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Impacts of Financial Characteristics and the Boom-Bust Cycle on the Farm Inventory-Cash Flow Relationship

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ABSTRACT

The sensitivity of farm inventory investment to movements in cash flow is tested. Inventories should be sensitive to shifts in cash flow because inventory investment is readily reversible and inventories are a significant portion of assets. Investment models estimated with Kansas farm panel data indicate that: (*a*) farms absorb internal finance shocks by adjusting inventories, (*b*) the inventory investment of livestock and high-debt farms are more sensitive to movements in cash flow than crop and low-debt farms, and (*c*) inventory investment is more sensitive to cash flow during the 1981–86 bust and the 1987–92 recovery than during the 1975–80 boom.

Key Words: cash flow, credit constraints, farm cycles, farm inventories, investment, investment models.

An important role of U.S. farms is the holding of storable crop and feeder livestock inventories. Farm producers store crops in order to take advantage of seasonal price increases and to meet on-farm feed needs. Feeder livestock inventories are held to attain physical maturity prior to slaughter and to take advantage of short-term price increases. Farm inventory levels play an important role in the determination of spot and futures prices, and thus in production decisions. In recognition of the important role played by farm inventories in the agricultural and food economy, an extensive farm inventory literature has developed (see, e.g., Gardner; Brennan; Helmberger and Weaver; Rucker, Burt, and LaFrance; Working; Wright and Williams).

In spite of the usefulness of previous farm inventory studies in explaining inventory decision making, several stylized facts have been ignored concerning production agriculture and inventories. First, inventories bear a disproportionately large share of internal financial fluctuations due to low transaction and adjustment costs. Second, farms are thought to be prime credit constraint candidates. Third, a financial accelerator effect serves to accentuate farm cycles by increasing credit availability during boom periods and decreasing credit availability during bust periods.

The purpose of this study is to link these three stylized facts by examining whether internal funds, as measured by cash flow, are an important driver of farm inventory investment. The study is based on the premise that when firms are credit constrained, their investment

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levels are sensitive to changes in cash flow. The presence of credit constraints is attributed to asymmetry of information between borrowers and lenders, and financial hierarchies in which internal funds have a cost advantage over debt or equity financing. In response to a sharp reduction in cash flow, financially constrained firms will reduce their accumulation of all assets, with the effect on each asset determined by transaction and adjustment costs. Since inventories have low transaction and adjustment costs, their decline as a result of a decrease in cash flow should be disproportionately large.

Typically, the credit constraint literature assumes that credit rationing is externally imposed by lenders and that management is risk neutral. Here, we recognize that because farmers hold a large equity stake in the operation, internal credit rationing may be present; i.e, farmers may not choose to borrow, even though external funds are available, due to risk aversion. However, lenders and borrowers are likely to use similar factors in determining credit rationing, so that external and internal credit rationing would be expected to be positively correlated.

The present study tests for linkages between farm inventories and cash flow by estimating inventory investment models augmented with a cash flow variable. The use of a rich farm-level panel data set allows for the comparison of cash flow effects across farms with heterogeneous financial characteristics and across the recent boom-bust farm cycle. This approach offers more compelling evidence of the inventory-cash flow relation than those based on macro-level time-series data, and also overcomes the problem that cash flow may be proxying for expectations about future investment opportunities.

Relevant Literature and Credit Constraint Issues

Previous research has focused on the sensitivity of capital investment to fluctuations in cash flow (see, e.g., Fazzari, Hubbard, and Petersen; Hoshi, Kashyap, and Scharfstein; Gilchrist and Himmelberg). With the use of cash flow augmented Q-theory investment models, these studies have shown that the investment of firms which are thought to be a priori credit constrained is more sensitive to fluctuations in cash flow than the investment of firms which are thought to be a priori noncredit constrained, and that investment is more sensitive to movements in cash flow in business downturns than upswings.

A recent segment of this literature has extended the internal finance literature to inventory investment. Carpenter, Fazzari, and Petersen observed that: (*a*) manufacturers' inventory disinvestment has accounted for more than half of the shortfall in output in postwar recessions, (*b*) financing constraints are important for a large portion of the economy, (*c*) cash flow is procyclical and tends to lead the cycle, and (*d*) inventories bear a disproportionate share of cash flow fluctuations due to low adjustment costs. With the aid of a cash flow augmented inventory investment model, they found that industrial firms absorb cash flow shocks through changes in inventory investment and that this effect is more important for small firms than for large firms. They further reported that cash flow's effect on inventory investment is not uniform across business cycles (from peak to peak).

Following a similar approach, Kashyap, Lamont, and Stein found that the inventory investment of firms without access to public bond markets is sensitive to fluctuations in internal funds during recessions which are caused in part by tight monetary policies.[1] However, the relation between internal funds and inventory investment is shown to weaken during periods of loose monetary policy.

Small, closely held firms with poor access to public debt and equity markets should be among the most credit constrained, yet few good data sets are available to test the inventory-internal funds relation for this class of firms. This study extends the inventory-inter-

[1] Unlike most studies in the literature, Kashyap, Lamont, and Stein do not measure internal funds with cash flow. Instead, they use a liquid asset measure which is the sum of cash on hand and marketable securities.

nal funds literature to examine the inventory investment of U.S. farms which are thought to be highly credit constrained. Farms are extremely capital intensive relative to their levels of sales and cash flow. Farm assets are undiversified and inflexible—being held almost exclusively in farm-specific capital, of which land is usually the major component. Typically, there is a substantial lag between the purchase of inputs and the sale of outputs. In spite of their large capital needs, sources of farm investment funds are limited to internal funds and external credit. Outside equity is typically not an option.

