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ABSTRACT

Relationships between the demand for credit (both operating and long term) and other inputs in agriculture were evaluated for the U.S. cornbelt states using a system of difference equations in a partial adjustment framework. Excess demand for long term debt was found to decrease demand for variable inputs including operating credit. Increases in the cost of operating credit were found to decrease demand for variable inputs and increase demand for quasi-fixed inputs. The opposite effects were generally found for changes in the cost of long term credit lending support to the hypothesis that subsidized interest rates become capitalized into asset prices.

Key Words: operating credit, term credit, demand, dynamics

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INTRODUCTION

Agriculture has become one of the more capital-intensive sectors of the U.S. economy and has also become increasingly dependent on debt financing. Nationally, farm debt rose an average of more than 10% per year during the 1970's, due partially to low and sometimes negative real interest rates (Choat and Plasico, 1987). In the 1980's real interest rates rose to record levels. As a result, the cost of borrowing funds has become one of the single most important factors affecting farmer incomes (Thompson, 1988). Not only did interest payments increase from $3.4 billion in 1970 to $21 billion in 1984 (or in 1982 dollars, from $8.1 billion in 1970 to $19.5 billion in 1984), but the increasing real interest rate, as the opportunity cost of capital, became an increasingly important determinant of the value of investments such as land the change in investments. For instance, the increase in real interest rates was likely one of the major factors causing land prices to fall throughout the 1980's. Furthermore, the increased variability in interest rates added another source of riskiness to farm income and investment, likely reducing the optimal debt load of individual farmers (Thompson, 1988).

At the individual farm level, the impacts from changes in the interest rate on farm profitability became painfully obvious in the early 1980's. A common reaction by governments was to offer interest rebates. For example, the Farmers Home Administration (FmHA) provides programs in which borrowers are charged subsidized interest rates and their regular contract rates, while not subsidized directly, are below competitive market rates for financing farm businesses. Critics of this government action have argued that the short-term benefits of subsidized interest rates are eventually capitalized into asset prices, i.e. causing higher land (and other input) prices, and thus actually create a barrier to entry into farming in the long run. This hypothesis maintains that interest rebates or subsidies increase the demand for agricultural inputs by increasing the demand for the complementary input, debt. The hypothesis of complementarity is based on the observation that credit is used to purchase other inputs, not replace them.

Although there has been an increasing level of academic interest in the effect of farm debt and agricultural interest rates on the agricultural economy, a largely neglected area in agricultural finance is the study of the demand for farm credit and its relationship to other inputs. While much of agricultural economic research focuses on providing demand and supply elasticities for agricultural inputs and outputs (e.g. Lopez, 1980 and Moschini, 1989), farm debt has not been included as an input to the production process. The rationale for including credit as an input to the production organization of the firm was provided by Baker in 1968. The essence of Baker's argument is that credit is an important source of liquidity, and since liquidity has value, borrowing generates a cost from loss of liquidity as well as from interest charges on loans. Since previous work on supply/demand relationships neglected credit as an input variable, the results of these studies may be biased given that an important variable, credit, was ignored. Ignoring farm debt in production studies may be excluding some very important information since the cost of servicing debt often exceeds the cost of other production inputs. For example, in Iowa in 1989, interest payments (including both term and operating interest) represented 11% of total production expenses. This study attempts to resolve the previous neglect of credit by estimating the demand for both operating and term credit and the interrelationships with other inputs.

The objective of this study is to evaluate the relationships between the demand for debt (both short-term and long-term debt) and the demand for other inputs in agriculture. This study utilizes a dual cost function approach to estimate output compensated demand elasticities for production inputs as well as the intangible inputs of operating and mortgage credit. The dynamic behaviour of long-term debt will be investigated using a partial adjustment or disequilibrium model. In the disequilibrium model, the movement of variables to their equilibrium values is approximated by a system of difference equations in a partial adjustment framework. This study focuses on the five U.S. cornbelt states: Illinois, Iowa, Missouri, Ohio, and Indiana. These states are chosen due to their close proximity and apparent homogeneity in the agricultural sector.

MODELLING THE DEMAND FOR CREDIT

Baker (1968) provided the rationale for including credit as an input to the production organization of the firm. His argument is based on the effects of liquidity value, in the form of credit, on the production organization of the firm. Baker points out that credit, defined as borrowing capacity, constitutes an important source of liquidity. Since liquidity has value, borrowing generates a cost from loss of liquidity as well as from interest charges on loans. Hence, Baker argues that credit is an asset which can be managed and which has important implications for the production organization of the firm.

