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Internal Net Worth and the Investment Process: An Application to U.S. Agriculture

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INTERNAL NET WORTH AND THE INVESTMENT PROCESS:
AN APPLICATION TO U.S. AGRICULTURE

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ABSTRACT

Recent models of firm investment decisions stressing informational imperfections in capital markets provide a foundation for interpreting evidence that movements in internal finance can predict investment spending, even after controlling for measures of firms' investment opportunities. While such evidence is suggestive, it is often open to other interpretations.

We examine these models using data on equipment investment in the U.S. agricultural sector. This sector is particularly interesting because it has experienced large fluctuations in net worth and the profitability of investment, and reasonable measures of net worth can be constructed. Our findings provide support for a class of "internal funds" models of investment under asymmetric information.

I. Introduction

A. Background

That financing and investment decisions are not in general independent has been recognized in applied discussions of the investment process for some time (see for example Eckstein and Sinai, 1986). Indeed, the potential role of internal finance in the investment process, holding constant investment opportunities, was stressed in early empirical investment models (notably in Meyer and Kuh, 1957). However, dissatisfaction with the theoretical underpinnings of these models led the profession to search for more completely specified optimizing models. By the late 1960s, the *neoclassical*[1] model (and its adaptations) had become the accepted framework for analyzing investment. Subsequently, the *q* theory[2] has also served as a benchmark for discussing investment. In these models, internal and external funds are generally treated symmetrically, as if they are perfect substitutes, except possibly for tax considerations. While both of these approaches are elegant in their derivation, they have enjoyed only limited empirical success. In fact, perhaps the most forceful criticism of these models has been that they are often outperformed by simple *ad hoc* accelerator models that assert a central role for internal funds.[3]

Recent research on the effects of asymmetric information in capital markets has made it possible to reinterpret the accelerator mechanism.[4] This reinterpretation is possible because, in many models in which asymmetric information is important, costs of external finance vary inversely with the level of "inside finance." Thus there is a direct channel for internal funds to affect investment: When borrowers' net worth improves, lenders becoming more willing to lend, and additional investment can be financed. A second implication of these models is that at sufficiently high levels of net worth, incentive problems should be less important. This paper shows that for U.S. agricultural equipment investment, this approach does appear to be relevant, and these implications are borne out by the data.

Recent empirical studies have tried to test directly the predictions of models of capital market frictions arising from asymmetric information by exploiting cross-sectional heterogeneity in micro data. That is, the strategy has been to isolate *a priori* groups of firms as plausibly "constrained," and test whether their investment behavior rejects a symmetric-information null model, while the investment behavior of the complement does not.[5] Fazzari, Hubbard, and Petersen (1988) and Hoshi, Kashyap, and Scharfstein (1991) have performed such tests for U.S. and Japanese firms, respectively, using the q-theory model of investment.[6]

These studies attempt to control for investment opportunities by incorporating marginal q, the increase in firm value from an increment to the capital stock. By specifying a functional form for costs of adjustment, one can solve for an investment function, relating the rate of investment to q (see for example Hayashi, 1982; and Summers, 1981). A stumbling block in this approach is that the empirical proxy for marginal q, average q, may be a poor proxy, because of imperfect competition in the product market, non-constant returns to scale in production, or capital-market frictions.[7]

With respect to capital-market frictions, the principal problems with this strategy are two. First, the q model is a questionable framework for analysis under the asymmetric-information alternative, as expectations reflected in prices quoted on centralized securities markets will not in general reflect insiders' valuations of future investment projects. Both Fazzari, Hubbard, and Petersen and Hoshi, Kashyap, and Scharfstein include q as a reduced-form control for investment opportunities (so that an internal funds variable does not proxy for expected future profits). However, the possibility remains that q is a poor proxy for investment opportunities. There is also a measurement problem: Cash flow is an imperfect proxy for the insiders' net worth variable stressed by the theories.

Second, augmenting the *q*-theory approach may be instructive in highlighting the importance of cross-sectional heterogeneity, but such revisions do not provide a test of an alternative structural model of internal finance and investment. Instead, the results reject a null hypothesis of perfect capital markets for some firms which might plausibly be credit constrained. Recent studies by Bond and Meghir (1990), Whited (1991), Gilchrist (1990), Hubbard, Kashyap, and Whited (1991), and Himmelberg (1990) make use of an Euler equation approach to testing the cross-sectional heterogeneity stressed by Fazzari, Hubbard, and Petersen (1988).

We depart from the *q* approach, and instead make use of the firm's Euler equation to model the investment decision (see for example Abel, 1980). Our Euler equation incorporates the possibility that borrowing constraints may be important: In particular, when internal net worth is "high," the usual Euler equation should hold across adjacent periods. Alternatively, with a significant decline in net worth, investment will also depend on collateralizable wealth, holding constant investment opportunities. This approach is in the spirit of the *q*-theory tests we described previously, but corrects two deficiencies. By not relying on the "investment function" representation (i.e., that using *q* explicitly to control for investment opportunities), we avoid problems of measuring marginal *q* which can complicate the interpretation of other (i.e., "internal funds") regressors. Second, by allowing the effect of net worth on investment to vary systematically, we are able to model directly its role in the investment process, so that links between internal finance and investment are less subject to alternative interpretations.

B. Agriculture as a Case Study

We selected the agricultural industry as most appropriate for our approach for a number of reasons. First, internal worth has traditionally been identified as being an important determinant of the availability of agricultural finance, particularly during agricultural credit crises. For instance, Tostlebe (1957) notes the historical importance of internal finance in agricultural investment finance, especially in periods of contraction. Stock (1984) concludes that the problem of heavy debt-service burdens in periods of low farm prices and the associated risks of foreclosure figured significantly in movements of agrarian unrest prior to World War I. Alston (1983), writing about the interwar period in the U.S., emphasizes the interaction of low collateral values and restrictions on credit in accounting for the very high farm foreclosure rates during the period. Calomiris, Hubbard, and Stock (1986) discuss the role of financial factors in amplifying the farm debt crisis of the 1980s.

In addition, the agricultural sector is a natural one in which to test information-based models of the effects of internal net worth on investment in particular. First, most models are cast in terms of an entrepreneur or small number of insiders negotiating with outsiders for financing. While this is an accurate characterization of the financing of agricultural investment, it is a less appropriate description for most large firms for which data are available.[8] Moreover, investment in agriculture is "information intensive"; monitoring of projects (and treatment of the land) and returns is difficult.[9]

A second reason for investigating agricultural investment is that it generally requires considerable upfront financing. There is a lengthy period between the purchase of input and the sale of agricultural output, and short-run variable costs are a small portion of total costs relative to the typical manufacturing industry. The volatility of the value of net worth (as measured by farm land values) and of profitability is high; we return to this point later.

A third advantage of studying this sector is that movements of the central variable of interest, insiders' net worth, can be identified. Both proprietors' equity and the value of farm land, the two most likely forms of collateral, are observable. In contrast, for most other types of firms, insiders' net worth is difficult to quantify. For instance, a corporation's internal funds are not equivalent to insiders' stakes, although this proxy has been employed by almost all past researchers, including ourselves, in testing these theories. A problem in most other applications is that measuring future collateralizable net worth is difficult.

A related point is that our data for the U.S. agricultural sector encompass episodes in which "debt deflations" have reduced farmers' net worth. This is important: The most appropriate experiment here is a change in internal net worth unaccompanied by a change in investment opportunities. Most existing studies have considered movements in proxies for inside finance (e.g., cash flow) which may be correlated with shifts in investment opportunities. This problem is compounded when controls for investment opportunities (e.g., Tobin's *q*) are imperfect. Some of our tests shed light on the effects on investment of "debt deflation" episodes described by Fisher (1933), Kindleberger (1973), and others. Such episodes occurred for agricultural prices in the early 1920s, 1930s, and again in 1980s, and each was exacerbated by coincident declines in land values.

The paper is organized as follows. In section II, we derive an investment model based on the Euler equation corresponding to farmers' intertemporal optimization problem for capital accumulation. In the presence of finance constraints during periods of low net worth, the Euler equation contains additional terms involving measures of internal net worth. We outline a set of tests designed to exploit predictions of this framework for differences in the appropriate specification of investment models in "falling net worth" and "rising net worth" periods. Our empirical tests are reported in section III, using a data set we constructed for the U.S. agricultural sector over the period from 1914 to 1987. The results are consistent with an important role of internal net worth in agricultural investment decisions in periods during which net worth declined significantly. In other periods, the standard neoclassical specification is not rejected by the data. Section IV concludes.