The U.S. farm economy is also susceptible to periodic and prolonged booms and busts. Earlier in the century, the 1900 to 1918 years of prosperity were followed by the prolonged farm depression of the 1920s and 1930s. Recently, the prosperous years of the 1970s were followed by the recessionary years of the early and middle 1980s. Explanations for farm cycles include the effects of nonagricultural markets (i.e., primarily interest and exchange rates), supply and demand forces, and public food and agricultural policies (Rausser et al.).

The financial accelerator notion indicates that farm financial markets amplify and propagate farm cycles. Contractionary shocks reduce net worth and collateral values, tightening the availability of credit. As credit conditions deteriorate, investment spending contracts, exacerbating and prolonging the downturn. The opposite is thought to occur in periods with strong commodity prices and rising asset values such as the 1970s and the current period. This supply-side failure may be even worse in agricultural credit markets because of information-intensive localized customer borrowing relationships rather than impersonal debt and equity markets, and regulatory restrictions on the ability of local banks to diversify risks (Calomiris, Hubbard, and Stock). In the recent 1980s downturn, over 300 agricultural banks failed (Kliesen and Gilbert).

Investment Model and Procedures

The farm inventory investment model employs the flexible accelerator principle, but parameterizes the model with variables that are relevant to agriculture (see, e.g., Carpenter, Fazzari, and Petersen; Blinder and Maccini; Kuznets). The function specification for inventory investment for farm j in period t can be expressed as:

$$(1)\quad I_{jt} - I_{jt-1} = \delta(I^*_{jt} - I_{jt-1}) + \theta(E_{t-1}Y_{jt} - Y_{jt}) + \sum \omega_i(E_{it}P_{ijt+1} - P_{ijt}) + \lambda CF_{jt} + e_{jt},$$

where $I_{jt} - I_{jt-1}$ is inventory investment, I^*_{jt} is the end-of-period target stock of inventories (made at the beginning of the period), I_{jt} is the actual end-of-period inventories, $E_{t-1}Y_{jt}$ is the forecasted level of production, Y_{jt} is the actual level of production, $E_{it}P_{ijt+1}$ is the forecasted price of commodity i, P_{ijt} is the actual price of commodity i, and CF_{jt} is cash flow. Coefficients to be estimated include δ, θ, ω_i, and λ. Since investment can be financed out of internal funds, λ is hypothesized to be positive. A large λ indicates that the farm is relatively more reliant on cash flow to finance inventory investment—and thus assumed to be relatively more credit constrained. The error term, e_{jt}, may contain fixed farm and time effects, as well as random errors.

Ignoring the cash flow term, the right-hand side of equation (1) is composed of what Blinder and Maccini refer to as "anticipated" inventory investment ($I^*_{jt} - I_{jt-1}$) and "unanticipated" inventory investment [($E_{t-1}Y_{jt} - Y_{jt}$) and ($E_{it}P_{ijt+1} - P_{ijt}$)]. The anticipated inventory investment term assumes that the operator makes an inventory investment decision at the beginning of the year based on the gap between the target end-of-year and the actual beginning-of-year inventories. The target end-of-year inventory can be thought of as the "desired" end-of-year inventory level based on expected prices and production levels. The speed of adjustment is given by the parameter δ.[2] The unanticipated investment terms recognize that

[2] The speed of adjustment is an indicator of how fast the operator can adjust inventories such that actual inventories are equal to the target stock of inventories. A coefficient of one indicates one year, while a coefficient of 0.5 indicates two years.

during the course of the year the investment decision may need to be revised based on the deviation of anticipated from actual production and prices. Actual production may deviate from predicted production due to weather, diseases, and pests. When "production shocks" are widespread, prices will be affected.

The model for the target stock of inventories is represented by:

$$(2) \quad I^*_{jt} = \alpha_j + \alpha_1 E_{t-1} Y_{jt} + \sum \alpha_2 E_{it-1} P_{ijt} + n_{jt},$$

where α_j is a fixed farm effect (to be estimated) that captures farm-specific effects on inventories which are thought to be slow to change, α_1 and α_2 are coefficients to be estimated, and n_{jt} is a random error term. For production agriculture, fixed effects may include the management skills and risk preferences of the farm operator, physical endowments of the operation, and available family labor (for further discussion, see Blinder; Carpenter, Fazzari, and Petersen). There are two opposing effects on producers' inventory decisions due to changes in prices. Increases in prices may cause producers to expect higher prices in the future, which leads them to increase inventories in order to take advantage of higher future prices. On the other hand, increases in prices may encourage producers to sell inventories immediately in order to profit from current high prices. Similarly, price decreases may induce producers to hold inventories in hopes of higher future prices or may lead producers to dispose of inventories because they fear that future prices will continue to fall.

Expected production and prices are forecasted with simple autoregressive models:

$$(3) \quad E_{t-1} Y_{jt} = \beta_j + \beta_1 Y_{jt-1} + \beta_2 Y_{jt-2} + w_{jt}$$

and

$$(4) \quad E_{it} P_{ijt+1} = \gamma_{ij} + \gamma_{1i} P_{ijt} + \gamma_{2i} P_{ijt-1} + z_{ijt},$$

where β_j and γ_{ij} are fixed farm effects to be estimated; β_1, β_2, γ_{1i}, and γ_{2i} are coefficients to be estimated; and w_{jt} and z_{ijt} are error terms.