Since the use of credit constitutes both a loss of liquidity and a tangible interest cost, it is assumed that farmers would only borrow when they are liquidity constrained in order to purchase other inputs. In other words, there is no value in borrowing merely for the sake of borrowing. The demand for credit (debt), D, is thus a derived demand conditional on the demand for all other inputs and output supply, $D = D(X(P,r,Y))$, where $X(P,r,Y)$ is a vector of Hicksian (constant-output) factor demand functions expressed in terms of input prices, P, the interest rate or the price of debt, r, and output levels, Y.

Since it is assumed that credit is utilized to purchase other inputs, not replace them, the relationship between the two is believed to be generally complementary. It is likely that as interest rates, r, rise, the demand for other inputs will decline causing a decline in the demand for credit. Baker states that as interest rates rise it is expected that farmers reduce farm inputs until the marginal value product of the input equals the cost of the input plus the cost of credit. Likewise, if input prices, P, rise, input demand would decrease resulting in a decrease in the demand for credit. However, while a complementary relationship may generally be expected between credit and farm inputs, it may not exist between different types of credit and specific inputs.

The model used to derive the demand for credit and the demand for other inputs is based on the dual cost function, defined as the sum of the input prices, multiplied by the respective output compensated demands for each of the n inputs

$$C(P,Y) = \sum_{i=1} P_i X_i(P,Y) .$$

A nonhomothetic multiproduct translog function exhibiting nonneutral technical change is assumed for the indirect cost function C(P,Y)[2]. It is of the form.[2]

$$(1)\quad lnC = \alpha_o + \sum_{i=1}^{8} \alpha_i \ln(P_i/P_o) + \sum_{y=c,1} \alpha_y \ln Y_y + \alpha_{iT} + \frac{1}{2}\sum_{i=1}^{8}\sum_{j=1}^{8} \gamma_{ij}\ln(P_i/Psuo)\ln(P_j/P_o)$$
$$+ \frac{1}{2}\sum_{y=c,l}\sum_{z=c,l} \gamma_{yz} lnY_y lnY_z + \frac{1}{2}\gamma_{tt}T^2 + \sum_{y=c,l}\sum_{i=l}^{8} B_{yi} lnY_y ln(P_i/P_o)$$
$$+ \sum_{i=l}^{8} \beta_{it} ln(P_i/P_o)T + \sum_{y=c,l} \beta_{yt} lnY_y T + \sum_{d=l}^{r} \delta_d S_d$$

Where ln = natural logarithm;
C = total cost or total production expenses;
P_i = price index of nine inputs (P_1 = feed price, P_2 = operating credit interest rate, P_3 = wage rate, P_4 = crop input price, P_5 = feeder livestock price, P_6 = long term interest rate, P_7 = land value, P_8 = machinery price, and P_9 = price index of other inputs);
Y_y = quantity index for two outputs (Y_c = crops and Y_1 = livestock);
T = time trend;
S_d = dummy variables for four of the five cornbelt states (S_1 = Illinois, S_2 = Indiana, S_3 = Iowa, and S_4 = Missouri).

α_i, α_y, α_q, γ_{ij}, γ_{yz},γ_{tt}, β_{yi}, β_{it}, β_{yt}, and δ_d, are coefficients to be estimated.

The above cost function (1) is continuous with respect to input prices and is nondecreasing in input prices and output, as required by the regularity conditions. In addition, the cost function must be at least quasiconcave in input prices which required the function to be twice differentiable. According to Young's theorem, this implies that the second cross partial derivatives must be equal, which can be imposed on (1) through the restrictions: $\gamma_{ij} = \gamma_{ji}$ and γ_{yz} for all i, j, y and z. Finally, in order for the cost function to be homogeneous of degree one in input prices, the following restrictions must hold:

$$(2)\quad \sum_{i=1}^{9} \alpha_i = 1, \sum_{i=1}^{9} \gamma_{ji} = \sum_{j=1}^{9} \gamma_{ji} = \sum_{i=j}^{9} \beta_{yi} = \sum_{i=1}^{9} \beta_{it} = 0$$

More specifically, the above restrictions result in the following specifications:

[2] A non homothetic cost function is more general than a homothetic function. With a homothetic translog cost function, expansion paths are assumed linear, meaning changes in the scale of production do not affect factor shares. The implication of this is that all changes in factor shares are attributed to substitution and/or factor augmenting technical change. If the production technology is not homothetic, however, a risk of overestimating the effect of factor substitution or, more likely, technical change exists because the time trend variable used as a proxy for technical change is generally positively correlated with output levels.

$$\alpha_9 = 1-(\alpha_1 + ... + \alpha_8)$$
$$\gamma_{i9} = 1-(\gamma_{i1} + ... + \gamma_{i8}),\ for\ i = 1, ..., 9,$$
$$\beta_{y9} = 1-(\beta_{y1} + ... + \beta_{y8}),\ for\ y = c, 1$$
$$\beta_{9t} = 1-(\beta_{1t} + ... \beta_{8t})$$

