2)(I_{t+1} / K_t)^2 - \mu(\alpha_0 - \alpha_1\mu / 2).$$

Substituting (16) and (17) into (14) yields the Euler equation:

$$\begin{aligned}
&\beta_{t+1}E_tF_{Kt} + \beta_{t+1}E_t\{(\alpha_1 / 2)(I_{t+1} / K_t)^2 + \mu\,(\alpha_0 - \alpha_1\mu / 2)\} \\
(18) \quad &- \alpha_0 - \alpha_1\,(I_t / K_{t-1} - \mu) - p_t^I \\
&+ \beta_{t+1}\,(1 - \delta)E_t\{\alpha_0 + \alpha_1\,(I_{t+1} / K_t - \mu) + p_{t+1}^I\} = 0.
\end{aligned}$$

We assume that expectations are rational and allow for an expectational error η, where $E_t\,(\eta_{t+1}) = 0$ and $E_t\,(\eta_{t+1}^2) = \sigma_\eta^2$. Hence we obtain:

$$\begin{aligned}
&\beta_{t+1}E_tF_{Kt} + \beta_{t+1}E_t\{(\alpha_1 / 2)(I_{t+1} / K_t)^2 + \mu\,(\alpha_0 - \alpha_1\mu / 2)\} \\
(19) \quad &- \alpha_0 - \alpha_1(I_t/K_{t-1} - \mu) - p_t^I \\
&+ \beta_{t+1}\,(1 - \delta)\,E_t\{\alpha_0 + \alpha_1\,(I_{t+1} / K_t - \mu) + p_{t+1}^I\} = \eta_{t+1}.
\end{aligned}$$

The model in (19) is a nonlinear equation in I/K and can be estimated to identify α_1.

We incorporate financial factors by adding a constraint on the use of debt finance by firms. In particular, we assume that the outstanding debt B must be less than a debt ceiling B^*. The ceiling, while possibly unobservable to the econometrician, depends on measures of collateralizable net worth. That is, movements in the value of firms' net worth will affect firms' ability to finance investment, holding constant actual investment opportunities.[11] If we let ω be the Lagrange multiplier associated with the constraint that $B \leqq B^*$, the first order condition for borrowing (from the maximization of [12]) is now

$$(20) \qquad 1 - \beta_{t+1}(1 + i_t) - \omega_t = 0,$$

so that when ω is nonzero, $\beta_{t+1} = (1 - \omega_t)/(1 + i_t)$. We can now rewrite equation (19) as:

$$\begin{aligned}
&\{\alpha_0[\beta_{t+1}(1 - \delta)\,(1 - \omega_t) - 1 + \mu] + \alpha_1\mu[(1 - \mu) / 2]\} \\
&+ \beta_{t+1}[F_{Kt} + (\alpha_1 / 2)(I_{t+1} / K_t)^2 + \alpha_1(1 - \delta)\,(I_{t+1} / K_t) \\
(21) \quad &+ (1 - \delta)p_{t+1}^I] - \alpha_1(I_t / K_{t-1}) - p_t^I \\
&= \eta_{t+1} + \omega_t\beta_{t+1}[F_{Kt} + (\alpha_1 / 2)(I_{t+1} / K_t)^2 \\
&+ \alpha_1(1 - \delta)(I_{t+1} / K_t) + (1 - \delta)p_{t+1}^I].
\end{aligned}$$

During periods in which the constraint is binding, $\omega > 0$, and the error term contains the additional expression in (21).

Two issues arise in the estimation of (21). First, there is an obvious simultaneity problem because of the presence of other endogenous variables along with I/K. This necessitates the use of instrumental variables. The exact set of instruments used is discussed below. Second, comparison of equations (19) and (21) reveals the significance of financial constraints for the model to be estimated. When ω is zero, the standard "perfect capital markets" model is a good approximation. When $\omega > 0$, however, financial constraints affect investment spending. Ideally, we would like to have data on "internal net worth" to specify a relationship between ω and observable variables. We argued in the section 1.1 that changes in the interest rate spreads can serve as proxies for unobserved effects of net worth on investment. Hence, following equation (11), we let

$$\omega_t = \gamma_1 + \gamma_2 \Delta S_{t-1}, \tag{22}$$

where S represents the interest rate spread. Again, in the empirical results reported below, we employ as a proxy the difference between yields on six-month commercial paper and Treasury bills.