Substituting equations (2), (3), and (4) into (1) yields the inventory investment regression equation:

$$\begin{aligned}(5) \quad I_{jt} - I_{jt-1} = & -\delta I_{jt-1} - \theta Y_{jt} \\ & + \sum (\omega_i \gamma_{1i} - \omega_i) P_{ijt} \\ & + \beta_1(\delta\alpha_1 + \theta) Y_{jt-1} \\ & + \beta_2(\delta\alpha_1 + \theta) Y_{jt-2} \\ & + \sum (\delta\alpha_{2i}\gamma + \omega_i\gamma_{1i}) P_{ijt-1} \\ & + \sum \alpha_{2i}\gamma_{2i} P_{ijt-2} + \lambda CF_{jt} + \mu_j \\ & + \mu_t + u_{jt},\end{aligned}$$

where μ_j is the linear combination of fixed farm effects, μ_t controls for time shocks, and u_{jt} is the linear combination of stochastic error terms.

Because of the panel nature of the data, there are most likely problems of heteroskedasticity. This is verified with the aid of Goldfeld-Quandt tests. To reduce heteroskedasticity, all variables are normalized by the beginning-of-period operating assets.[3] Although normalizing significantly reduces heteroskedasticity, Goldfeld-Quandt tests indicate that it still remains a problem. To handle the remaining heteroskedasticity, the models are estimated with generalized method of moments (GMM) (Hansen and Singleton). GMM is an instrumental variables procedure which is appropriate when the error variance relationship is unknown. (See the appendix for a list of instruments.) The variables are first differenced following Holtz-Eakin, Newey, and Rosen to account for fixed farm effects, and annual time dummy variables are added to the model to account for fixed time effects.[4]

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[3] Operating assets include owned assets plus leased land. In the current Kansas farm data set, the typical operator leases 55% of total operating acres.

[4] First differencing is used to account for fixed farm effects rather than dummy variables due to a problem associated with the dummy variable approach. A straightforward explanation of the problem associated with dummy variables is given by Chamberlain (p. 1248). The gist of the problem is that in the levels, a cross-section regression of y on x will give a biased estimate of β if the firm dummy coefficients are correlated with x, as would be expected. First-differencing y and x resolves this problem—as well as sweeping out the firm effects—if the change in x has sufficient variation.

In equation (5), not only is cash flow endogenous, but there is also an accounting identity by which cash flow and inventory investment are related. Cash flow typically is measured as cash sales less variable costs. Cash sales is equal to production less the change in inventories. If the change in inventories is somewhat small relative to production (as in the above cited studies with large industrial firms), then the effect on cash flow caused by a change in inventory is not a concern. However, when the change in inventories is typically large relative to production (as would be expected for farms), then cash flow and inventory investment are likely to be negatively related, contrary to the credit constraint hypothesis. Since financing for farm production typically is arranged in advance of actual production, it is the cash flow in the prior year that affects planned inventory fluctuation in the present year.

As a result of equation (4) being substituted into equation (1) twice, once current and once lagged, a moving average component is added to the error term. This implies generalized least squares would be the efficient estimator, although least squares is still consistent. We ignore the problems induced by the moving average process on the assumption that heteroskedasticity and the accounting identity are the more important problems, and that given the panel nature of the data, and the other hypothesized sources of random error (n_{jt} and w_{jt}), the bias induced by the moving average component of the z_{jt} is minor and can be ignored.

Data

The data consist of 417 farms which were continuously enrolled in the Kansas Farm Management Association (KFMA) program over the 1973–92 period (Langemeier). The KFMA takes the following steps to ensure that the data are complete and accurate: (*a*) operators record events as they occur, and not retrospectively; (*b*) standardized forms and accounting procedures are used; and (*c*) the process is supervised and reviewed by KFMA staff.

Classified according to dominant enterprises, the farms are composed of 250 cash crop, 21 livestock, 22 dairy, 99 mixed crop/livestock, and 25 general farms (Langemeier). About 75.3% of farms have both crop and livestock enterprises, 17.7% have exclusively crop enterprises, and 7% have exclusively livestock enterprises. Kansas is the largest U.S. producer of wheat and a top five beef cattle producer. Other cash crops grown in substantial quantities include corn, soybeans, and sorghum. Because typical KFMA farms are larger than average Kansas farms, the results should be considered as representative of Kansas full-time farm operators or commercial farms (see Featherstone, Griebel, and Langemeier for a comparison of KFMA and Department of Commerce census farms).

Farm inventories are composed of end-of-year inventories of grain, soybeans, hay and forage, feed, beef feeders, sheep feeders, hog feeders, poultry, fuel and oil, and livestock-crop supplies. Production is calculated as the sum of accrual sales of livestock, grain, soybeans, hay and forage; and sales of milk, eggs, fruit, wool, and hides. All inventories and production are valued at fair market price. Cash flow is the sum of beginning-of-period cash on hand, sales of machinery and equipment, government payments, and gross farm income less cash operating expenses, taxes, and interest payments. (See the appendix for additional definitions of model variables.)