The cost-minimizing input demand equations are derived through logarithmical differentiation of the cost function (1) with respect to input prices (employ Shephard's Lemma which along with Young's theorem also holds for interest rates and the derived demand for debt) to obtain the cost share equations:

$$(3) \qquad \frac{\partial \ln C}{\partial \ln P_i} = \frac{P_i}{C} \cdot \frac{\partial C}{\partial P_i} = \frac{P_i X_i}{C} = CS_i$$

for i = 1, ... n and where

$$\sum_i P_i X_i = C .$$

The eight long run equilibrium cost share equations to be estimated are of the form

$$(4) \qquad CS_i = \alpha_i + \sum_{j=1}^{8} \gamma_{ij} \ln(P_j/P_o) + \sum_{y=c,1} B_{yi} \ln Y_y + B_{it} T + \sum_{d=1}^{4} \delta_d S_d \quad i=1,2...8 .$$

The ninth cost share equation, for "other" inputs, is not estimated directly due to singularity, but it can be retrieved from the parameter restrictions provided by (2).

The price elasticities for the inputs assumed to be in long run equilibrium are calculated as

$$(6) \qquad \epsilon_{ij} = \frac{\gamma_{ij} + CS_i CS_j}{CS_i} \quad i,j=1,...,n, \quad but\ i \neq j$$

$$\epsilon_{ii} = \frac{\gamma_{ii} + CS_i^2 - CS_i}{CS_i}, \quad i=1, ... ,n$$

In the above static model, variables adjust instantaneously to equilibrium values. Dynamic models, on the other hand, allow for an adjustment period or for a partial movement toward the equilibrium value rather than forcing a complete and total adjustment. The rationale for allowing an adjustment period lies in the existence of unobserved costs associated with the adjustment of inputs and outputs.

Nadiri and Rosen (1969) have pointed out that the quantity of physical capital cannot be rapidly adjusted without incurring significant economic adjustment costs. Furthermore, due to unique adjustment considerations, different factors will adjust at different rates. For example, it is expected that land will adjust more slowly than the stock of seed or fertilizer due to the nature of each input. Not only is land generally a much larger expense, but there are also location, size, and quality constraints to consider. Tsigas and Hertel add that these adjustment costs may be external or internal to the firm. External adjustment costs are separable from the production process. Internal adjustment costs arise from a reduction in productivity which occurs when capital stocks are changed.

A variety of methods for incorporating dynamics into an empirical system exist. Berndt, Morrison, and Watkins (1981) classify dynamic models by dividing them into three "generations". First generation models are essentially single-equation models incorporating an ad hoc dynamic specification or the basic partial adjustment framework. Economic theory in general is virtually ignored in the dynamic specification of first generation models, and since they are primarily single-equation models, there exists no interaction with other inputs. Second generation models are more general in that they incorporate interaction with other inputs in the short run, but the role of economic theory is still limited in determining the time path of adjustment from short to long run. Third generation models, on the other hand, not only yield interrelated factor demands, but also provide well-defined measures of short, intermediate, and long-run price elasticities by explicitly incorporating dynamic optimization.

Tsigas and Hertel (1989) argue that the value function approach is quite restrictive in that it postulates that the firm is continually in equilibrium, subject to adjustment costs. Consequently, they found that the hypothesis that farms maximize net present value of future profits, subject to adjustment costs and static price expectations did not hold, and proposed that a less restrictive model might postulate that the adjustment process is one of disequilibrium, attaining equilibrium only in the long run. Given that the sector analyzed in their study also consisted of Mid-western farmers, the less restrictive partial adjustment model is used in this study rather than a dynamic duality approach. Thus, the dynamic specification for this model will be a combination of the second generation approaches; a system of interrelated disequilibrium equations which explicitly incorporates the objective function to be optimized.

The static model is modified to account for the non-instantaneous adjustment of the quasi-fixed inputs using the following partial adjustment model

$$(7) \qquad CS_t - CS_{t-1} = M(CS_t^* - CS_{t-1})$$

where CS^* is the vector of fully adjusted levels of CS (the vector of n cost share dependent variables) and M is an n x n matrix of constant adjustment coefficients, which determine the adjustment rate of CS towards its fully adjusted level. The change in actual cost shares between periods is thus assumed to be proportional to the desired change.

