Debt Depreciation, Conglomeration, and Credit Constraints: Evidence from Cattle Cycles

Abstract

A breeding cattle inventories example is used to study the effects of debt depreciation and firm conglomeration on credit constraints. Breeding cattle inventories is an interesting example to study credit constraints because it is among the most cyclical of economic time-series and firms have differential conglomeration levels. The results are consistent with previous credit constraint studies, i.e., breeding cattle inventories are sensitive to debt depreciation and firms with higher conglomeration levels are less affected by credit constraints.

Ralph Bierlen[1]
Bruce L. Dixon
Bruce L. Ahrendsen
Dept. of Agric. Econ. and Agribusiness
221 Agri. Bldg.
University of Arkansas
Fayetteville, AR 72701
(501)-575-2130
rbierlen@comp.uark.edu

Selected Paper

Annual Meeting of the American Agricultural Economics Association
Salt Lake City, Utah, August 2-5, 1998

---

[1]Ralph Bierlen, Bruce L. Dixon, and Bruce L. Ahrendsen are research associate, professor, and associate professor, respectively, in the Department of Agricultural Economics and Agribusiness at the University of Arkansas. Dixon and Ahrendsen are principals of the Center for Farm and Rural Business Finance. This material is based upon work supported by USDA-CSREES Agreement No. 95-34275-1319. The authors would like to thank David Hennessy, Charles P. Himmelberg, and Terry Kastens for their helpful suggestions and comments.

Debt Depreciation, Conglomeration, and Credit Constraints: Evidence from Cattle Cycles

In the investment literature there has been a revived interest in the wedge between the costs of internal and external investment funds due to imperfections in capital markets--commonly referred to as credit constraints. Empirical studies have taken two approaches to test the credit constraint hypothesis. The first approach, historical case studies, emphasizes the role of debt deflation--the erosion of borrowers' net worth relative to debt burdens during periods of severe economic downturns which reduces real output by tightening credit to information-intensive borrowers. The second approach uses firm-level panel data to estimate standard investment regression models (the most common being q theory) appended with a cash flow variable. Higher investment-cash flow sensitivities for firms with greater informational and incentive problems are taken as evidence of credit constraints.

Several studies--focusing on the 1921-1933 and the 1981-1986 periods--point to agricultural credit availability as being particularly affected by debt deflation. The current study follows in the tradition of previous agricultural credit constraint studies in emphasizing episodes of debt deflation, but focuses on beef breeding cattle, one of the most periodic of economic cycles.[1] The focus is on breeding cattle inventories because it is at that level that the decision is made to either breed or consume beef cattle--the decision which is thought to largely drive cattle cycles. Cattle prices and the value of breeding cattle inventories follow similar cycles which generally lead inventory cycles. These relationships are consistent with increasing net worth

---

[1]Bierlen et al. (forthcoming) is the only previous study which has tested the credit constraint hypothesis for beef cattle firms. The results presented here, however, are generally not comparable to Bierlen et al. (forthcoming) because of differences in models, data sets, and a cattle cycle versus a general agricultural boom-bust orientation.

inducing inventory buildups and declining net worth inducing liquidations through the net worth/credit availability mechanism.

A potential response of cattle breeding firms facing debt deflation induced credit constraints is to conglomerate. Specifically, in many cattle firms, cattle is only one of several enterprises--the others being crop and other livestock enterprises whose asset values are not generally affected by shocks to breeding cattle asset values. Another important method of conglomeration for breeding cattle firms is for managers to pursue off-farm employment. Due to periodic debt depreciation and differential levels of conglomeration, the beef breeding cattle example is able to combine the historical case study with the panel data approach.

In spite of advances in modeling, recent breeding cattle inventory studies have ignored the potential role of credit constraints in amplifying and propagating cattle cycles. Recent studies emphasize biological constraints and the decision to either breed or consume breeding cattle as the driving forces behind cattle cycles. These breeding/consumption decisions alter the age distribution of breeding cattle inventories and, when combined with biological constraints, cause cyclical “echo” responses as the age distribution converges to a stable equilibrium (Rosen et al.).