Due to the high correlation among crop and livestock prices, and thus the potential for multicollinearity, only wheat and slaughter cattle and hog prices are chosen for inclusion in the model (Kansas Department of Agriculture). The slaughter hog price is included because hogs are the second most important feeder livestock industry, and hog inventories are sensitive to price swings. The wheat price is the annual per bushel price as reported by each of nine agricultural statistical districts in Kansas. The per cwt slaughter cattle and hog prices are annual state averages. The model assumes that all farms receive the same prices; this may not be an unreasonable assumption given that agricultural commodities are fungible, farms are price takers, and commodity prices have been shown to be temporally and

Table 1. Means and Standard Deviations for Kansas Farm Management Association Farms, 1976–92

		Farm Characteristics							
		Assets		Debt		Farm Types		Operators	
Variable	Full Sample	Small	Large	Low	High	Crop	Livestock	Young	Old
Noncapital Inventories ($)	151.5	89.5	238.0	131.0	159.5	114.3	197.6	162.4	128.7
	(182.8)	(161.3)	(215.2)	(150.9)	(230.9)	(122.3)	(244.2)	(190.3)	(135.0)
Inventory/Assets (%)	18.6	19.0	19.0	16.9	19.7	15.8	21.5	19.6	16.8
	(15.3)	(16.7)	(15.0)	(14.0)	(17.2)	(14.6)	(17.7)	(13.7)	(15.3)
Cash Flow ($)	87.7	63.2	113.7	95.4	72.7	104.8	73.9	88.0	88.4
	(84.1)	(58.3)	(103.7)	(82.4)	(89.2)	(78.5)	(95.9)	(81.2)	(84.1)
Owned Assets ($)	847.4	458.6	1,359.0	832.7	805.0	797.9	964.4	842.7	849.2
	(677.0)	(260.6)	(874.2)	(623.0)	(767.2)	(611.6)	(832.8)	(764.6)	(617.5)
Operating Assets ($)	1,532.6	1,077.7	2,190.2	1,396.4	1,558.6	1,536.1	1,574.8	1,594.8	1,474.5
	(1,027.5)	(655.2)	(1,229.6)	(901.4)	(1,168.1)	(1,037.7)	(1,093.8)	(1,123.8)	(940.2)
Sales ($)	295.1	199.6	424.6	240.0	345.9	264.2	371.3	318.8	262.7
	(328.0)	(333.6)	(359.1)	(224.8)	(456.7)	(198.1)	(478.4)	(356.3)	(229.6)
Operator Age (years)	53.0	50.5	54.0	54.9	50.8	52.9	53.5	44.9	59.9
	(10.9)	(9.4)	(11.8)	(11.1)	(10.7)	(11.1)	(11.3)	(7.6)	(11.4)
Debt/Asset (%)	29.6	34.8	27.2	13.3	49.2	28.8	33.1	37.9	20.3
	(29.1)	(34.7)	(25.4)	(16.9)	(33.6)	(32.4)	(29.4)	(31.5)	(22.4)
Livestock Inventory/Total	37.0	31.5	41.8	32.2	42.5	13.0	60.0	36.9	35.9
Inventory (%)	(30.3)	(29.5)	(30.5)	(29.0)	(32.4)	(20.4)	(24.5)	(29.3)	(32.0)
Irrigated Crop Acres	101.9	71.2	160.8	88.8	105.6	158.9	55.0	110.6	91.5
	(298.4)	(260.8)	(381.8)	(282.5)	(325.5)	(377.3)	(199.1)	(290.9)	(268.2)
Dryland Crop Acres	843.3	681.8	1,091.8	741.1	835.4	990.8	661.3	872.5	781.9
	(673.0)	(531.8)	(819.3)	(634.2)	(666.6)	(808.1)	(565.8)	(651.6)	(646.6)
Pasture Acres	602.2	296.5	1,027.2	507.2	664.8	232.8	997.5	569.6	625.5
	(924.9)	(371.9)	(1,304.8)	(724.3)	(1,139.6)	(336.5)	(1,163.6)	(829.3)	(934.7)
Feeder Cattle Inventories ($)	62.7	32.9	107.2	46.2	80.4	19.1	118.9	66.9	51.1
	(134.9)	(142.2)	(151.2)	(94.7)	(188.7)	(58.1)	(196.6)	(135.8)	(91.1)
Beef Cow Inventories ($)	28.6	17.5	43.0	23.8	29.7	7.9	46.4	35.9	24.4
	(56.5)	(141.6)	(76.7)	(37.2)	(75.1)	(18.4)	(82.6)	(68.9)	(45.0)

Table 1. (Continued)

		Farm Characteristics							
	Full	Assets		Debt		Farm Types		Operators	
Variable	Sample	Small	Large	Low	High	Crop	Livestock	Young	Old
Feeder Pig Inventories ($)	6.2	5.6	6.3	5.2	6.9	0.8	11.6	7.6	5.3
	(17.9)	(14.2)	(18.3)	(16.0)	(17.4)	(4.4)	(25.1)	(19.2)	(17.2)
Grain Inventories ($)	48.2	31.2	74.0	47.8	39.2	63.5	31.7	48.7	42.9
	(66.9)	(40.5)	(91.9)	(64.4)	(63.2)	(82.3)	(46.3)	(59.8)	(62.3)
Soybean Inventories ($)	11.2	6.2	14.8	11.3	8.4	14.4	5.6	14.8	8.4
	(26.9)	(15.5)	(32.6)	(27.1)	(22.2)	(32.7)	(18.2)	(29.2)	(23.7)
Hay/Forage Inventories ($)	15.3	8.8	23.5	12.4	16.8	11.9	19.2	15.7	14.8
	(21.3)	(11.9)	(29.2)	(15.2)	(27.1)	(23.3)	(21.9)	(20.4)	(24.6)
No. of Observations	7,089	2,363	2,363	2,363	2,363	2,363	2,363	2,295	2,448

Notes: Standard deviations are in parentheses. Dollar amounts are in thousands of 1992 dollars. All inventories are end of year. Acres include both owned and leased. (Refer to the appendix for sample split criteria.)

spatially linked by the cost of storage and transportation, respectively.