Rearranging equation (7) to solve for CS_t results in

$$(8) \qquad CS_t = M \cdot CS_t^* + (I-M)CS_{t-1}$$

The observed cost share for each input is thus a function of the optimal long run cost shares, CS_t^*, as defined by equation (4) and the previous period's cost shares, CS_{t-1}. Different factors have different costs of adjustment and adjust at different rates which are reflected in the adjustment coefficients, m_{ij} of M. If adjustment to equilibrium for input i was instantaneous and there were no costs associated with its own adjustment and the adjustment of other inputs the m_{ij} would equal one and m_{ij} would equal zero for $i \neq j$. In the static model it is assumed that all inputs adjust instantaneously, so the m_{ij} coefficients are restricted accordingly. In the case of all variable inputs, the vector of fully adjusted levels of cost shares, CS^*, is equal to the observed vector of cost shares, CS, for each period. Thus, the static model is a restricted version of the disequilibrium system with M equal to an identity matrix.

In both the equilibrium and disequilibrium systems the cost shares must sum to one. In a partial adjustment model, this will occur if the sum of changes in cost shares across all inputs equals zero:

$$(9) \qquad i(CS_t - CS_{t-1}) - iM(CS_t^* - CS_{t-1}) = 0$$

where i is a unit vector of dimension 1 x n and M is the full n x n matrix. The above equation is satisfied for autoregressive models if iM = zi, where z is an unknown constant (Berndt and Savin, 1975).

Since only n - 1 of the cost share equations are linearly independent one of the cost share equations must not be included in estimation to avoid singularity problems. The equation for the "other" inputs is dropped from the estimation and its price index used to normalize the remaining eight input prices. The effect on the adjustment matrix M is to change it to M^1 where

$$(10) \qquad \begin{bmatrix} m_{11}-m_{19} & m_{12}-m_{19} \ldots m_{18} & - m_{19} \\ m_{21}-m_{29} & m_{22}-m_{29} \quad m_{28} & - m_{29} \\ \cdot & & \\ \cdot & & \\ m_{81}-m_{89} & m_{82}-m_{89} \ldots m_{88} & - m_{89} \end{bmatrix}$$

Since the change in all cost shares must sum to zero, the cost share equation for the "other" input, CS_9, can be retrieved as

$$(11) \qquad CS_{9,t} - CS_{9,t-1} = -\sum_{j=1}^{8} (m_{99} - m_{9j}) (CS_{j,t}^* - CS_{j,t-1})$$

where the difference in adjustment coefficients are determined by

$$(12) \qquad (m_{9j} - m_{99}) = \sum_{k=1}^{8} - (m_{kj} - m_{k9}) \quad j = 1....8$$

for j = 1, 2 .. 8 (Norsworthy and Harper, 1981).

The element of the original adjustment matrix M cannot be uniquely determined unless additional restrictions are imposed (Berndt and Savin, 1975). In this study, the first four inputs (feed, short term credit, labor and crop expenses) along with "other" inputs were assumed to be variable. If j is a variable input, then $m_{jj} = 1$ and $m_{ij} = 0$ $(i \neq j)$. The other four inputs (livestock, long-term credit, land and machinery) are assumed to be quasi-fixed factors which do not adjust instantaneously to their optimum levels. Imposing these restrictions, the estimated adjustment matrix M^1 will be of the form

$$(13) \qquad M^1 = \begin{bmatrix} 1 & 0 & 0 & 0 & m_{15} \ldots m_{18} \\ 0 & 1 & 0 & 0 & m_{25} \ldots M_{26} \\ 0 & 0 & 1 & 0 & m_{35} \quad . \\ 0 & 0 & 0 & 1 & m_{45} \quad . \\ & & & . & \\ & & & . & \\ 0 \ldots\ldots 0 & & m_{85} & & m_{88} \end{bmatrix}$$

The individual adjustment coefficients for the first eight inputs can then be uniquely determined from M^1. These can then be used along with equation (12) to calculate m_{95}, m_{96}, m_{97}, and m_{98} which indicate the effect of disequilibrium in the quasi-fixed inputs on the demand for "other" inputs.

Plugging in the adjustment matrix given by (12) into equation (8), the system of disequilibrium cost-share equations to be estimated is of the form;

$$(14) \qquad CS_{i,t} = CS^*_{i,t} + \sum_{j=5}^{8} m_{ij}(CS^*_{j,t} - CS_{j,t-1}) + \mu_{ti} \qquad i = 1,2,3,4$$

for the variable inputs and

$$(15) \qquad CS_{i,t} = \sum_{j=5}^{8} m_{ij}(CS^*_{j,t} - CS_{j,t-1}) + \mu_{ti} \qquad i = 5,6,7,8$$

for the fixed inputs, where CS_j^* is the long run equilibrium cost share for input i given by equation (4) and μ_t is a random error term. The inter-relatedness of disequilibrium in input markets is explicitly recognized with this approach. For example, even though a variable input may be able to adjust instantaneously it may not be at its long run equilibrium value because other related inputs may not be able to adjust as quickly.