II. Modeling the Investment Decision

A. Extending the Neoclassical Specification

Farmers maximize the present discounted value (V) of net cash flows (Π) from investment, where

$$V_0 = E_0 \sum_{t=1}^{\infty} [\prod_{j=0}^{t-1} \beta_j] \Pi_t, \tag{1}$$

and β_t is the discount factor at time t (i.e., the inverse of one plus the appropriate discount rate).[10] The maximization takes place subject to the following constraints:

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 rate of depreciation (assumed constant).

Net Cash Flow: Net cash flow Π is the residual after taxes, payments to variable factors, investment (and adjustment costs), and debt service. Finance is composed of internal equity and debt; no external equity is permitted.[11]

Let:

K = stock of capital

I = Gross investment in capital

N = vector of variable factors of production

w = vector of variable factor prices

L = land

ℓ = rental rate on land

B = value of net debt outstanding (one-period loans)

i = interest rate on loans

p = agricultural price

p^I = effective price of capital goods at time t (incorporating tax considerations)

$F(K_{t-1}, L_{t-1}, N_t)$ = revenue function ($F'_K > 0$, $F''_K < 0$)

$A(K_{t-1}, I_t)$ = costs of adjusting the capital stock.

Then,

$$\Pi_t = p_t F(K_{t-1}, L_{t-1}, N_t) - w_t N_t - \ell_t L_{t-1} - A(I_t, K_{t-1}) - i_{t-1} B_{t-1} + B_t - B_{t-1} - p_t^I I_t \quad . \tag{2}$$

To restrict internal equity contributions to retained earnings, $\Pi \geq 0$. Also, all prices and values are expressed relative to the general price deflator.[12]

<u>Transversality Condition</u>: So that a farming enterprise cannot borrow an infinite amount to distribute, we require that

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

Let λ and φ represent the multipliers associated with the capital accumulation constraint and the non-negative dividend constraint respectively. The first-order conditions for the revised optimization problem with respect to I, K, and B are given by[13]

$$(1+\varphi_t)(-A_I(K_{t-1}, I_t) - p_t^I) + \lambda_t = 0, \tag{3}$$

$$E_t((1+\varphi_{t+1})\beta_t[(p_{t+1}F_{Kt}) - A_K(K_t, I_{t+1})]) - \lambda_t + E_t(\beta_t(1-\delta)\lambda_{t+1}) = 0, \tag{4}$$

and

$$(1+\varphi_t) - E_t((1+\varphi_{t+1})\beta_t(1+i_t)) = 0. \tag{5}$$

It is convenient to define $\tilde{\beta}_t = 1/(1+i_t)$.

To obtain an equation for investment, it is necessary to parameterize the adjustment cost function A. We follow the approach taken in the *q*-theory literature, and let[14]

$$A(K_{t-1}, I_t) = [\alpha_0((I_t/K_{t-1}) - \mu) + (\alpha_1/2)((I_t/K_{t-1}) - \mu)^2]K_{t-1}, \tag{6}$$

where μ is the average (normal) investment rate.[15] Now,

$$A_{It} = \alpha_0 + \alpha_1(I_t/K_{t-1} - \mu), \text{ and} \tag{7}$$

$$A_{Kt} = -(\alpha_1/2)(I_{t+1}/K_t)^2 - \mu(\alpha_0 - \alpha_1\mu/2). \tag{8}$$

The recent tradition in this literature is to use equation (7) in conjunction with equation (3) and an assumption about the equality of marginal and average *q*, to obtain an estimating equation. Instead of following this route, we eliminate the shadow value of capital from the equation and work with the dynamic equation for investment. Thus, substituting for λ_t and λ_{t+1} using equations (3) and (4) yields

$$E_t(\beta_t\{p_{t+1}F_{Kt} - A_K(K_t, I_{t+1}) + (1-\delta)[A_I(K_t, I_{t+1}) + p^I_{t+1}]\}) \tag{9}$$
$$- A_I(K_{t-1}, I_t) - p^I_t = 0.$$

Substituting (7) and (8) into (9) yields

$$E_t(\beta_t\{\ p_{t+1}F_{Kt} + [(\alpha_1/2)(I_{t+1}/K_t)^2 + \mu(\alpha_0 - \alpha_1\mu/2)] \tag{10}$$
$$+ (1-\delta)E_t[\alpha_0 + \alpha_1(I_{t+1}/K_t - \mu) + p^I_{t+1}]\})$$
$$- \alpha_0 - \alpha_1(I_t/K_{t-1} - \mu) - p^I_t = 0.$$

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

$$\beta_t\{\ p_{t+1}F_{Kt} + [(\alpha_1/2)(I_{t+1}/K_t)^2 + \mu(\alpha_0 - \alpha_1\mu/2)] \tag{11}$$
$$+ (1-\delta)[\alpha_0 + \alpha_1(I_{t+1}/K_t - \mu) + p^I_{t+1}]\}$$
$$- \alpha_0 - \alpha_1(I_t/K_{t-1} - \mu) - p^I_t = \eta_{t+1}.$$

The model in (11) is a nonlinear equation in I/K, which can be estimated to identify α_1.

We incorporate financial factors by adding a constraint on the use of external finance by farmers. In particular, we assume that the outstanding debt, B, must be less than an 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 farmers' net worth will affect farmers' ability to finance investment, holding constant actual investment opportunities. If we let ω be the Lagrange multiplier associated with the constraint that $B \leq B^*$, we can rewrite the first-order condition in (5) as

$$(1+\varphi_t) - E_t\{\beta_t(1+\varphi_{t+1})(1+i_t)\} - \omega_t = 0. \qquad (5')$$

It is convenient to normalize ω_t relative to $(1 + \varphi_t)$ and denote the resulting ratio by $\tilde{\omega}_t$.[16] Thus when ω_t is non-zero, $\beta_t = (1-\tilde{\omega}_t)[(1+\varphi_t)/(1+\varphi_{t+1})]/(1+i_t)$. We can now rewrite equation (11) as:

$$\tilde{\beta}_t(1 - \tilde{\omega}_t)\{\ p_{t+1}F_{Kt} + [(\alpha_1/2)(I_{t+1}/K_t)^2+\mu(\alpha_0-\alpha_1\mu/2)] \qquad (12)$$

$$+ (1-\delta)[\alpha_0 + \alpha_1(I_{t+1}/K_t - \mu) + p_{t+1}^{I}]\ \}$$

$$- \alpha_0 - \alpha_1(I_t/K_{t-1}-\mu) - p_t^{I} = \eta_{t+1}\ ,$$

or

$$\tilde{\beta}_t\{\ p_{t+1}F_{Kt} + [(\alpha_1/2)(I_{t+1}/K_t)^2+\mu(\alpha_0-\alpha_1\mu/2)] \qquad (12')$$

$$+ (1-\delta)[\alpha_0 + \alpha_1(I_{t+1}/K_t - \mu) + p_{t+1}^{I}]\ \}$$

$$- \alpha_0 - \alpha_1(I_t/K_{t-1}-\mu) - p_t^{I} =$$

$$\eta_{t+1} + \tilde{\beta}_t\tilde{\omega}_t\{\ p_{t-1}F_{Kt} + [(\alpha_1/2)(I_{t+1}/K_t)^2+\mu(\alpha_0-\alpha_1\mu/2)]$$

$$+ (1-\delta)[\alpha_0 + \alpha_1(I_{t+1}/K_t - \mu) + p_{t+1}^{I}]\ \}\ .$$

During periods in which collateralizable net worth is low and the credit constraint is binding, $\omega > 0$, and the error term contains the additional expression in (12').