Unlike large, publicly held firms which are listed on stock exchanges and have bond ratings, there are no readily available criteria to place farms into a priori more and less credit-constrained splits. Here, farms are split according to asset size, debt-to-asset ratios, livestock-to-total inventory ratios, and operator age.[5] Small farms are thought to have less access to debt financing than large farms, presumably because they lack the necessary collateral to back up their borrowing and lack sufficient cash flow to service additional debt. The inventories of farms with relatively high debt should be more sensitive to cash flow because external lenders may be more reluctant to lend to them due to low collateral levels and higher risk. Similarly, the inventory investment of livestock farms should be more sensitive to cash flow because they are more dependent on short-term borrowing, and disinvestments in production inputs (feed and feeder livestock) are more reversible than disinvestments in crop inputs (primarily land and machinery). Older operators should be less credit constrained than younger operators because they have longer standing relations with their lenders, greater equity accumulations, and generally better financial variables.

Two regression models—one representing the upper one-third of farms and the other representing the lower one-third of farms—are estimated for each of the four credit-constraining criteria (see the appendix for details). The middle one-third of the farms are omitted in an attempt to obtain greater differences among sample splits. Equal sample sizes are used in order to avoid any potential test bias associated with sample size. Splits are based on presample farm means for 1973 and 1974. The models then are estimated using 1976–92 data. Separate models also are estimated for the 1976–80 "boom period," the 1981–86 "bust

[5] The credit scoring literature indicates that farm size, liquidity, profitability, leverage, and available collateral are factors which affect borrower quality (Turvey; Splett et al.; Miller and LaDue). The asset size, debt-to-asset ratio, and operator age splits follow Bierlen and Featherstone.

Table 2. GMM Estimates of Farm Inventory Investment Models by Asset Size and Farm Cycles

	Farm Cycle Period					
	1976–80 (Boom)		1981–86 (Bust)		1987–92 (Recovery)	
Variable	Small Asset	Large Asset	Small Asset	Large Asset	Small Asset	Large Asset
I_{jt-1}	−1.05159	−1.00422	−1.05633	−0.99192	−1.07801	−0.87140
	(8.42)	(17.25)	(15.51)	(17.35)	(9.00)	(12.53)
$PROD_{jt}$	0.46919	0.45126	0.37389	0.27475	0.41134	0.42092
	(7.25)	(11.83)	(8.42)	(8.13)	(7.68)	(9.22)
$PROD_{jt-1}$	0.05725	0.10846	0.05422	−0.03625	0.06731	0.07933
	(1.30)	(2.53)	(1.06)	(1.11)	(1.28)	(2.19)
$PROD_{jt-2}$	0.04553	−0.00743	−0.01311	−0.03643	−0.02409	0.11669
	(1.74)	(0.33)	(0.21)	(1.00)	(0.67)	(2.23)
$CASHFLOW_{jt-1}$	0.12270	0.04282	0.22308	0.10567	0.18275	0.08165
	(1.98)	(1.20)	(2.71)	(2.19)	(3.19)	(2.21)
$PWHEAT_t$	10.21326	−25.57446	−2.56395	27.72602	19.21617	11.77394
	(1.80)	(1.81)	(0.79)	(2.95)	(3.63)	(0.95)
$PWHEAT_{t-1}$	−4.91715	−2.47951	0.36606	−14.23183	−2.57088	−7.27915
	(1.80)	(0.43)	(0.06)	(1.25)	(0.48)	(0.59)
$PWHEAT_{t-2}$	−1.70407	1.39863	−9.40175	−34.76999	−5.51416	6.02468
	(1.37)	(0.45)	(1.75)	(3.38)	(1.12)	(0.44)
$PCATTLE_t$	−0.12538	0.97256	0.01373	−4.49863	−2.12833	−1.34568
	(0.50)	(1.51)	(0.03)	(3.54)	(4.75)	(1.12)
$PCATTLE_{t-1}$	−0.33472	0.88109	−0.30275	0.60333	0.43908	0.66278
	(2.01)	(2.43)	(0.82)	(0.95)	(0.80)	(0.52)
$PCATTLE_{t-2}$	0.40109	0.23873	0.36686	−0.02206	0.47681	−0.50623
	(1.74)	(0.66)	(1.53)	(0.03)	(1.09)	(0.44)
$PHOGS_t$	−0.42553	1.75837	0.34776	4.38914	1.98228	1.65374
	(1.35)	(2.65)	(0.95)	(3.58)	(4.41)	(1.20)

Table 2. (Continued)

Variable	Farm Cycle Period: 1976–80 (Boom) Small Asset	Large Asset	1981–86 (Bust) Small Asset	Large Asset	1987–92 (Recovery) Small Asset	Large Asset
$PHOGS_{t-1}$	0.70889	−1.21776	0.19665	−0.19797	−0.61537	−0.75327
	(2.84)	(1.96)	(0.56)	(0.18)	(1.16)	(0.62)
$PHOGS_{t-2}$	−0.25065	−0.33532	0.14619	2.87341	−0.27675	0.19035
	(0.96)	(0.71)	(0.40)	(3.34)	(0.70)	(0.18)
Adjusted R^2	0.6089	0.6639	0.5634	0.5379	0.5678	0.4156

Notes: Numbers in parentheses are absolute values of asymptotic *t*-values. The dependent variable is inventory investment. All equations are estimated by GMM. All variables are normalized by beginning-period operating assets and first differenced. Fixed annual time effects coefficients are not reported. (For sample split criteria and a list of instrumental variables, see the appendix.)

period," and the 1987–92 "recovery period." It is expected a priori that inventory investment will be the least sensitive to fluctuations in cash flow during the boom period and the most sensitive during the bust period.