The long-run elasticities are the same as calculated for the static equilibrium model (6) but short-run price elasticities are calculated as:

$$\epsilon_{ij} = \frac{\sum_{k=1}^{n} m_{kj}\gamma_{jk} + CS_i CS_j}{CS_i}, \qquad ij=1,\ldots,n, \quad but\ i \neq j$$

$$\epsilon_{ii} = \frac{\sum_{k=1}^{n} m_{ik}\gamma_{ik} + CS_i^2 \quad CS_i}{CS_i}, \qquad i=1,\ldots, n$$

and are interpreted as the first period response of factor demands to changes in factor prices.

DATA

Empirical estimates have often utilized aggregate U.S. data, which implies that the production technology employed in agriculture is the same throughout the U.S. Lass and Weaver (1988) state that production should be analyzed for homogeneous regions of the U.S. to account for environmental and physical differences. The cornbelt states are a fairly homogeneous group of states both environmentally and physically as well as in cropping patterns and general agricultural practices. Therefore, data collected at this level avoids the concerns of Lass and Weaver (1988) and does not suffer the same level of aggregation problems as national data.

Panel data[3] for farm income and expenditures was collected from 1949 to 1989 for each of the five cornbelt states: Illinois, Indiana, Iowa, Missouri, and Ohio. The 1949-75 expense data and the 1949-81 income data was obtained from Lucier, Chesley, and Ahearn (1985). The more recent data was obtained from "Economic Indicators of the Farm Sector: State Financial Summary" published by the USDA. Income was broken down into total crop receipts, total livestock receipts, and government payments. Government payments were included in total crop receipts as the vast majority of government support has been for crops.

Annual expenditure data was collected from the following categories: total production expenses; feed purchased; non-real estate interest expenses; contract and hired labor expenses; crop expenses defined as seed, fertilizer and lime, plus pesticide purchased; land expenses defined as net rent to non-operator landlords plus property taxes; real estate interest expenses; livestock and poultry purchased; machinery expenses defined as depreciation, repairs, plus fuel purchased; and other expenses which include electricity, insurance, and other miscellaneous costs.

Output, like receipts, was divided into crops and livestock and was measured from 1949-89 by quantity indices for the cornbelt region since state level indices were not available

[3] The panel data in this study thus consists of five cross-sectional units (states rather than individual farms in each state) over 41 years. Panel data not only contain a larger number of observations, but also suffer less from simultaneity and multicollinearity than do aggregate time-series data. This reduces bias and increases efficiency (Tsigas and Hertel, 1989).

(USDA, ERS, "Economic Indicators of the Farm Sector: Production and Efficiency Statistics", 1989). Quantity indices for the quasi-fixed inputs were derived from the expenditure data.

Land values were measured by state as index numbers of average value per acre of farm real estate (Agricultural Statistics). Indices for hourly wage rates were available by state from 1965-84 and by region from 1984 to present (Agricultural Statistics). A U.S. wage rate index was available for the full period of study. Specifying the U.S. index as the independent variable, each state's wage rate index from 1965-84 was regressed against the U.S. wage rate index for the same period. Using the regression results, we extrapolated back from 1964 to 1949 and ahead from 1985 to 1989 to obtain the full range of state level indices.

The cost of long term credit used in this study is the average rate on new loans through Federal Land Bank Associations. The cost of operating credit used is the average cost of loans outstanding during the year through Production Credit Associations (Agricultural Statistics). These are U.S. level rates but given the efficiency of the money market, regional or state level data (if available) should not differ significantly. Interest rate data was only available to 1988, which resulted in an estimation period ending in 1988.

All other prices were collected from 1949-89 and were at the national level since regional or state level data were not available. The other prices are U.S. price indices for feed, feeder livestock, seed, fertilizer, pesticides, machinery, and for "other" inputs an index of prices paid by farmers for all production inputs excluding interest, taxes, and wages was used. The price index for the crop category was a cost share weighted index of the price indices for seed, fertilizer, and pesticides which resulted in a unique index for each state. The indices from 1949-78 were obtained from Agricultural Statistics and from 1979-89 from "Economic Indicators of the Farm Sector: Costs of Production -- Major Field Crops". All indices were converted so 1977 as the base year (1977=100).

RESULTS

The disequilibrium model consisting of the eight cost share equations (equations 14 and 15) was estimated simultaneously with a maximum likelihood procedure in SHAZAM which utilizes a Quasi-Newton algorithm (White et al 1990). Over 95% of the 105 parameters estimated had an associated t-ratio greater than 2. Conventional R^2's ranged from 0.82 for land to 0.98 for long term credit. The Durban-Watson statistics (rho values) ranged from 1.55 (.22) for labour to 2.44 (-.23) for long term credit.