Our approach follows the intuition from the previous section. We first estimate the null model corresponding to equation (19) over our sample period. Second, we estimate the altemative model corresponding to (21), with the additional interaction terms incorporating the role of the interest rate spread.[12]

1.2.3 The Data

The data used in estimating the Euler equations for equipment investment are standard macroeconomic time-series that are available from several sources. From the terms in equation (19), the discount factor β is constructed using one of two proxies for the ex ante real rate of interest. First, we define the real rate as the difference between the average market yield on U.S. Treasury securities at a one-year constant maturity and the average expectation of the one-year-ahead change in the consumer price index. Expectations data are taken from the survey on inflation expectations conducted by the Survey Research Center of the University of Michigan.[13] Second, as a risky interest rate altemative, we use the Moody's Baa Bond rate minus the expected inflation proxy suggested in Gordon and Veitch (1986).

We use a series on the average product of capital to proxy for the marginal product of capital. The two variables will be proportional when the technology is constant returns to scale and factors are paid competitively. While the assumption that the ratio of price to marginal cost is unity is questionable, the altemative approach of using separate data for output and cost and estimating a markup is even more difficult at this level of aggregation. The difficulty arises primarily because, when using the National Income and Product Accounts, it is not possible to separate completely the retums to different factors.[14] Thus, we use the sum of pre-tax corporate profits (with capital consumption and inventory valuation adjustment) and net interest as the retum to capital. In particular, the ratio of this sum to the beginning-of-period capital stock is our average product-of-capital measure.

As noted earlier, our investment data pertain to real gross private domestic investment in fixed, nonresidential producers' durable equipment. The corresponding capital-stock series is constructed by a perpetual inventory calculation starting in 1950 using an assumed (annual) rate of depreciation of 0.137 (the estimated rate obtained by Auerbach and Hines 1987). The initial value of the series for the capital stock is taken from the Bureau of Economic Analysis.

The price variable appearing in equation (19) is the tax-corrected price of investment goods (relative to the output price). The price deflators used in constructing this ratio are the implicit price deflator for gross private domestic investment in fixed, nonresidential producers' durable equipment and the implicit GNP deflator.

1.2.4 Evidence for Investment

Before outlining the results, we should stress two features of our estimation procedures. First, since we use interest rate data (nominal interest rates and measures of expected inflation) in constructing the discount factor β, shifts in interest rates are already accounted for, and cannot explain a correlation between the change in the interest rate spread and the investment residuals from equation (19). Second, we estimate using an instrumental variables procedure and exclude the current observed change in the spread from the instrument list. This is important, since using contemporaneous data on the change in the spread would not allow us to distinguish our hypothesis from a competing model in which contemporaneous movements in the spread reflect contemporaneous technology shocks not accounted for in our approach.

We present our results from estimating the structural model for investment in tables 1.1 and 1.2. The data are quarterly, covering the period from 1964 through 1989. First, we estimate the null model in equation (19) for producers' durable equipment. Second, we estimate the alternative model incorporating (21); that is, we allow the multiplier on the credit constraint to depend on a constant and lagged change in the spread.

Results from estimating (19) and (21) by generalized methods of movements are presented in table 1.1. Instruments for the endogenous variables include a constant and four lagged values of each of the following: I/K, $(I/K)^2$, the ratio of profits to capital, the commercial paper–Treasury bill interest rate spread, and the change in the log of the S&P 500 stock index, as well as a single lag of the discount factor and the current and lagged values of the tax-adjusted relative price of equipment investment goods. The two columns shown for each model correspond to the two ex ante real rate proxies used in constructing β—the "riskless" and "risky" alternatives, respectively. Overidentifying restrictions associated with the null model are soundly rejected at the 2 percent and 7 percent levels, respectively.

As noted in the second set of columns in table 1.1, the alternative model—in which the change in the interest rate spread affects the value of the Lagrange multiplier associated with the financial constraint—can be rejected only at the 10 or 11 percent level. The adjustment cost coefficient remains precisely estimated, and the estimate of the (transformed) share of equipment capital does not change much.[15] The coefficient on the (lagged) change in the interest rate spread, which measures the marginal impact on the Lagrange multiplier, is positive and precisely estimated. Taken literally, the implied effect is very large; a 10-basis-point increase in the spread would be equivalent to lowering

Table 1.1 **Euler Equation Estimates for U.S. Equipment Investment (1964–89), Including Interest Rate Spread Effects**