That the credit availability of cattle breeding firms is tied to net worth is plausible for several reasons. Credit is virtually the only source of external investment funds. Due to market efficiencies, lenders can readily value land and breeding cattle inventories. Because neighboring firms can acquire and manage land and breeding inventories with low transaction costs and breeding inventories can readily be sold to abattoirs or to the finishing industry, breeding cattle assets are redeployable and thus have high liquidation values. Because breeding cattle assets have high liquidation values, lenders can readily sell them at their value in best use with minimal transaction costs. This makes breeding cattle assets strong candidates for debt financing.

Separate models are estimated with state-level panel data for beef cows and replacement heifers--the two major components of beef breeding herds--in order to test the hypothesis that breeding cattle firms adjust their inventories of beef cows, but not replacement heifers, in response to shifting levels of credit availability.

Breeding Cattle Inventory Models, Data, and Conglomeration Groupings

The following beef cattle and heifer replacement equations from Foster and Burt, appended with a cash flow variable, are estimated to test the credit constraint hypotheses:

Beef cows: $C_t = a_0 + a_1C_{t-1} + a_2P_{t-2} + a_3H_{1,t-1} + a_4CF_t + z_t,$ **(1)**

Heifer replacements: $H_{1t} = b_0 + b_1P_{t-1} + b_2H_{1t-1} + b_3H_{1t-2} + b_4(C_{t-2} - b_2C_{t-3} - b_3C_{t-4}) + b_5CF_t + u_t,$ **(2)**

where the a_k and b_k are unknown parameters to be estimated, C_t is the number of beef cows at time t, H_{1t} is the number of replacement heifers, P_t is the price of calves, CF_t is cash flow, and z_t and u_t are random disturbance terms. We assume that replacement heifers are one year of age and beef cows are two years of age and older.

A complication in estimating equations (1) and (2) is that current cash flow is likely endogenous. To handle the endogeneity problem here, models are estimated with two-stage least squares in which binary variables are added to equations (1) and (2) to account for fixed state effects. Fixed time effect dummy variables are not included because they are highly collinear with the price of calves--which should account for the primary time shocks to beef cow and replacement heifer inventories.

In keeping with the goal of being able to reach conclusions at the aggregate level, while exploiting the advantages of panel data, the econometric models are estimated with 1966 through 1995 annual data for the 32 states (see the Appendix for a list) with the largest breeding cattle inventories. Inventory numbers are taken from Agricultural Statistics (various years); calf prices from Agricultural Prices: Annual Summary (various years); and cash flow from Economic Indicators of the Farm Sector: State Financial Summary (various years) and unpublished data from the USDA's Economic Research Service. State beef cow and replacement heifer inventories are estimated at the beginning of each calendar year, calf prices are weighted annual state averages, and cash flow is annual net cash income.

In order to split the time-series element of the data into more and less credit constrained years, we utilize the net worth-credit constraint relation, i.e., a negative shock to cattle prices reduces net worth and increases credit constraints. A positive price shock has the opposite effect. Since net worth, and thus credit constraints, are driven by calf prices, investment-cash flow sensitivities will be higher in periods of falling than rising calf prices. To test this hypothesis, separate inventory equations are estimated for a 15 year period of falling calf prices and a 15 year period of rising calf prices. Years of falling calf prices include 1974 through 1977, 1980 through 1986, and 1992 through 1995. Years of rising calf prices include 1966 through 1973, 1978 and 1979, and 1987 through 1991.

To test the ability of breeding cattle firms to reduce credit constraint levels through conglomeration, states are subsequently sorted into high and low conglomeration groupings for an alternative set of estimated models. The procedure for grouping the states into two equal conglomeration groupings of 16 is described in the Appendix.

Model Results

Two-stage least squares coefficient estimates for the full sample beef cow and replacement heifer equations are reported in Table 1. Hausman tests reject cash flow exogeneity in both the 1966-95 beef cow and replacement heifer equations--thus our choice of a two-stage least squares is appropriate. As expected, all the 1966-95 beef cow equation coefficient estimates in section A of Table 1 are positive and all are statistically significant at the 1% level. That the once-lagged beef cow and replacement heifer inventory coefficient estimates of 0.769 and 0.505, respectively, are similar in magnitude to Foster and Burt's estimates of 0.801 and 0.409, is encouraging. Because of their use of U.S. aggregate data, Foster and Burt's (1992) twice-lagged calf price coefficient estimate of 215.5 is much larger than the estimate of 0.392 here.