The parameter estimates for the adjustment coefficients are presented in Table 1. The m_{ij}'s indicate the effect of disequilibrium in input j on the demand for input i. In terms of the 5 variable inputs, disequilibrium in long term credit has a much larger effect on the demand for the variable inputs than the other three quasi-fixed inputs of livestock, land and machinery. For example, if there is a positive gap between the optimal level of long term credit and the actual level, there is a negative effect on the demand for feed of 0.628. In contrast, excess demand for the other three quasi-fixed inputs has a much smaller effect on the demand for feed. Increasing to the optimal level for all quasi-fixed inputs decreases the demand for the variable inputs with the exception of "other" inputs.

The own adjustment rate is significantly smaller for long term credit than the other quasi-fixed inputs. The value of 0.029 suggests that it takes approximately 30 years for long term credit to adjust to its optimal level. The adjustment period is approximately the period between the time a farmer takes over an enterprise and succeeds it to the next generation. A large debt level is generally assumed during the initial takeover. Thus, the adjustment in long term credit may be related to the family life cycle hypothesis. Further support is provided by Collins and Karp (1993) who show that the optimal farm financial leverage decreases with age.

In contrast to the slow adjustment exhibited by long term credit to its equilibrium level, machinery adjusts within 3 years (1/0.334) and land in less than 2 years (1/0.623). Disequilibrium in the other three quasi-fixed inputs has a small effect on the demand for long term credit. However, excess demand for long term credit has a significant negative influence on the demand for land and a positive influence on machinery demand. Of the four quasi-fixed inputs, machinery is most affected by disequilibrium in the other markets.

The short run price elasticities for the conditional input demands are given in Table 2. All own price elasticities are negative as required by theory. Of the five variable inputs, crop expenses are the most inelastic (-0.05) while short term credit and hired labour expenses are the most elastic (-0.69). Land is the only input with an elastic short run response rate (-1.14). Since land expense is measured largely in terms of rental expenses, the result implies leased farm land is sensitive to changes in the rental rates. Although the demand for long term credit is inelastic (-0.84), farmers in the U.S. cornbelt do show a marked response in debt levels to long term interest rates.

Short term credit is a complementary input in the short run for the variable inputs with the exception of feed expenses. Feed use increases with an increase in interest rates due to its close linkage with livestock which also increases. The largest effect from a change in the interest rate on operating loans is in the amount of labour hired by farmers. However, the effect is small for a 1% increase in the interest rate causes a 0.27% decrease in the demand for hired labour. The effect of changes in the cost of operating credit on the short run demand for the four quasi-fixed inputs is also small but, in contrast to the variable inputs, is generally positive with the exception of machinery (-0.02).

Changes in the cost of long term credit also have a relatively small effect on the short run demand of all inputs. However, the effect is positive (substitutes) for the variable inputs and negative (complements) for the quasi-fixed inputs with the exception of land (0.34). The latter result may be due to the measurement of land expenses as largely those associated with renting land. As the cost of purchasing land as reflected in long-term interest rates goes up, farmers will opt for renting rather than buying farm land which pushes up the demand for rented land.

The demand for operating credit in the short run is affected more by the price of other inputs than is the demand for long-term credit. With the exception of labour, increases in the price of variable inputs increases the demand for short-term credit as expected. Since farmers are liquidity constrained, increases in the cost of necessary variable inputs will require additional operating credit. In contrast, increases in the prices of the quasi-fixed inputs generally decrease the short run demand for operating funds since the demand for these costly items will fall thereby decreasing all associated expenditures. The exception is land which my be again a result of the way in which it is measured. Changes in long-term interest rates have a minimal effect on the short-run demand for operating credit.

Prices of all the variable inputs has a relatively minor impact on the demand for long-term credit in the short run. The impact of changes in the price of the other three quasi-fixed inputs is larger but still relatively small. For example, a 1% increase in the price of land increases the demand for long-term credit by 0.3% in the short run. The positive or complementary relationship on long-term debt was found for all inputs with the exception of livestock price.

The long-run elasticity estimates for the dynamic partial adjustment model are given in Table 3. All own-price elasticities for the conditional inputs are negative as suggested by theory. In addition, since the long-run values are more responsive than the short-run elasticity estimate presented in Table 2, the results are consistent with the Le Chatelier-Samuelson principle. Most inputs now have an elastic own demand in contrast to the short-run scenario where only land exhibited an elastic response. Though the own price elasticity estimates are significantly larger in terms of absolute value, feed, crops and livestock still have an inelastic demand.

In the long run, an increase of 1% in the cost of operating credit decreases the use of that credit by 2.46% which is approximately three times the effect that such a rate increase would have in the initial period. The interest rate on operating credit was found to again have a complementary relationship with the other variable inputs with the exception of feed expenses. The largest effect of changes in the rate was noted on the demand for hired labor and "other" inputs. As for the demand for quasi-fixed inputs in the long run it was found that an increase in the short-term interest rate increases the demand for livestock and land but decreases the demand for machinery and long-term credit. The latter result may indicate the presence of internal and/or external credit rationing.