This approach in general underestimates the importance of financial constraints on the investment process. That is, merely satisfying the Euler equation between adjacent periods does not mean that investment corresponds to that predicted by the null "perfect capital markets" model. There is in principle a set of financial constraints for all future periods. Hence, the Euler equation for investment does not hold for current adjacent periods if, conditional on all future constraints, the contemporaneous constraint is binding. It will nonetheless be the case that, even if the current constraint is not binding, farmers may accumulate financial resources against the possibility of binding future constraints.[17] Our intent is not to simulate long-run under-investment because of "precautionary saving" by firms, but rather to study the effects of shocks to net worth on the timing of investment.[18]

B. Problems for Econometric Estimation

Three issues arise in the estimation of (12′). First, because the model is nonlinear in I/K (the dependent variable in the linear regression model in the *q* framework), estimation by nonlinear least squares is required. Second, there is an obvious simultaneity problem because of the presence of the expected marginal product of capital F_K in the model. The instrumental variables used are reported in the tables outlining our estimation results in Section IIIC. Generally, we used current and/or once-lagged values of key prices: the lagged value of the *ex ante* real interest rate (described in Section IIIA), and current and lagged values of the log of the relative price of land, and the tax-corrected relative price of equipment investment goods. Additional instrumental variables include: (i) a single lag of I/K, $(I/K)^2$, and the ratio of farm profits to capital; (ii) the change in real agricultural exports scaled by capital (as a demand shifter); and (iii) proxies for shifts in farmers' net worth (the change in the ratio of farmers' equity to assets and the change in the rate of real capital gains on debt); and (iv) the change in real lending by the Farmers Home Administration normalized by K, and the change in real government payments to farmers (normalized by K). Some of the instruments were first differenced to induce the stationarity required in the use of generalized method of moments estimation.

Land prices are an important instrumental variable to permit evaluation of competing hypotheses. Movements in land prices (in response to shifts in current and expected future agricultural prices) affect not only the value of land as a part of farmers' net worth, but also the expected profitability of agricultural investment. The land price variable allows for the role of expectations of movements in commodity prices. Hence, when we examine the effects of movements in internal net worth on capital spending, we are holding constant the impact of the associated price effects of those movements on investment opportunities.

Finally, the estimation strategy must reflect the fact that the appropriate model depends on whether the financing constraint is binding. We consider three approaches here. After estimating the basic model without credit constraints (i.e., equation (11)), we estimate (12) over a restricted sample including only periods in which, *a priori*, $\omega = 0$. Second, we parameterize ω as a function of an observable proxy for internal net worth, including interaction terms in (11) where appropriate; the estimated coefficients on those interaction terms should be zero under the symmetric-information null hypothesis. Finally, we investigate an implication of some models of the role of internal net worth in the investment decision that holding constant investment opportunities, net worth effects on investment are more pronounced in "bust" periods than in "boom" periods. We discuss these approaches in more detail in section III, after reviewing sources of data for the variables in the model.

III. Data and Estimation

A. Construction and Data Sources

Before presenting our econometric evidence, we describe briefly the data we used in the estimation. Details of the data construction are contained in the Appendix; we summarize the principal points below. Proceeding term by term through equation (11), the capital stock series is calculated using the perpetual inventory method. The geometric depreciation rate used in the calculation is 0.12, which is consistent with estimates for tractors and agricultural machinery in Hulten and Wykoff (1981).[19]

The investment series that we used in forming the capital stock is the series on agricultural equipment provided by the Bureau of Economic Analysis of the U.S. Commerce Department. Equipment capital is an important factor of production that has traditionally accounted for much of the investment in the agricultural sector.[20] In addition, a long consistent time series is available for this type of investment, and not for investment in structures.[21] Since the data are available back to 1910, several important pre-war agricultural credit crises are included in the samples.

The components of equipment investment consist of tractors, agricultural machinery except tractors, metal working machinery, automobiles, trucks, buses and truck trailers and other equipment. However, tractors, agricultural machinery, and trucks, buses, and truck trailers are the dominant components of the series, accounting for over 80 percent of the investment in most years.

In the empirical tests discussed in section III C, we will estimate versions of equations (11) and (12) with a constant discount factor $\tilde{\beta}$ or a time-varying discount factor. In the former case, the discount factor is a parameter to be estimated, and the (constant) *ex ante* real interest rate can be inferred from the estimate of $\tilde{\beta}$. In the latter case, we must construct a series for $\tilde{\beta}$ (i.e., based on a constructed series for the *ex ante* real interest rate). The nominal interest rate for farm loans is described in the Appendix. We construct a time-series for the expected inflation rate in the GNP deflator using the procedure suggested by 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 Cobb-Douglas and factors are paid competitively.

Our approximation to this average product is gross income less payments to variable factors. This measure also includes returns to land, of course. If output is Cobb-Douglas in capital, "labor" (variable factors), and land, the coefficient we estimate can be transformed to an estimate of the capital share.[22]

The last variable in the equation, the relative price of investment goods, is multiplied by a tax correction factor that recognizes the benefits of the investment tax credit and the tax shields arising from depreciation expenses. None of our subsequent results is noticeably affected by whether or not we make the tax adjustment.

In the Appendix, we describe our sources for the variables we use as instruments or as proxies for creditworthiness. These variables include measures of land prices, equity and asset values, agricultural exports, interest rates, and government subsidies.

B. Summary Statistics: Investment and Net Worth

Figure 1 plots the ratio of equipment investment to the stock of equipment (at the beginning of the year). The figure demonstrates that agricultural investment was quite volatile during our sample period. Major fluctuations have taken place around both World Wars, during the Depression, and during the 1980s. The first column in Table 1 shows that despite these large fluctuations the mean and variance of the investment rate are quite similar during the pre-war and post-war periods. In each case, the average rate is between 14 and 15 percent and the standard deviation is approximately 5 percent.

The next two figures illustrate proxies for of net worth. Figure 2 shows the evolution of the price of land (relative to the GNP deflator). The top portion of this figure shows that the relative price of land has moved over a wide range during the past seventy years, including a change of more than 60 percent over the past decade. The bottom portion of the figure highlights this volatility by graphing the annual percentage change in the relative price.

Figure 3 shows movements in the ratio of farm equity to farm capital (at the beginning of the year). As with the land price series, the large fluctuations are quite common; over the last ten years of the sample, the ratio declined by over 30 percent before partially recovering in 1986 and 1987.

Movements in the value of net worth can be used to identify periods in which farmers' creditworthiness is likely to be particularly high or low. The series suggest two episodes where net worth declined significantly in the period prior to World War II. First, all measures indicate large declines following the 1920-21 deflation. A second major collapse occurred at the onset of the Depression, between 1930 and 1933, although the level of net worth remained low for some time thereafter. Standard accounts of this period, for instance Tostlebe (1957), corroborate the view that these two episodes were quite severe. In our empirical work we will consider the suggestion by Kindleberger (1973) and others that the entire 1921-33 period should be treated as a single regime where farmers' net worth was unusually low.

Following World War II, the situation was much better. As discussed by Calomiris, Hubbard, and Stock (1986), the period between 1955 and 1979 was one without any major declines in agricultural commodity prices or farmers' net worth. Indeed, the commodity and land price boom of the seventies suggest that creditworthiness was especially high over the last few years of this period. However, agriculture was particularly hard hit during the general macroeconomic decline in the early 1980s. As the two figures suggest, the 1981-86 period was another episode where insiders' stakes were likely to have been very low. On balance, it appears that the 1921-33 and 1981-86 periods were "busts" while the 1955-79 period was a "boom" period.

These impressions are confirmed by the lower two rows of Table 1. The average annual decline in the relative price of land over the low-net-worth years was 5.13 percent; in terms of the equity-to-assets ratio, the difference was also evident, particularly in terms of volatility. These years also stand out in the agricultural equipment investment data. The gross investment rate averaged only 11 percent per year during these episodes, so that net investment would typically have been negative.

A striking contrast emerges when these years are compared to the period between the Korean War and the second oil shock. As reported in the table, the average increase in the two measures of farmers' net worth over these years was 3.31 and 0.37 percent, respectively. Notice also that the volatility of both measures is considerably lower in this period. Investment between the middle 1950s and late 1970s was also quite steady, reinforcing the view that this was a healthy period for U.S. agriculture.

C. Estimation

We pursue several tests with a common underlying strategy. Namely, if the standard (null) model which does not include a role for financial factors is correct, then the overidentifying restrictions associated with the model should not be rejected by the data. Conversely, if the alternative model is correct, so that ω is nonzero on average, then the null model should fail the test of overidentifying restrictions. Furthermore, in cases for which the restrictions implied by the null model can be rejected, our alternative model suggests modifications which should help overturn the rejections.