Variable means by sample splits are reported in table 1. The full sample mean farm had nearly $850,000 in owned assets and over $1.5 million in operating assets. The mean farm operated 945 crop acres and 602 pasture acres. The mean ending inventory was $151,000, or about 18% of owned assets and just under 10% of operating assets. Feeder livestock represented about 37% of total inventories. Mean cash flow was $88,000 and sales $295,000, representing 10.3% and 34.8% of owned assets, respectively. The mean operator was 53 years old. The average farm had a debt-to-asset ratio of 0.296. There are significant differences among means by sample split criteria.

The mean large-asset farm had nearly three times the owned assets of the mean small-asset farm, $1.36 million versus $459,000. In operating assets, however, this relation was about two to one—$2.19 million versus $1.08 million. The mean low-debt and high-debt farms had similar owned assets, operating assets, and operating acres. However, mean debt-to-asset ratios diverged sharply. The mean low-debt farm had a debt-to-asset ratio of 0.133, while that of the mean high-debt farm was 0.492. The mean crop farm held only 13% of its inventories in livestock, compared to 60% for the mean livestock farm. This is reflected in their portfolio of operating acres. The mean crop farm had 1,150 crop and 233 pasture acres, while the mean livestock farm had 716 crop and 998 pasture acres. The mean young operator was 45 years of age compared to 60 years of age for the mean old operator. Both owned and operating assets, and cash flows were similar between the two age groups. However, the mean young operator had a substantially higher debt-to-asset ratio than the mean old operator, 0.379 versus 0.203.

Regression Results

All model coefficients are reported in table 2 (except the coefficients on the annual dummy variables) for the asset size splits. As expected, and consistent with other studies, the coefficients on lagged inventory investment are always negative, highly statistically significant, and robust across sample splits. The magnitudes of the coefficients indicate that adjustment speeds range from 87% to 108% per year. Adjustment speeds in excess of 100% indicate overadjustment, which is likely to occur when economies of scale are present. It is generally recognized that economies of scale exist for livestock feeding and for crop production and storage.[6] The time t production coefficients are positive and highly significant for all models, indicating a strong positive relation between current production and inventory investment levels.

The nine price variables are of mixed signs and generally not statistically significant. This is not surprising given that the cross-section component (139 farms) is much larger than the time-series component (five or six years) for each split. A positive sign on period t price of wheat suggests that high prices cause producers to store more newly harvested wheat, while a negative sign indicates that high prices cause producers to increase harvest-time sales. Since crops typically are not stored across marketing years (harvest to harvest), the price in year t should not affect the beginning-of-year crop inventory; i.e., we would expect producers to dispose of their old crops despite price levels. A positive coefficient for period $t - 1$ price of wheat indicates that (*a*) a high price in period $t - 1$ led the producer to cultivate more wheat in period t, and thus increase period t inventories, and/or (*b*) a high price in period $t - 1$ led the producer to increase harvest-time sales in period $t - 1$, and thus beginning of period t inventories were lower than normal. A negative coefficient for period $t - 1$ price of wheat indicates that a high price in period $t - 1$ led the producer to increase storage in period $t - 1$, and thus beginning of period t inventories were higher than normal. A positive coefficient for period $t - 2$ price of wheat could be attributed largely to a continued "production or supply effect." A negative coefficient on the period $t - 2$ price is more difficult to explain. It may merely be an indication of a complex lag structure. Except that cattle feeding inventories can be held for multiple years before sale, a similar interpretation can be placed on the signs of the slaughter cattle and hog price coefficients.

In this study, the main focus of interest is the cash flow coefficients. With the exception of boom period large-asset farms, all cash flow coefficients in table 2 are positive and statistically significant—indicating that inventory investment generally responds to movements in cash flow regardless of farm size or general farm conditions. As expected, the small-asset cash flow coefficient is consistently larger than the large-asset coefficient. Similarly, the magnitudes of the coefficients indicate that inventory investment is most sensitive to fluctuations in cash flow in the bust period, followed by the recovery and boom periods.[7] That the recovery cash flow coefficients are similar in magnitude to the bust coefficients is not surprising. The farm crisis period ushered in a more conservative management and lending regime which extended into the 1990s. Many farms also reacted slowly to the farm crisis due to false hopes for a quick recovery—postponing the decision to sell assets, reduce debt, and lower risk. This aggravated the situation and delayed recovery. (For further discussion,

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[6] Steigum notes that many adjustment costs (transaction, search, and information) are in fact concave. Interestingly, he argues that previous studies have found adjustment costs to be convex because they fail to account for the movements in internal funds—the primary impediment to adjusting inventories.