Although the price of short-term credit has a generally inelastic effect on the demand for quasi-fixed inputs, the reverse is not true. Changes in the price of the four fixed inputs result in a larger absolute change in the use of operating credit. The effect is generally negative with the exception of land rental rates (3.08). The demand for operating credit is also elastic with respect to the price of the other four variable inputs. With the exception of the wage rate, increases in the cost of the other variable inputs act to increase the long-run demand for operating credit.

Changes in the interest rate for long-term credit generally has a larger effect on the long-run demand for inputs than do changes in the short-term rate. An increase in mortgage rates serve to increase the demand for feed, labor and crop inputs while decreasing the demand for 'other' inputs and operating credit. The latter input is particularly responsive to changes in the long-term interest rate as indicated by the elasticity estimate of -3.28. The elasticity estimates with respect to the long-term interest rate are also negative for the quasi-fixed inputs. The exception is land which suggests that as mortgage rates rise, the demand for rental land increases as the value of land is decapitalized. The own price elasticity estimate for long-term credit is -3.57 which is comparable to the value of -2.89 obtained by

Boyette and White in a study which used a system of demand and supply equations to analyze the U.S. agricultural credit market.

As with the demand for operating credit, the demand for long-term credit is elastic with respect to changes in the prices of the other inputs. Increases in the price of the other quasi-fixed inputs decreases the demand for long-term credit with the elasticity estimates ranging from -1.98 for livestock to -3.24 for land. In contrast, increases in the prices of the variable inputs act to increase the demand for long-term credit. The exception is the negative effect noted for shorter term interest rates. This relationship would be expected to hold in the long run since short term and long-term interest rates tend to move together.

The long-run elasticity estimates obtained from the system of disequilibrium equations (Table 3) can be compared to those estimated from the long-run static model which assumes that $CS_i = CS_i^*$ for all i and that the adjustment matrix, M, is an identity matrix. The elasticity estimates for the static model given in Table 4 generally have the same signs as the long-run elasticity estimates for the dynamic model. However, the absolute values are much smaller for the static elasticity estimates. For example, own price elasticity estimates for short-term credit are -0.77 in the static model versus -1.46 in the dynamic model and -1.09 in the static model versus -3.57 in the dynamic model for long-term credit.

CONCLUSIONS

As farm debt levels rose significantly throughout the 1970's and interest rates in the early 1980's interest payments became one of the more dominant input costs for farmers and interest rates became one of the most important prices of concern to farmers. Consequently, interest rates and debt levels have become popular research topics. The vast majority of this research has focused on the linkages between macroeconomic policy (i.e. interest rates and exchange rates) on the general agricultural sector and the effects of interest rates on commodity prices and land values. The effect of interest rates, however, has been ignored in most previous works on supply/demand analysis. This may in part be due to the intangible nature of credit as opposed to other production inputs but excluding it from supply/demand analysis may bias the results and prevent the determination of how interest rates affect other inputs. The latter is necessary information if one wishes to evaluate the impact of government policies such as subsidized interest rates.

The relationships between the demand for credit (both operating and long term) and other inputs in agriculture was evaluated for the U.S. cornbelt states using a system of difference equations in a partial adjustment framework. It was found that disequilibrium in the level of long-term credit has a significant impact on the demand for variable inputs. Excess demand for long-term debt was found to decrease the demand for the variable inputs including operating credit whereas disequilibrium in the other three quasi-fixed inputs (livestock, land and machinery) had a generally negligible effect on variable input demand. Movement toward equilibrium was much quicker for the other three quasi-fixed inputs than long-term credit which was estimated to take over 30 years to adjust to its optimal level. The adjustment period is approximately the length of time that one generation controls a farm enterprise before passing it on to the next.

Increases in the cost of operating credit were found to decrease the demand for variable inputs while generally increasing the demand for quasi-fixed inputs. The opposite effects were generally found for changes in the cost of long-term credit. The complementary relationship found between long-term interest rates and the demand for quasi-fixed inputs lends support to the hypothesis suggesting subsidized rates become capitalized into asset price. Given the potential for capital gains and its influence on investment decisions, future research should consider the effects of risk and taxation on the demand for credit.