As a starting point we estimate equation (11), the Euler equation under perfect capital markets, for the period between 1914 and 1987, the longest period for which consistent data series are available. In all of what follows we omit the period surrounding World War II (1940-1947). There are several reasons for the omission. First, two factors changed incentives facing farmers: (i) price controls for agricultural products that likely disrupted production incentives; and (ii) changes in marketing agreements over this period. Second, there were quantitative restrictions on investment goods during the period (see Gordon and Veitch, 1986).

As mentioned in the previous section, the number of parameters to be estimated depends upon whether we treat the discount factor as constant or time-varying. There are logical arguments for both approaches. On the one hand, a reasonable and often-made assumption is that the *ex ante* real interest rate is constant. This assumption also allows us to sidestep difficult issues involved in constructing a real interest rate series, issues compounded in the alternative model in which asymmetric information is important. In this first strategy, the discount factor is a parameter to be estimated. On the other hand, the assumption of a constant discount factor necessarily means that any shifts in *ex ante* real interest rates will induce model misspecification. Thus, despite the difficulties in constructing a real interest rate series, there are reasonable doubts about any results which cannot be confirmed when data are used in constructing the discount factor. Rather than adopt a single strategy, we pursue both approaches, although we will emphasize the results with a time-varying discount factor, since *a priori* this approach leans most favorably toward accepting the null model.

In addition to the discount factor, there are other parameters which must be estimated: (a transformation of) the relative share of equipment capital in output, the adjustment-cost coefficient (α_1) and the constant term. In specifications in which the discount factor is time-varying, there is an additional coefficient attached to the discount factor which must be estimated. Both this parameter and the constant term are nonlinear combinations of parameters which cannot be identified.[23]

The first two columns of Table 2 present estimates for equation (11). In the first column, we report the estimates under the assumption that the discount factor $\bar{\beta}$ is constant. In this case, our implicit estimate of the real interest rate faced by farmers is approximately 1 percent. The implied share parameter is around 0.04. Assuming that the production function is Cobb-Douglas (see footnote 21), this estimate is in line with estimates reported in Tostlebe (1957), Griliches (1963), and Mundlak and Hellinghausen (1982).

The adjustment cost parameter is estimated to be slightly larger than unity (about 1.05). This estimate is very encouraging since the typical *q* model typically leads to estimates that are implausibly large. One way to assess the plausibility of this estimate is to use it to infer the equilibrium value of *q* that is consistent with this sized adjustment parameter. Since the rate of depreciation of equipment capital is assumed to be 12 percent, a quadratic adjustment parameter of 1.05 implies an equilibrium value of *q* of 1.13.[24]

In the second column, we report the estimates under the assumption that the discount factor is time-varying (that is, it varies with the constructed real interest rate series). The estimates for the two common parameters, α_1 and the share, are quite similar to those found with specification in which β is constant. However, under both specifications, the model's overidentifying restrictions are rejected at about the 1 percent significance level. The remainder of the empirical work investigates whether this rejection is attributable to financial factors.

Our first set of tests examines whether shifts in net worth are responsible for these rejections. To explore the link between shifts in net worth and investment, we re-estimated equation (11), but excluded the net worth variable from the set of instrumental variables. The result from this experiment are shown in the next two columns of Table 2. In both cases, the overidentifying restrictions are no longer rejected. That the model is not rejected when we omit the net worth proxy is evidence that shifts in the real interest rate *per se* are not responsible for the model's rejection, even though real rates may have been high during periods in which internal net worth was low. Repeating this experiment, but dropping instead the land price instrument or other instruments proxying for shifts in demand or income (the agricultural exports, government payments, or Farmers Home Administration lending variables) did not reverse the rejection of the overidentifying restrictions. Thus, the residuals from the null model are significantly predictable on the basis of past movements in *net worth* while there is little predictability contained in current or past movements in land prices per se. We view this evidence as highly suggestive that fluctuations in farmers' net worth play an important role in the investment process, even after controlling for shifts in investment opportunities.

Turning to the details of the estimates which exclude the net worth instrument, the results for the time-varying discount factor model are more plausible than the estimates from the model with a constant discount factor. One difference between the two sets of estimates is that the time-varying-discount factor specification produces a slightly lower estimate for the adjustment-cost parameter. A second difference is that the constant discount-factor model implies a real interest rate which is negative, although not statistically significantly different from zero. For simplicity of exposition and given the importance of allowing for shifting interest rates, we focus the remainder of our discussion on the specification with a time-varying discount factor.[25]

We next attempt to isolate the periods when shifts in net worth may have been responsible for breakdowns in the standard model. The first test in this respect focuses on whether the ability of the investment model to explain the data is altered in periods of declining net worth. We estimated the model in equation (11) over the sample period excluding 1921-33 and 1981-86. The results from the estimation are shown in the first column of Table 3. The standard model now marginally passes the test of overidentifying restrictions. The estimated adjustment cost parameter is somewhat lower than before, but still is plausible. The estimated share parameter remains is similar to those in Table 2. Similar results are obtained in one omits all of the 1920s, 1930s, and 1980s. These finding suggest that the rejections in Table 2 may be attributable to the sustained periods of low net worth as might be expected with the credit constraint under the asymmetric-information view.

To pursue this idea more formally, we adopt a more parametric approach to studying the effects of movements in internal net worth on investment spending, holding constant investment opportunities. Thus for these periods of persistently low net worth, we allow ω, the multiplier on the borrowing constraint, to depend negatively on changes[26] in internal net worth, a^*, so that

$$\tilde{\omega}_{t+1} = \gamma a_t^*, \qquad (13)$$

where $\gamma < 0$. Here we use the first differences in the value of farmers' net worth (assets less liabilities) relative to beginning-of-period assets as a proxy for the internal net worth measure.[27,28] To ensure that the multiplier is always nonnegative, we set a^* to zero in years when net worth increased.[29]

The results reported in the second column of Table 3 incorporate this generalized version of the model, allowing for the possibility that the net worth constrains finance and investment. Given this parameterization, γ, the constant of proportionality in (13), should be negative. This parameterization also necessitates the estimation of an additional nuisance parameter, since, in equation (12), $\tilde{\omega}$ also multiplies part of the constant term. We find that γ is indeed negative and large enough to suggest that effects of shifts in net worth and investment are potentially very important. Taken literally, the estimated value of γ indicates large effects of movements in net worth on capital spending, all other things equal; using the coefficient estimates obtained in the second column, a 1-percentage-point decline in farmers' real net worth would lead to a rise in the implicit discount rate of 11.2 percent, i.e. from, say 0.95 to 0.838.[30] In addition, this alternative parameterization also slightly improves the margin by which the model passes the test of overidentifying restrictions.

The results in the second column of Table 3 highlight the importance of the periods with large shocks to net worth. To investigate whether this specification is appropriate, our last set of results allows for the possibility of asymmetry by permitting different values of γ in periods of "low net worth" and "high net worth". For the former, we again used the 1921-33 and 1981-86 periods. For the latter, we use the periods from 1955 to 1979, a long period without important deflationary shocks to farmers' net worth, including periods of rising commodity prices and land values. The results are suggestive. In particular, the negative estimate of γ, which links movements in net worth and the multiplier on the credit constraint, is traceable *only* to the periods of persistently low net worth. During the period of relatively high levels of net worth, isolated declines in equity seem to have a negligible effect on effective discount rates. The other parameter estimates in the model are relatively unaffected by this new parameterization, and the overidentifying restrictions associated with the model are still not rejected by the data.

In summary, the empirical tests presented above lend support the proposition that movements in collateralizable net worth are economically important factors in the determination of investment spending. This conclusion is supported by several pieces of evidence. First, there is systematic variation in investment which is unexplained by the standard neoclassical model, but which is significantly correlated with movements in net worth. Second, the importance of this relationship is most pronounced in which net worth is falling. For instance, modifying the standard neoclassical model in the direction of an alternative model in which net worth constrains finance and investment improves the performance of the model. Moreover, the improvement is attributable to an enhanced fit during deflationary periods; the standard neoclassical model performs reasonably well in high-net-worth periods, and the impact of declines in net worth on the discount factor is concentrated in periods in which farmers' net worth is low.

IV. Summary and Conclusion

Recent models of firm investment decisions stressing problems of asymmetric information in capital markets provide a foundation for interpreting evidence that movements in internal finance can predict investment spending, even after controlling for measures of firms' investment opportunities. While such evidence is suggestive, it is often open to other interpretations; most models stress the importance of *collateralizable net worth*, while empirical studies using aggregate time-series data or firm-level panel data have employed proxies such as *cash flow*.