[7] A potential explanation of the asset size results is that small farms earn relatively more off-farm income and thus have less need for borrowing. This explanation does not appear valid here for several reasons. First, both the small and large farms are clearly of commercial size, and off-farm income is relatively unimportant for both. Over the study period, mean annual off-farm income (including wages, rent and royalties, and dividend and interest income) in 1992 dollars was $10,028 and $15,225 for small and large farms, respectively. Second, small farms had higher debt-to-asset ratios than large farms. Small farms had a mean debt-to-asset ratio of 0.348 and an equity stake in their total operating assets of only 34.4%. Large farms had a mean debt-to-asset ratio of 0.272 and an equity stake in their total operating assets of 50.3%.

Table 3. Asymptotic t-Values and p-Values for Tests of Differences Between Cash Flow Coefficients by Sample Splits

	Farm Characteristics							
	Assets		Debt		Farm Types		Operators	
Farm Cycle Period	Small	Large	Low	High	Crop	Livestock	Young	Old
Boom	1.119[a]		2.080		0.397		0.899	
	(0.264)		(0.038)		(0.692)		(0.369)	
Bust	1.233		1.855		3.077		1.714	
	(0.218)		(0.064)		(0.002)		(0.087)	
Recovery	1.408		1.853		2.281		2.851	
	(0.160)		(0.064)		(0.004)		(0.004)	
Boom vs. Bust	0.976	0.922	0.483	3.077	0.891	2.345	1.856	0.839
	(0.329)	(0.357)	(0.629)	(0.002)	(0.373)	(0.019)	(0.064)	(0.402)
Boom vs. Recovery	0.710	0.576	0.722	3.625	0.098	2.004	1.109	0.010
	(0.478)	(0.565)	(0.471)	(0.000)	(0.922)	(0.045)	(0.268)	(0.992)
Bust vs. Recovery	0.405	0.400	0.291	0.657	1.012	0.665	3.214	1.138
	(0.686)	(0.689)	(0.771)	(0.511)	(0.312)	(0.506)	(0.001)	(0.255)

Notes: Numbers in parentheses are p-values. Using asset size as an example, the hypotheses tested are boom small vs. boom large, bust small vs. bust large, recovery small vs. recovery large, boom small vs. bust small, boom large vs. bust large, boom small vs. recovery small, boom large vs. recovery large, bust small vs. recovery small, and bust large vs. recovery large. (Refer to the appendix for sample split criteria.)

[a] The asymptotic t-values are obtained by differencing the two estimated coefficients of interest and dividing by the square root of the sum of the two variances less twice the covariance [see Gujarati (p. 227) for details]. Because the farms can be thought of as i.i.d. samples from a larger population of farms, we expect the error terms to be uncorrelated across the equations, implying a zero covariance.

see Peoples et al.; Bultena, Lasley, and Geller; U.S. Department of Agriculture.)

Tests for statistical differences among the cash flow variables (table 3), however, fail to support the idea that large farms are less dependent on internal funds as a source of inventory investment funds than small farms, or that inventory investment becomes more sensitive to internal funds during periods of farm business downturns than upturns. This result may be an indication that (*a*) asset size is not a factor in determining credit constraints, (*b*) the difference in asset size between the two splits is not sufficient enough to indicate a difference, and/or (*c*) the investment behavior of farms with "average" financial variables, regardless of size, is not significantly affected by boom-bust cycles.

Excluding the boom period high-debt farms, all cash flow coefficients for the debt-to-asset ratio splits are positive and statistically significant (table 4). The nonsignificance of the boom high-debt coefficient is likely indicative of the high investment level (fueled by borrowing) of this group during the period. That the low-debt coefficients are statistically significant is not surprising since these farms tend to have a more conservative, "pay-as-you-go" managerial style. The high-debt coefficients are statistically larger than the low-debt coefficients in the bust and recovery periods at the 0.06 level. Although the low-debt coefficients increase in magnitude throughout the three periods, there is no statistical difference among them—indicating that farm business cycles do not affect farms with strong financial positions. The bust and recovery high-debt coefficients are statistically larger than the boom high-debt coefficient, but there is no statistical difference between the bust and recovery high-debt coefficients. These results are consistent with the notion that high-debt farms are especially vulnerable to credit constraints during periods of downturns. However, during periods with a strong farm econ-

Table 4. GMM Estimates of Cash Flow Coefficients by Sample Splits and Farm Cycles

	Farm Cycle Period		
Farm Characteristics	1976–80 (Boom)	1981–86 (Bust)	1987–92 (Recovery)
Low Debt	0.06158	0.08020	0.09083
	(2.06)	(3.31)	(3.33)
High Debt	−0.07078	0.24760	0.18413
	(1.26)	(2.85)	(4.35)
Crop Farms	0.04145	0.00135	0.04538
	(1.40)	(0.04)	(1.67)
Livestock Farms	0.01501	0.21309	0.16362
	(0.25)	(3.56)	(3.71)
Young Operators	0.11984	0.01599	0.05362
	(2.38)	(0.43)	(2.02)
Old Operators	0.05861	0.10639	0.05362
	(1.38)	(2.80)	(2.02)

Notes: Numbers in parentheses are absolute values of asymptotic t-values. The dependent variable is inventory investment. All equations are estimated by GMM. All variables are normalized by beginning-period operating assets and first differenced. Non-cash flow coefficient estimates are not reported. (See table 2 for a complete list of model variables; see the appendix for sample split criteria and a list of instrumental variables.)

omy, high debt-to-asset ratio farms are not credit constrained.