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Table 1: Adjustment Matrix Coefficients, Effect of Disequilibrium in Input j on Demand for Input 1

Input i	Quasi-Fixed Input j			
	Livestock	Long Term Credit	Land	Machinery
Feed	-0.071 (0.026)	-0.628 (0.009)	-0.006 (0.015)	-0.256 (0.016)
Short-term Credit	-0.258 (0.011)	-0.506 (0.004)	-0.034 (0.006)	-0.205 (0.007)
Labour	-0.236 (0.014)	-0.631 (0.007)	-0.048 (0.011)	-0.147 (0.009)
Crop	-0.287 (0.029)	-0.481 (0.012)	-0.113 (0.020)	-0.216 (0.018)
Livestock	0.496 (0.037)	-0.072 (0.014)	-0.040 (0.021)	-0.293 (0.023)
Long-term Credit	-0.043 (0.008)	0.029 (0.003)	-0.025 (0.005)	-0.035 (0.006)
Land	0.054 (0.046)	-0.561 (0.020)	0.623 (0.029)	-0.094 (0.026)
Machinery	-0.514 (0.037)	0.289 (0.012)	-0.204 (0.017)	0.334 (0.019)
Other	0.141	-1.561	1.152	0.159

Standard errors are in parentheses

Table 2: Short Run Price Elasticities

	With Respect to Price of								
Quantity	Feed	Short Term Credit	Labour	Crops	Livestock	Long Term Credit	Land	Machinery	Other
Feed	-0.24	0.04	0.03	0.38	0.09	0.12	-0.04	-0.51	0.14
Short Term Credit	0.41	-0.69	-0.17	0.38	-0.31	0.05	0.40	-0.75	0.67
Labour	0.06	-0.27	-0.69	0.22	-0.44	0.17	-0.04	-0.88	1.87
Crop	0.43	-0.03	0.08	-0.05	-0.21	0.15	0.14	-0.79	0.28
Livestock	0.56	0.22	0.21	0.52	-0.05	-0.06	-0.22	0.00	-1.18
Long Term Credit	0.11	0.02	0.07	0.06	-0.10	-0.84	0.30	0.25	0.14
Land	0.06	0.15	-0.04	0.21	0.40	0.39	-1.14	0.72	-0.74
Machinery	0.07	-0.02	0.03	0.01	-0.22	0.14	0.27	-0.75	0.48
Other	0.35	-0.16	-0.05	1.28	0.03	-0.83	0.47	-0.73	-0.36

Elasticities calculated for the mean share of each input

Table 3: Long Run Price Elasticities for Dynamic Model

	With Respect to Price of								
Quantity	Feed	Short Term Credit	Labor	Crops	Livestock	Long Term Credit	Land	Machinery	Other
Feed	0.62	0.64	0.71	0.72	0.44	0.82	-0.76	-0.39	-1.56
Short Term Credit	2.61	-2.46	02.80	2.74	-1.77	-3.28	3.08	-1.68	3.56
Labour	2.13	-2.06	02.25	2.27	-1.43	2.66	-2.44	-1.38	2.50
Crop	0.89	-0.84	0.94	-0.91	-0.58	1.08	1.02	-0.91	-0.69
Livestock	0.88	0.86	0.95	0.93	-0.65	-1.07	-1.04	1.11	-1.97
Long Term Credit	3.02	-2.88	3.24	3.17	-1.98	-3.57	-3.24	-2.10	4.33
Land	0.87	0.88	0.95	0.96	-0.11	1.03	-2.32	1.56	-3.82
Machinery	0.19	-0.21	0.23	0.20	-0.40	-0.28	0.33	-1.69	1.63
Other	-5.40	-2.63	-4.18	-5.72	5.26	-1.12	7.28	8.89	-2.38

Elasticities calculated for the mean share of each input

Table 4: Long Run Price Elasticities for Static Model

	With Respect to Price of								
Quantity	Feed	Short Term Credit	Labor	Crops	Livestock	Long Term Credit	Land	Machinery	Other
Feed	-0.30	-0.11	0.23	0.37	0.19	0.03	0.27	-0.53	-0.16
Short Term Credit	-0.44	-0.77	-0.35	0.37	0.08	-0.37	0.74	-0.04	0.78
Labour	0.67	-0.25	-1.17	0.12	0.72	0.22	0.20	0.32	-0.84
Crop	0.47	0.11	0.05	-0.28	0.09	-0.04	0.15	-0.09	-0.47
Livestock	0.37	0.04	0.48	0.14	-0.50	0.06	-0.18	-0.39	-0.02
Long Term Credit	0.10	-0.33	0.28	-0.10	0.11	-1.09	0.39	0.70	-0.05
Land	0.32	0.21	0.08	0.14	-0.11	0.12	-1.63	0.93	-0.05
Machinery	-0.26	-0.01	0.05	-0.04	-0.10	0.09	0.39	-0.62	0.48
Other	-0.31	0.36	-0.55	-0.73	-0.02	-0.03	-0.08	1.88	-0.52

Elasticities calculated for the mean share of each input