Our paper addresses this gap in two ways. First, we focus on the U.S. agricultural sector during the twentieth century; the sector has experienced large fluctuations in farmers' net worth and in the profitability of agricultural investment, and reasonable measures of net worth can be constructed. Second, rather than relying on investment function representations (such as the often used q-theory approach), we make use of predictions generated by firms' Euler equation for capital accumulation. Intuitively, during periods in which net worth is high, the Euler equation should hold across adjacent periods; the equation will not hold for periods in which the shadow price of external finance is high because of low net worth (loosely speaking, periods in which "finance constraints" bind). Such an approach offers an alternative model for periods in which internal net worth is low (holding constant investment opportunities), and generates a link between internal net worth and investment spending during periods of significant deflation on the value of net worth.

Our empirical evidence is presented in three parts. First, the structural model for investment corresponding to the standard neoclassical (perfect-capital-markets) approach is rejected by the data. The rejection can be traced to systematic correlations between the unexplained component of investment and movements in farmers' net worth positions. The correlation is strongest during periods of low net worth. A second finding is that extending the model to allow for movements in farmers' net equity position contributes importantly to explaining investment. Third, the effect of changes in net worth on investment is significantly more important during the deflationary periods previously identified than during "boom" periods. Taken together, these findings provide support for a class of "internal funds" models of investment under asymmetric information.

We believe that the findings presented here illustrate the potential richness of research programs to formalize tests of capital-market frictions and to measure their importance for investment and financial decisions of business firms. Two research strategies are particularly promising: (i) extending the modeling approach to panel data on business corporations, linking rejections of standard neoclassical models to plausible structural alternative models of capital-market frictions[31]; and (ii) developing additional case studies in which the sources of such frictions can be identified or proxies for internal net worth or insiders' stakes measured.[32]

DATA APPENDIX

The data used in this paper are taken from a number of sources and are available on a diskette from the authors. The details regarding the data sources and data construction are as follows:

Investment: The basic data are the Commerce Department's constant-cost series for Farm Equipment Investment. Data prior to 1985 are published in Table B-4 of Fixed Reproducible Tangible Wealth in the United States, 1925-1985 (published by the Commerce Department). The more recent data were obtained from unpublished Commerce Department data. We also used investment data for Farm Structures to construct a second capital series to use in the net worth proxy described below. These data are collected from the same sources shown above.

Capital Stock: The capital stock series are built up using a perpetual inventory method with an assumed depreciation rate of 12 percent for equipment and 2.37 percent for structures. The initial values for these series were taken from the 1910 Census of Agriculture, which is reprinted in Tostlebe (1957, Table 9).

Proprietors' Equity: Our proxy for farmers' net worth is the ratio of farm proprietors' equity to capital. The equity series is taken from Table 411 in Melichar (1987). The capital series is the sum of the equipment and structures series whose construction was discussed above.

Price Indices: The land price index we use is the Farm Real Estate Index which is stored on line in the Federal Reserve Board's Macro Data Library. The original source for this series is the USDA's Farm Real Estate Market Developments publication. The GNP deflator is taken from the Economic Report of the President and Balke and Gordon (1989). The investment-goods price deflator is inferred from the difference between the Commerce series for nominal and real investment.

Tax Corrections: The relative price of investment goods is corrected for the presence of the depreciation allowances and the investment tax credit. Time series for corporate tax rates, investment tax credit rates, and the present value of one dollar's worth of depreciation allowances are taken from Pechman (1987).

Average Product of Capital: The average product of capital is calculated by taking the ratio of net income to capital. Net income is the difference between the gross income and production and labor expenses. The "Gross Income" series is taken from Table 111 in Melichar (1987). The "Production Expenses" series appears in the USDA's Economic Indicators of the Farm Sector, 1987 National Financial Summary, Table 24, not including interest expense. "Labor expenses" are reported in Table 60 (column 2) of the same publication. Data prior to that which appears in the National Financial Summary are taken from the Federal Reserve Board's Macro Data Library.

Rates of Return: The nominal interest rate used to calculate the real interest rate is a spliced rate that combines the average contract rate on farm mortgages obtained from banks and the Production Credit Association's (PCA) average cost of loans. The splice was necessary because the PCA did not exist prior to 1934. We view this rate as the best proxy for farm lending rates and therefore use it as soon as it becomes available. This series is taken from the USDA's Agricultural

Statistics publication. The rate we use for the 1910 to 1934 period is taken from USDA Miscellaneous Publication 478, "Farm-Mortgage Credit Facilities in the Unites States." Our expected inflation series refers to the GNP deflator, and follows the procedure in Gordon and Veitch (1986). The real rate of capital gains on farm debt was also used as an instrument. This series was taken from Table 101 of Melichar (1987).

Agricultural Exports: This series is also used as an instrument in the estimation. It is taken from the Economic Report of the President, 1988; US Foreign Agriculture Statistics-- Calendar Year Supplement for 1970; and Historical Statistics of the United States from the Colonial Times to 1970. The data from the first two sources are on a calendar-year basis and are available back to 1930. The data from the Historical Statistics are on a fiscal-year basis; we spliced the two series assuming that growth rates across fiscal years is the same as across calendar years.

Government Payments and Lending: Data on the value of total government payments to farmers was also used as an instrumental variable. This series is taken from the USDA publication titled Agricultural Statistics. The most recent data come from Table 583 in the 1988 edition. Data from earlier editions along with the Historical Statistics of the United States from Colonial Times to 1970 were used to construct the complete series. The value of Farmers Home Administration (FmHa) lending was also used in constructing an instrument. These data are taken from Table 511 in Melichar (1987). The GNP deflator was used to convert both these nominal series into constant dollar series.

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Notes

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[1]See the derivation in Hall and Jorgenson (1967).

[2]See for example Hayashi (1982) and Summers (1981).

[3]Various forms of "accelerator" models appear to fit the data better than the more structured *q* or neoclassical models (see the review of studies in Fazzari, Hubbard, and Petersen, 1988). Recently, Abel and Blanchard (1986) found strong output and profits effects on aggregate investment in a *q* model.

[4]See for example Jaffee and Russell (1976), Leland and Pyle (1977), Stiglitz and Weiss (1981); Greenwald, Stiglitz, and Weiss (1984); Myers and Majluf (1984); Bernanke and Gertler (1990); Calomiris and Hubbard (1989, 1990); and the review of approaches in Hubbard (1990).

[5]Related issues have, been addressed in models of consumption. One can solve for "consumption functions" out of (human and nonhuman) wealth from consumers' intertemporal utility maximization. Alternatively, the approach pioneered by Hall (1978) makes use of the Euler equation, avoiding the problems of measuring wealth. This approach has been used in a test for "liquidity constraints" by Zeldes (1989), who finds that the Euler equation holds for "high wealth" individuals, but is rejected for "low wealth" individuals, for whom current resources help to predict consumption.

[6]Using panel data on U.S. manufacturing firms, Fazzari, Hubbard, and Petersen (1988) grouped firms by long-run dividend payout in order to test whether the sensitivity of investment spending to internal finance, holding constant investment opportunities (measured by *q*), varied systematically across groups. They found that excess sensitivity to expected movements in firm cash flow were a feature of low-payout firms, which were primarily smaller, rapidly growing enterprises. In a similar vein, Hoshi, Kashyap, and Scharfstein (1991) exploited Japanese panel data, grouping firms according to whether they were members of industrial groups, or *keiretsu*. They find that membership in a group and the presence of a group "main bank" are important in the provision of information and the avoidance of credit rationing when investment opportunities are promising. While liquidity effects on investment are quite important for non-group firms, they are much less important for member firms.

[7]An alternative to using financial variables as proxies for marginal *q* is to use a forecasting approach, as in Abel and Blanchard (1986). As that approach requires imposing structure on the expectations process, it is subject to the Lucas (1976) critique.

[8]This, of course, does not imply that problems arising from asymmetric information in financial markets cannot be important for

large firms. See discussion in Gertler and Hubbard (1988) and Gertler, Hubbard, and Kashyap (1991).

[9]Woodruff (1937) concluded that, during the Depression of the 1930s, poor soil maintenance practices were thought by lending agents of life insurance companies to accompany credit constraints for farmers. More recently, Lee (1980) notes a relationship between uncommitted cash flows and expenses for soil conservation.