	Coefficient Estimates			
Parameter	Null Model		Alternative Model	
Constant	−1.04	−1.07	−.933	−1.02
	(.160)	(.168)	(.188)	(.167)
Constant (time-varying β)	1.03	1.08	.921	1.04
	(.164)	(.175)	(.191)	(.172)
Quadratic adjustment cost factor (α_1)	4.18	3.21	2.08	1.90
	(.864)	(.949)	(1.19)	(1.15)
Equipment share	.045	.103	.044	.113
	(.015)	(.036)	(.027)	(.046)
γ_1 (lagged change in spread)	—	—	.0054	.004
			(.002)	(.002)
Shift in constant due to time-varying credit-constraint multiplier (lagged change in spread)	—	—	−.0045	−.004
			(.0015)	(.002)
χ^2—Orthogonality test	34.4	29.9	25.5	25.9
(p value)	(.024)	(.072)	(.112)	(.102)

Note: The models are estimated using generalized method of moments. For the "null" and "alternative" models, the two columns refer to measures of β constructed from one-year Treasury and Baa bond rates, respectively. Instrumental variables include a constant and four lagged values each of I/K, $(I/K)^2$, the ratio of profits to capital, the commercial paper–Treasury bill interest rate spread, and the change in the log of the S&P 500 stock index, as well as a single lag of the discount factor and the current and lagged values of the tax-adjusted relative price of equipment investment goods. Heteroscedasticity-consistent standard errors are reported in parentheses.

the (quarterly) discount factor β from an average of about 0.99 to about 0.94, significantly increasing the (implied annual) discount rate. Given that information about future payoff risk is already in the level of the interest rate, such a shift is difficult to explain without information-related capital-market frictions.

We considered the possibility, however, that potential misspecification of the underlying null model could lead to a spurious correlation between the residuals (from [19]) and any forward-looking variable. To explore this case, we tried two other "leading indicator" variables suggested by Stock and Watson (1989), the percentage changes in "housing starts" and "manufacturers' unfilled orders" instead of the change in the spread. Those results are reported in table 1.2 using the "risky" discount factor; results using the risk-free rate in constructing β were virtually identical.

The first column for each variable represents results from estimating the null model in equation (19), adding the leading indicator variable to the instrument list. In both cases, the overidentifying restrictions associated with the model are rejected by the data; the coefficient estimates resemble closely those reported for similar cases in table 1.1. Allowing a separate effect of the lagged percentage change in housing starts or manufacturers' unfilled orders does not change this result. Rejection levels actually increase, and the signs on the coefficients on both variables are counterintuitive from the perspective of an omitted-leading-indicators explanation, although these coefficients are imprecisely estimated.

Finally, we add both the (lagged) change in the interest rate spread and the percentage change in the alternative "leading indicator" variables. Those results are reported in table 1.3 (using the risky rate alternative in constructing β). In both cases, the coefficient on the change in the spread is positive, precisely estimated, and approximately the same size as the estimate in table 1.1. The coefficients on either of the alternative leading indicator measures (housing starts and manufacturers' unfilled orders) are of the wrong sign and are very imprecisely estimated. The factors leading to the acceptance of the overidentifying restrictions for the alternative model are associated only with the interest rate spread variable and not with alternative "leading indicator" measures.

Table 1.2 Euler Equation Estimates for U.S. Equipment Investment (1964–89), Including Alternative "Leading Indicator" Variable Effects

	Coefficient Estimates			
	Null Model		Alternative Model	
Parameter	H	UO	H	UO
Constant	−1.03	−.987	−1.00	−1.02
	(.158)	(.150)	(.163)	(.179)
Constant (time-varying β)	1.02	.978	.990	1.02
	(.163)	(.155)	(.167)	(.187)
Quadratic adjustment cost factor (α_1)	4.10	3.92	4.38	3.51
	(.855)	(.859)	(.913)	(1.01)
Equipment share	.059	.055	.046	.044
	(.020)	(.020)	(.021)	(.063)
γ_2 (lagged percentage change in leading indicator variable)	—	—	.152	.254
			(.130)	(1.34)
Shift in constant due to time-varying credit-constraint multiplier (lagged percentage change in leading indicator)	—	—	−.137	−.388
			(.115)	(1.14)
χ^2—Orthogonality test	35.8	37.0	36.1	49.1
(p value)	(.057)	(.043)	(.030)	(.0008)

Note: The models are estimated using generalized method of moments. In all cases, β is constructed from the Baa bond rate and our measure of expected inflation. Instrumental variables include a constant and four lagged values each of I/K, $(I/K)^2$, the ratio of profits to capital, the percentage change in the "leading indicator" variable, and the change in the log of the S&P 500 stock index, as well as a single lag of the discount factor and the current and lagged values of the tax-adjusted relative price of equipment investment goods. The two leading indicator variables are denoted by "H" (housing starts) and "UO" (manufacturers' unfilled orders). Heteroscedasticity-consistent standard errors are reported in parentheses.