As shown in table 4, results indicate that farm type is an important factor in explaining the sensitivity of inventory investment to movements in cash flow. Among the crop farm coefficients, only the recovery cash flow coefficient is positive and statistically significant (although weakly so). The livestock cash flow coefficient is positive and statistically significant during the bust and recovery periods. While there is no statistical difference between the two boom period cash flow coefficients, the livestock farm coefficients are significantly larger than their crop farm counterparts during the bust and recovery periods. The bust and recovery livestock coefficients are significantly larger than the boom coefficient, but there is no statistical difference between the bust and recovery livestock coefficients. There is no statistical difference among the three crop farm coefficients. These findings support the notion that the inventories of farms with enterprises in which fixed assets are important are less sensitive to movements in internal funds than the inventory investment of farms with the opposite characteristics. However, during boom periods, the investment of neither crop nor livestock farms appeared to be sensitive to movements in cash flow.

There is no consistent relationship between the old and young operator cash flow coefficients. There is no statistical difference between the two coefficients during the boom period, and the old operator coefficient is statistically larger than the young operator coefficient in the bust period, while the opposite result occurs in the recovery period. Not unexpectedly, there is no statistical difference among the three old operator coefficients. Surprisingly, both the boom and recovery young operator coefficients are statistically larger than the bust coefficient, but there is no statistical difference between them. Based on these results, it is difficult to draw conclusions about the inventory investment-cash flow relation based on operator age.

The operator age results may be due to the distribution of the farm operator population in the data set and intergenerational farms. The age of operators tends to be skewed to age 35 and older. Here, to be included in the young operator split, farmers had to be less than 40.5 years old based on the 1973–74 mean. In reality, the young farmers were older than this during the sample period and not well distributed—being skewed to the right. In addition, farms tend to be intergenerational. It is likely that young farmers worked with their parents (and even grandparents) before becoming the principal operator, and parents (and even grandparents) may continue to actively participate in the business even after the child (or even grandchild) becomes the principal operator. Consequently, it is likely that much of the reputation enjoyed by the child (or grandchild) may be based on the reputation of the parents (and even grandparents) and that of the farm as an ongoing concern.

Summary and Conclusions

Study results show that: (*a*) farms absorb shocks to internal finance by adjusting inventories, (*b*) the inventory investment of high-debt farms and livestock farms is more sensitive to fluctuations in cash flow than the inventory investment of low-debt farms and crop farms, and (*c*) inventory investment was more sensitive to cash flow during the 1981–86 bust and the 1987–92 recovery periods than during the 1976–80 boom period. There is weak support that farm size and the age of the principal operator play a role in the determination of credit constraints.

The finding that the inventory investment of livestock farms is more sensitive to cash flow (an indicator of credit constraints) than the inventory investment of crop farms is consistent with the trend toward larger externally funded feeder livestock operations. While crop farms have lower feeder livestock inventories than livestock farms, they are in a better position to provide self-produced feed and forage and to finance their feeder livestock enterprises with cash flow generated from crop enterprises. This suggests that while there are financial incentives for large, externally funded feeder livestock operations, smaller feeder cattle (especially) and hog production enterprises likely will persist on crop farms.

The results by farm business periods are consistent with the financial accelerator concept. However, because the current study uses farm-level data from only one state, we are unable to comment on the effects of the financial accelerator on aggregate U.S. farm inventories. A direction for future study is to use U.S. aggregate or a panel of state aggregate data with a longer time series in an effort to quantify the effect of the financial accelerator on U.S. farm inventories. This approach also could be used to explore the importance of the financial accelerator—if any—on cattle and hog cycles.

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Appendix: Variable Definitions, GMM Instruments, and Sample Splits

Value of Land. Each farm reports the number of operating acres of irrigated cropland, nonirrigated cropland, and pasture. The Kansas Board of Agriculture reports annual per acre land values for irrigated cropland, nonirrigated cropland, and pasture land for nine statistical districts (Schlender). Land values are estimated by multiplying reported acreage by the district price and summing across land types.

Owned Assets. The sum of end-of-year inventories, owned land, stock of motor vehicles and machinery, breeding livestock, nonresidential buildings, and cash on hand. The depreciable capital stock is built up using the perpetual inventory method (see Bierlen and Featherstone).

Operating Assets. The sum of owned assets and leased land. The farm data set reports owned acres, leased acres, and total operating acres by land type. This enables the value of owned and leased land to be estimated. Each land type, regardless of ownership, is given the same per acre valuation within a statistical reporting district.

GMM Instruments. These include all explanatory variables; once and twice lagged values of land and cash sales; and current, once lagged, and twice lagged prices of soybeans and sorghum. All instruments are normalized by the beginning-of-period operating assets.

Sample Splits. Small-asset farms comprise the lower one-third of 417 Kansas farms in which mean 1973–74 owned assets are < \$480,480 (1992 dollars). Large-asset farms are the upper one-third of 417 Kansas farms in which mean 1973–74 owned assets are > \$748,072. Low-debt farms are the lower one-third of 417 Kansas farms in which mean 1973–74 debt-to-asset ratios are < 0.177. High-debt farms are the upper one-third of 417 Kansas farms in which mean 1973–74 debt-to-asset ratios are > 0.377. Crop farms are the lower one-third of 417 Kansas farms in which mean 1973–74 feeder livestock-to-total inventory ratios are < 0.147. Livestock farms are the upper one-third of 417 Kansas farms in which mean 1973–74 feeder livestock-to-total inventory ratios are > 0.410. Young operator farms are the lower one-third of 417 Kansas farms in which the mean 1973–74 operator age is < 40.5. Old operator farms are the upper one-third of 417 Kansas farms in which the mean 1973–74 operator age is > 48.