[10]The question arises as to whether an observed sensitivity of investment spending to movements in net worth or internal finance might reflect "risk aversion" on the part of farmers. We chose not to model risk aversion in this context for two reasons. First, risk-averse farmers could hedge in futures markets or sell output via long-term contracts to risk-neutral borrowers (as in Carlton, 1979; or Hubbard and Weiner, 1991). Second, that farmers appear to care about the variance of cash flows need not reflect risk aversion per se. A very large fraction of farmers' net worth is held in farm land, so that their portfolios are poorly diversified. This lack of diversification corresponds more closely to the capital-market frictions we discuss, wherein insiders' stakes in projects are important, holding constant investment opportunities.

[11]That is, we assume that the dissociation of farm ownership and management leads to efficiency losses associated with agency costs (see e.g. Jensen and Meckling, 1976, 1979). As an example, separation of equity ownership and management can create disincentives for soil conservation and maintenance (hence decreasing output in the future) because of short-term leases or inequitable sharing of the benefits and costs of conservation investments (see Calomiris, Hubbard, and Stock, 1986).

[12]We do not parameterize the F function owing to data considerations, principally the inability to obtain reliable data on individual variable production inputs.

[13]There are also first-order conditions for land and variable factors, of course.

[14]This formulation assumes convex adjustment costs.

[15]There are other plausible specifications of adjustment costs, of course. For example, Abel (1983) and Blanchard and Fischer (1989) discuss models for which $A(I_t) = gI_t^{\varepsilon}, g>0, \varepsilon>1$. We wanted to preserve comparability of our approach with existing derivations in the *q*-theory approach (see for example Hayashi, 1982; Summers, 1981; and Fazzari, Hubbard, and Petersen, 1988).

[16]Another way to incorporate this feature would be to allow B^* to depend on, say, asset values less debt. If we denote net worth by W, the constraint on finance would then be

$$B_t \le B_t^*(W_{t-1}), \text{ or}$$

$$B_t \le dW_{t-1},$$

if d is a constant leveraging factor. Equation (5') in the text would then become $(1 + \varphi_t) - E_t[\beta_t(1 + i_t)(1 + \varphi_{t+1})] - \omega_t + E_t[\beta_t d\omega_{t+1}] = 0$.

If, for example, $\omega_{t+1} = \rho\omega_t + u_{t+1}$, where $E_t(\omega_{t+1} | \omega_t) = \rho\omega_t$, then this can be simplified to

$$(1 + \varphi_t) - E_t[\beta_t(1 + i_t)(1 + \varphi_{t+1})] - (1-\beta_t)d\rho\omega_t = 0.$$

[17]This point is related to the Euler equation formulation generally. See for example the discussion in the context of "liquidity constraints" and consumption in Zeldes (1989).

[18]These issues are discussed in detail in Gale (1983, Chapter 4).

[19]We varied this rate between 0.10 and 0.20, and found that none of the results was substantively affected.

[20]Tostlebe (1957) notes that, historically, most non-real-estate debt is used to finance equipment investment rather than additions to working capital.

[21]The implied capital stock arising from the reported investment series for agricultural structures is suspicious, declining for most of the first half of the sample and then rising over the second part of the sample.

[22]To see this, let $F = K_e^a N^b K_s^c L^{1-a-b-c}$, where K_e and K_s refer to the capital stocks We use as our proxy for the average product of equipment capital

$$\bar{F}_e \text{ where } \bar{F}_e = \frac{\text{Value of agricultural production - production expenses}}{\text{Value of equipment capital}}.$$

Using the Cobb-Douglas assumption, the marginal product of equipment capital F_e is given by $F_e = (a/(1-b))\ \bar{F}_e$.

Denoting the estimated "share coefficient" by e, $a = e(1-b)/a$, so that the implied equipment share a is given by $\sqrt{e(1-b)}$.

[23]Given our setup, the constant term and the coefficient on the discount factor β are each nonlinear functions of two parameters from the adjustment cost function, μ and α_0, which cannot be separately identified. Hence, there is no loss from estimating freely these parameters, and thereby not trying to impart to them a structural interpretation.

[24]This calculation is based upon the linear relationship between q and (I/K) in this setup. More specifically, substituting equation (7) into equation (3) yields $q = \lambda = p^I+\alpha_0+\alpha_1(I/K-\mu)$. The reported result follows from assuming that if (i) adjustment costs are in terms of gross investment; (ii) $\alpha_0 = 0$; (iii) $p^I = 1$; and (iv) the net investment rate is equal to μ in the steady state.

[25]The working paper version of this paper (Hubbard and Kashyap, 1990) provides results analogous to what follows using the specification with a constant discount factor.

[26]We use changes in net worth in equation (13), rather than the level of net worth, in order to maintain comparability with the models of informationally related capital-market frictions we discussed in section I. In the models of Gertler and Hubbard (1988) and Gertler, Hubbard, and Kashyap (1991), the *level* of net worth matters for the determination of the *capital stock*, holding constant investment opportunities, when firm insiders have private information about the

allocation of funds for investment. Hence, the change in the capital stock, *investment*, depends on the *change* in net worth.

[27]Hayashi and Inoue (1991) have correctly criticized the use of "cash flow" as a proxy for a^* since movements in cash flow may be correlated with shocks to the production function (which are not explicitly considered here). In our case, movements in the net worth variables are (historically) in large part accounted for by redistributions (i.e., "debt deflations") so that any correlation with shifts in the production function are much weaker. For example, during the "debt-deflationary" episodes in the early 1920s and 1930s, the decline in farmers' net worth as a result of revaluation of existing debt was over half as large as the contribution from the decline in asset (largely land) values (see Melichar, 1987, Table 101). Hence, reductions in net worth were significant, holding constant any change in agricultural investment opportunities.

[28]We experimented with proxies for federal farm lending through the Farmers Home Administration in parameterizing (13) (treating such lending as endogenous), but we were unable to isolate any important effect in lowering the multiplier associated with the net worth constraint.

[29]We thank one of the referees for this suggestion.

[30]The impact may be even larger given the measurement difficulties associated with the most recent farm debt crisis. Specifically, our measure of net income of farmers includes direct payments under government programs, but it does not incorporate implicit subsidies from renegotiated debt settlements or partial or complete loan chargeoffs. During the middle 1980s there were substantial injections of funds from the Economic Disaster Program and Farm Operating Loan Program of the Farmers Home Administration (FmHA). Though there were official funding limits prescribed by the Congress, some loan programs (e.g., the FmHa's Economic Disaster Program) had entitlement status with broad funding limits, so the Secretary of Agriculture could transfer funds from them to operating loan programs to circumvent official lending ceilings (see Calomiris, Hubbard, and Stock, 1986). To the extent that this extra lending or reduced debt burdens was important, farmers' effective resources would be understated, and our estimate of γ would be too low.

[31]See for example Hubbard, Kashyap and Whited (1991). Pakes (1991) analyzes some structural modeling approaches for this problem.

[32]One example is the careful study of heterogeneity in financing constraints on oil firms' drilling and exploration activities in Reiss (1990). Another possible application would be to firm heterogeneity in financing arrangements and investment decisions in young, technology-intensive industries. Finally, Calomiris and Hubbard (1991) consider the effects of exogenous changes in the relative cost of internal finance arising as a result of certain tax changes.

TABLE 1

SUMMARY STATISTICS FOR INVESTMENT AND MEASURES OF NET WORTH

	Investment Capital		Annual % Change in Relative Land Price		Annual % Change in Equity to Assets Ratio	
Period	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1914-87	.15	.05	-.13%	6.47%	.18%	7.98%
1914-39	.15	.05	-2.41	6.30	.15	9.96
1948-87	.14	.05	1.01	6.24	-.36	6.85
1921-33; 1981-86	.11	.04	-5.13	7.41	-.31	10.18
1955-79	.15	.02	3.31	3.64	.37	5.09

SOURCE - Authors' calculations as described in the text.