The main focus of interest is the cash flow coefficient estimate. With a coefficient estimate of 0.223 and a t-ratio of 3.09, the cash flow coefficient is positive as expected and significant at the 1% level. This agrees with the hypothesis that beef cow inventory levels are sensitive to movements in cash flow and that breeding cattle firms are credit constrained.

Consistent with the 1966-95 coefficient estimates, the non-cash flow coefficient estimates in the falling and rising net worth equations in section A are positive and significant at the 1% level. Smaller lagged beef cow and larger lagged replacement heifer coefficient estimates in the falling than in the rising net worth equation are consistent with the notion that during periods of falling prices and tighter credit, breeding cattle firms cull beef cows at a higher rate--therefore making replacement heifers a relatively more important component of the breeding herd and having the effect of decreasing the mean herd age. This positions breeding cattle firms to maximize calf output for the next price upswing. Similarly, during periods of rising prices and looser credit, breeding cattle firms retain a higher number of beef cows--and non-producing replacement heifers become less important--in order to maximize current calf production.

Consistent with the hypothesis that credit availability decreases with falling net worth, the falling net worth cash flow coefficient estimate is large and significant at the 1% level, while the rising net worth coefficient estimate is small and insignificant. The hypothesis that the two cash flow coefficient estimates are equal is rejected at the 1% level on a one-sided test which is how we test all differences in magnitude of cash flow coefficients.

Unlike the beef cow inventory equations, only the once-lagged replacement heifer inventory and once-lagged calf price coefficient estimates are consistently of the anticipated sign (positive) and significant in the replacement heifer equations in Table 1, section B. This is contrary to Foster and Burt in which the twice-lagged beef cow and twice-lagged replacement heifer inventory coefficients are also significant. The 1966-95 once-lagged replacement heifer inventory coefficient estimate of 0.743 is smaller than Foster and Burt's estimate of 1.31. However, if like here, Foster and Burt's coefficient estimate for the twice-lagged replacement heifer inventory coefficient is zero (it in fact is -0.560), their coefficient estimate on once-lagged heifer inventories would likely be about 0.75. Consistent with the once-lagged beef cow coefficient estimate in the beef cow inventory equations, the coefficient estimate on once-lagged heifer inventories is larger in the period of rising than falling net worth, 0.856 versus 0.636.

The 1966-95, and falling and rising net worth replacement heifer cash flow coefficient estimates are all small (less than 0.07) and only the 1966-95 coefficient estimate is significant. These and the beef cow results indicate that: 1) replacement heifer inventories may be affected by credit constraints, but the replacement heifer inventories-credit constraint relation is not sensitive to shifting net worth, and 2) in response to shifting net worth, breeding cattle firms choose to largely adjust their beef cow--and not their replacement heifer--inventories.

We now estimate inventory equations to test the hypothesis that the inventory levels of breeding cattle firms with higher conglomeration levels are less sensitive to credit constraints. Initially, we utilize the fact that beef calves are produced by both specialized and non-specialized breeding cattle firms as defined in the Appendix. We hypothesize that non-specialized cattle breeding firms are less credit constrained than specialized cattle breeding firms because shocks to cattle breeding assets affect net worth less. The specialized group includes states primarily in the Rockies, Northwest, and California, but also five southeastern states. States in the non-specialized group include the Midwest and Plains states plus Washington and five southeastern states.

The non-cash flow coefficient estimates in section A of Table 2 are all positive and significant at least at the 5% level. The magnitudes of the once-lagged beef cow inventory and once-lagged replacement heifer inventory coefficient estimates in the falling and rising net worth equations have the relationships indicated in the full sample discussion.

There is a substantial difference in investment-cash flow sensitivities between the specialized and non-specialized groupings in section A. The 1966-95 specialized cash flow coefficient estimate is over four times the magnitude of the 1966-95 non-specialized cash flow coefficient estimate, 0.545 versus 0.123, and is significantly different from zero at a higher level, 1% versus 10%. That the specialized 1966-95 cash flow coefficient estimate is significantly larger than the non-specialized 1966-95 cash flow coefficient estimate at the 1% level is consistent with the hypothesis that firms with higher conglomeration levels are less credit constrained. The falling net worth cash flow coefficient estimate is significantly larger than the rising net worth cash flow coefficient estimate at the 1% level for both the specialized and non-specialized groupings. This result is consistent with the full sample models and is further support that credit constraint levels are sensitive to shifting net worth under the asymmetry of information hypothesis. That the specialized cash flow coefficient estimate is significantly larger at the 5% level than the non-specialized cash flow coefficient estimate in the falling, but not the rising net worth regime, indicates that the effects of conglomeration in alleviating credit constraints is more important in periods of falling than rising net worth.