Table 1.3 Euler Equation Estimates for U.S. Equipment Investment (1964–89), Including Interest Rate Spread and "Leading Indicator" Effects

	Coefficient Estimates for Alternative Model	
Parameter	H	UO
Constant	−1.01	−.974
	(.182)	(.183)
Constant (time-varying β)	1.00	.963
	(.19)	(.193)
Quadratic adjustment cost factor (α_1)	2.77	2.34
	(1.24)	(1.13)
Equipment share	.055	.034
	(.026)	(.050)
γ_2 (lagged change in spread)	.0034	.0048
	(.0014)	(.0018)
Shift in constant due to time-varying credit-constraint multiplier (lagged change in spread)	−.0029	−.0038
	(.0011)	(.0013)
γ_2 (lagged percentage change in leading indicator variable)	.218	.043
	(.190)	(1.13)
Shift constant due to time-varying credit-constraint multiplier (lagged percentage change in leading indicator variable)	−.182	−.056
	(.154)	(.911)
χ^2—Orthogonality test	27.2	29.4
(p value)	(.129)	(.080)

Note: The models are estimated using generalized method of moments. In both cases, β is constructed from the Baa bond rate and our measure of expected inflation. Instrumental variables include a constant and four lagged values each of I/K, $(I/K)^2$, the ratio of profits to capital, the percentage change in the "leading indicator" variable, and the change in the log of the S&P 500 stock index, as well as a single lag of the discount factor and the current and lagged values of the tax-adjusted relative price of equipment investment goods. The two leading indicator variables are denoted by "H" (housing starts) and "UO" (manufacturers' unfilled orders). Heteroscedasticity-consistent standard errors are reported in parentheses.

1.3 Conclusion and Implications

In this paper, we have presented a simple framework that incorporates a role for "interest spreads" in models of investment fluctuations. Our empirical work suggests that links between changes in interest rate spreads and investment are consistent with models emphasizing (i) how movements in agency costs of external finance can amplify investment fluctuations and, relatedly, (ii) how changes in the interest spread may signal movements in these agency costs. Because we worked with aggregate time-series data, the usual caveats apply. The results suggest, however, that fluctuations in agency costs (induced in large part by changes in firms' net worth) significantly affect the timing of investment. In addition, the findings shed light on the significance of widening interest rate spreads for predicting output declines in postwar time-series (Stock and Watson 1989), as well as during earlier periods of financial crises (Bemanke 1983; Calomiris and Hubbard 1989).

That the predictive power of short-term interest differentials likely reflects more than simple technological risk has also been argued recently by Bernanke (1990). Bemanke finds further that the commercial paper–Treasury bill spread measures the stance of monetary policy; specifically, he notes that the spread is related to traditional indicators of monetary policy (e.g., the Federal funds rate). An explanation, consistent with our analysis, is that contractionary monetary policy shrinks commercial bank lending, forcing marginal (high-agency-cost) firms to raise funds through the commercial paper market (e.g., see Kashyap, Stein, and Wilcox 1991). As well, in part, an increase in the riskless rate of interest (resulting from a tightening of monetary policy) lowers the value of firms' collateralizable net worth, increasing agency costs of extemal finance. That is, the effect on investment and output of a change in the riskless rate associated with contractionary monetary policy is magnified through the information-related channel we have stressed. While more careful research on these transmission mechanisms is needed, we believe that our approach and that taken by Bemanke are complementary.

A logical extension of our approach would be to study panel data and exploit predictions about cross-sectional differences in firm behavior. For example, as Calomiris and Hubbard (1990) note, the "perfect markets" neoclassical model of investment should work for firms unlikely to face financial constraints. Movements in the interest spread should be relevant to the investment behavior of those firms likely to be constrained. Presuming it is possible to divide the sample appropriately, it would be interesting to investigate this hypothesis with panel data.[16]

Notes

1. The associations with financial crisis of widening interest rate differentials among securities of different quality was stressed early on by Sprague (1910), who studied financial panics during the National Banking Period in the United States. During panic episodes, rates changed to risky borrowers rose dramatically relative to rates on safe securities. Historical accounts generally link financial crises to subsequent fluctuations (see, e.g., Bagehot 1873; Sprague 1910; and Mitchell 1913), though the precise channels are not always clear. Mishkin (in this volume) has documented the historical association of a widening differential between risky and safe rates and subsequent recessions.