TABLE 2

EULER EQUATION ESTIMATES FOR INVESTMENT MODEL

(U.S. AGRICULTURAL SECTOR, 1914-1987)

---- Basic Model (equation (11) ----

Parameter	Constant $\tilde{\beta}$	Time-varying $\tilde{\beta}$	-- (No Net Worth Instrument) -- Constant $\tilde{\beta}$	Time-Varying $\tilde{\beta}$
Constant	-.118 (.064)	-1.70 (.214)	.054 (.108)	-1.41 (.273)
Constant discount factor ($\tilde{\beta}$)	.992 (.073)	-------- --------	1.17 (.099)	------- -------
Adjustment cost coefficient (α_1)	1.05 (0.265)	1.15 (0.211)	2.59 (.679)	1.66 (.441)
Share parameter	.040 (.019)	.043 (.008)	-.011 (.026)	.050 (.012)
Constant associated with time-varying $\tilde{\beta}$	------ ------	1.62 (.224)	----- -----	1.31 (.286)
χ^2 - Orthogonality test (p value)	23.9 (.008)	22.0 (.015)	8.38 (.496)	12.8 (.171)

NOTE - The models are estimated using generalized method of moments. Instrumental variables include a constant; a single lag of I/K, $(I/K)^2$, and the average product of farm equipment capital; the change in the ratio of real agricultural exports to K; the change in Farmers' Home Administration lending (normalized by K); the change in real government payments to farmers (normalized by K);the change in the ratio of farmers' equity to assets; the rate of real capital gains on farm debt; a single lag of the constructed *ex ante* real interest rate; and current and once-lagged values of the relative price of equipment investment goods and the log of the relative price of agricultural land. (Relative prices are defined with respect to the price deflator for the Gross National Product). Heteroscedasticity-consistent standard errors are reported in parentheses.

TABLE 3

EULER EQUATION ESTIMATES FOR ALTERNATIVE INVESTMENT MODEL
(U.S. AGRICULTURAL SECTOR, 1914-1987)

Parameter	Baseline Model (Excluding 1921-33; 1981-86)	-----Net Worth Effects----- Periods with Low Levels of Equity	Separate Effects for "Boom and "Bust" Periods
Constant	-2.45 (.220)	-2.08 (.194)	-2.02 (.330)
Adjustment-cost coefficient (α_1)	.219 (.319)	.413 (.316)	.475 (.364)
Share Parameter	.062 (.007)	.051 (.007)	.053 (.009)
Constant (Time-varying $\tilde{\beta}$)	2.41 (.233)	2.03 (.207)	1.97 (.352)
Proportionality factor (γ) between credit-constraint multiplier ($\tilde{\omega}$) and change in net worth (1921-33; 1981-86)	------- -------	-.112 (.028)	-.121 (.032)
Shift in constant due to time varying credit-constraint multiplier ($\tilde{\omega}$) (1921-33; 1981-86)	------- -------	.093 (.024)	.165 (.264)
γ: "Boom" periods (1955-79)	------- -------	------- -------	.103 (.028)
Shift in constant (boom periods)	------- -------	-------- --------	-.135 (.219)
χ^2--Orthogonality test (p value)	16.6 (.083)	15.4 (.117)	13.7 (.132)

NOTE - The models are estimated using generalized method of moments. Instrumental variables include a constant; a single lag of I/K, $(I/K)^2$, and the average product of farm equipment capital; the change in the ratio of agricultural exports to K; the change in Farmers' Home Administration lending (normalized by K); the change in real government payments to farmers (normalized by K); the change in the ratio of farmers' equity to assets; the rate of real capital gains on farm debt; a single lag of the constructed *ex ante* real interest rate; and the current and once-lagged values of the relative price of equipment investment goods and the log of the relative price of agricultural land (Relative prices are defined with respect to the price deflator for the Gross National Product). Additional dummy variables are used as instruments in models in which parameters are allowed to vary over certain periods. Heteroscedasticity-consistent standard errors are reported in parentheses.

Figure 1

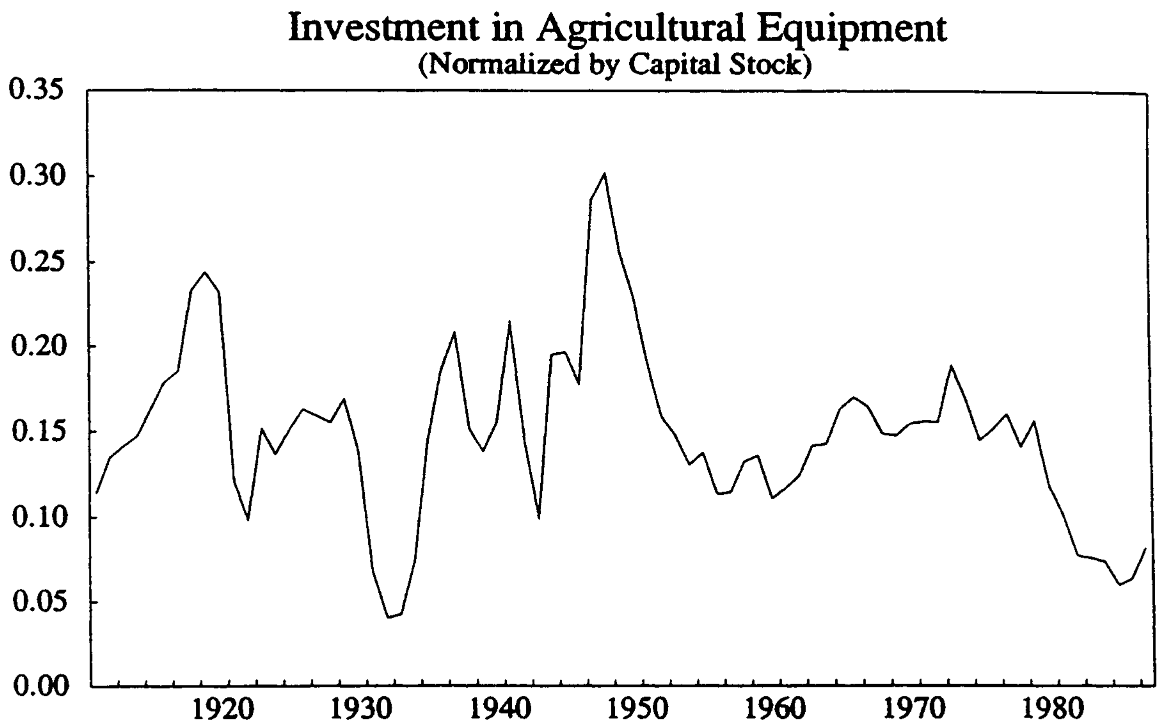
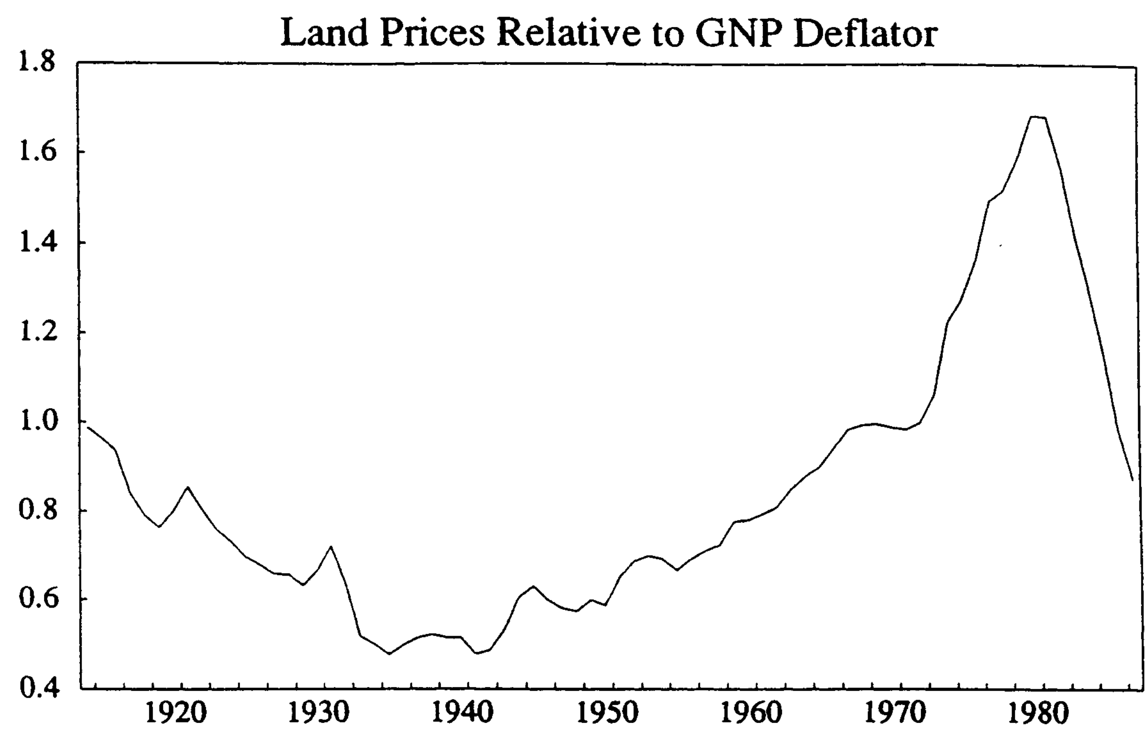
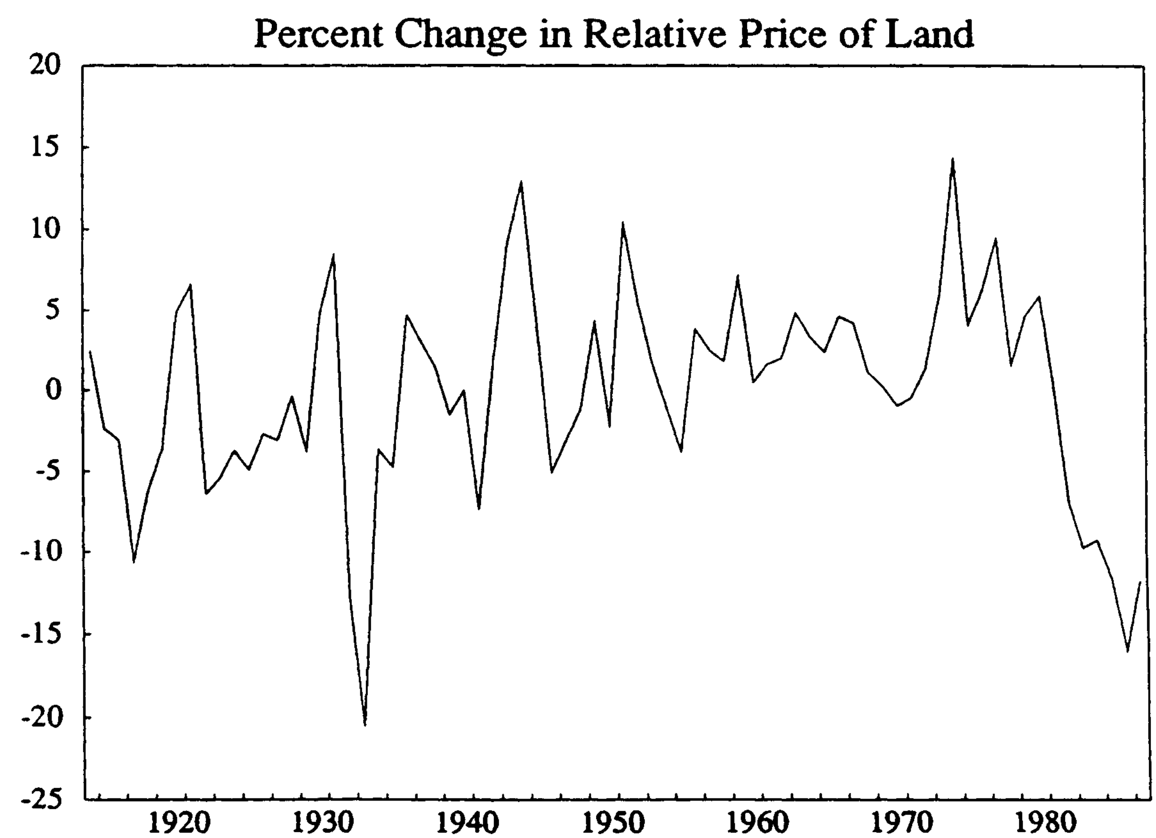

Investment in Agricultural Equipment
(Normalized by Capital Stock)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1920
1930
1940
1950
1960
1970
1980

Figure 2

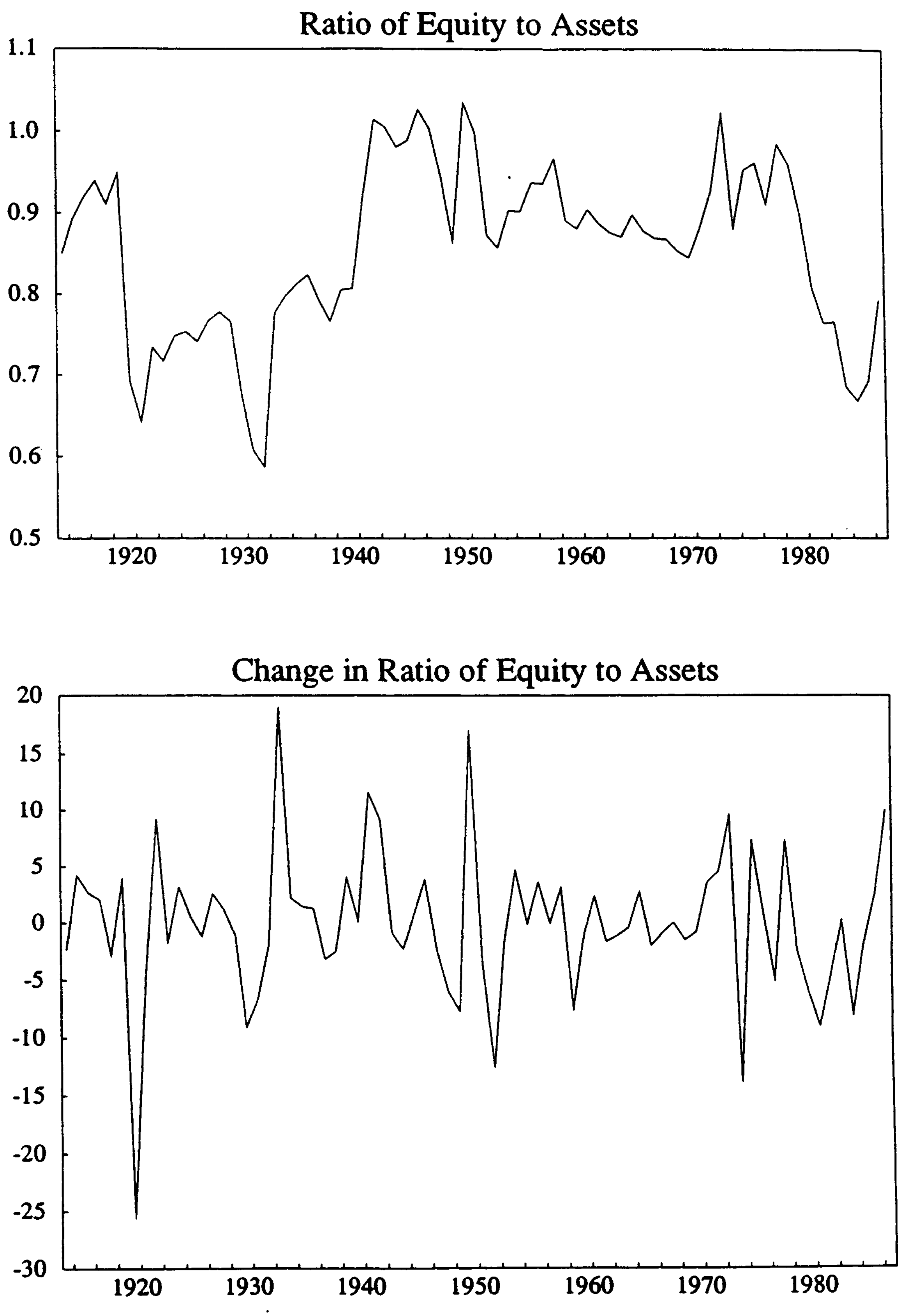


Land Prices Relative to GNP Deflator
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
1920
1930
1940
1950
1960
1970
1980



Percent Change in Relative Price of Land
20
15
10
5
0
-5
-10
-15
-20
-25
1920
1930
1940
1950
1960
1970
1980

Figure 3


Ratio of Equity to Assets
1.1
1.0
0.9
0.8
0.7
0.6
0.5
1920
1930
1940
1950
1960
1970
1980
Change in Ratio of Equity to Assets
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1920
1930
1940
1950
1960
1970
1980