Calomiris and Hubbard (1989) use models based on links between interest differentials and subsequent output fluctuations under asymmetric information in the period just prior to the founding of the Federal Reserve system. They construct a set of instruments to approximate the difference between the low-risk cost of capital under symmetric information and the actual cost of borrowed funds. Using a structural VAR model, they find that shocks to risk differentials had a positive effect on business failures and negative effects on bank loans and output. This focus on interest differentials parallels the seminal study by Bernanke (1983) of financial factors in the propagation mechanism of the economic downturn of the early 1930s. Focusing on the breakdown of the banking system, Bernanke notes that the pool of borrowers in loan markets (some of which would have been serviced by banks) was of lower quality in the 1930s, raising the differential between risky and safe interest rates. The differential between Baa corporate bond yields and the yields on U.S. government bonds was a strong explainer of current and future output growth.

2. A possible exception to this argument is that taxes and regulatory frictions may lead to shifts in safe rates and thereby widen the spread (for a discussion, see Cook and Lawler 1983).

3. See, for example, Keeton (1979), Stiglitz and Weiss (1981), Greenwald, Stiglitz, and Weiss (1984), Myers and Majluf (1984), Williamson (1987), Bernanke and Gertler (1990), Calomiris and Hubbard (1990), and the survey in Gertler (1988). Countercyclical movements in agency costs may be explained by procyclical movements in borrowers' net worth. See Hoshi, Kashyap, and Scharfstein (1991b) for evidence on the real costs (in terms of reduced investment and sales) of financial distress.

4. The use of zero in the bad-state outcome and the two-state description of the production realization are not crucial for the qualitative results that follow.

5. Strictly speaking, we are treating W_0 as "internal funds," so that $I - W_0$ is the amount borrowed. The real equilibrium is unaffected if W_0 is instead "collateralizable resources."

6. See also Jensen and Meckling (1976), Jensen (1986), and Gertler and Hubbard (1991).

7. Strictly speaking, in the example we present, the capital stock K contains as much information about internal net worth as does S (see eq. [9]). This is only because we have treated W_0 as "internal funds" to minimize algebra. If W_0 instead represented "collateralizable resources," S would reflect some information about W_0 not contained in K.

8. In micro-data studies in this area, "q" has been used as a reduced-form control for investment opportunities, so that some included measure of inside finance (arguably) does not substitute for expected future profits (see Fazzari, Hubbard, and Petersen 1988; and Hoshi, Kashyap, and Scharfstein 1991a).

9. We do not mean to suggest that equity finance is irrelevant at the margin in actual data. However, the inclusion of equity finance adds little to the basic setup for testing the effects of internal net worth on investment spending.

10. This formulation assumes convex adjustment costs. In addition, those costs are decreasing in the size of the capital stock.

11. This specification of a "finance constraint" is not particularly restrictive. If firms faced an upward-sloping debt-supply schedule, so that $i_t = i(B_{t-1} - B^*)$, where $i' > 0$, then $\beta_{t+1} = (1 - i'_t)/(1 + i_t)$.

12. Here we are building on recent Euler equation tests of effects of financial constraints on investment (see, e.g., Hubbard and Kashyap 1990; Whited 1990; Gilchrist 1989; and Himmelberg 1989). For an earlier treatment, see Bernstein and Nadiri (1986).

13. Using the (one-year-ahead) ex ante real rate calculated by Huizinga and Mishkin (1986) produced qualitatively similar results.

14. For example, proprietors' income relative to capital has declined markedly over the last forty years. If one excludes proprietors' income from variable costs, then the difference between output and cost (relative to capital) likewise has a downward trend.

Unfortunately, it is not possible to identify the portion of proprietors' income that represents labor input. Therefore, it is not possible to make a simple adjustment to produce a reliable series on variable costs.

15. The estimate is that of the share of equipment capital in total capital.

16. Work by Hubbard, Kashyap, and Whited (1991) directly pursues this approach. Other recent empirical studies have emphasized shifts in the distribution of net worth across firms (see Bernanke and Campbell 1988; Bernanke, Campbell, and Whited 1990; and Warshawsky, in this volume).

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