The non-cash flow coefficient estimates for the replacement heifer inventory equations in section B of Table 2 are consistent with the full sample coefficient estimates. All of the cash flow coefficient estimates are relatively small and insignificant. There are no significant differences among the cash flow coefficient estimates. These results are consistent with the notion that breeding cattle firms largely adjust their beef cow--and not replacement heifer-- inventories in response to shifting credit constraints.

In results not presented here because of space limitations, we test the conglomeration hypothesis with respect to differential levels of off-farm income. We hypothesize that cattle breeding firms with substantial off-farm income are less credit constrained due to conglomeration effects--specifically that loans to breeding cattle firms with substantial off-farm income are perceived as less risky because they are better able to meet loan payments regardless of shocks to breeding cattle assets. We determine whether breeding cattle firms have substantial off-farm income based on whether the firm operator is full- or part-time on the farm. The grouping with a high percentage of part-time operators is denoted as “high off-farm income” and the other grouping as “low off-farm income” as described in the Appendix.

In general, the off-farm income groupings for the cow inventory equation offer some support for the ability of conglomeration to reduce credit constraints, but the results are not as compelling as the firm specialization groupings. There is no statistical difference among the cash flow coefficient estimates of the heifer equations. This further supports of the notion that breeding cattle firms largely adjust their beef cow--and not replacement heifer-- inventories in response to shifting credit constraints.

Summary

We use a breeding cattle industry example to further explore investment-cash flow sensitivities using combined historical case study and panel data approaches. By appending a cash flow variable to a reduced form investment model and testing the hypotheses that firms become more credit constrained during periods of falling net worth, we find that firms with higher conglomeration levels are less credit constrained, and breeding cattle firms adjust beef cow--and not replacement heifer--inventories in response to shifting credit constraints.

Results are consistent with earlier studies. Breeding cattle inventories are found to be sensitive to movements in cash flow, particularly during periods of falling net worth, which is consistent with debt deflation. Similarly, the inventories of breeding cattle firms with higher conglomeration levels are less affected by credit constraints, especially during periods of falling net worth--consistent with the credit constraint under asymmetry of information hypothesis. Finally, equation estimates support the hypothesis that breeding cattle firms adjust beef cow--and not replacement heifer--inventories in response to shifting credit constraints. All of these findings indicate that credit constraints play a role in amplifying and propagating cattle cycles.

Table 1. Full Sample 2SLS Beef Cow and Replacement Heifer Inventory Equations

	$Cows_{t-1}$	$Cows_{t-2}$	$Heif_{t-1}$	$Heif_{t-2}$	$Pcalf_{t-1}$	$Pcalf_{t-2}$	$Cash_t$	N	R^2
A. Beef Cow Inventory Equations									
1966-95	0.769	-	0.505	-	-	0.392	0.223	960	0.988
	(31.01)		(4.85)			(5.18)	(3.09)		
Falling net worth	0.663	-	0.714	-	-	0.316	0.309	480	0.983
	(16.04)		(4.34)			(5.17)	(2.83)		
Rising net worth	0.827	-	0.552	-	-	0.358	0.029	480	0.996
	(38.49)		(4.92)			(4.26)	(0.39)		
B. Replacement Heifer Inventory Equations									
1966-95	-	0.013	0.743	-0.021	0.146	-	0.070	960	0.950
		(0.68)	(14.06)	(0.43)	(4.93)		(2.60)		
Falling net worth	-	0.004	0.636	0.048	0.231	-	0.043	480	0.938
		(0.11)	(9.24)	(0.69)	(3.67)		(0.98)		
Rising net worth	-	0.035	0.856	-0.035	0.071	-	0.035	480	0.965
		(1.60)	(10.47)	(0.56)	(2.28)		(1.35)		

Notes: The dependent variable in section A is thousands of head of beef cows and in section B is thousands of head of replacement heifers. The absolute values of the asymptotic t-values are in parentheses. The period of falling net worth includes 1974-77, 1980-86, and 1992-1996. The period of rising net worth includes 1966-73, 1978-79, and 1987-91. Coefficients on state dummy variables are not reported. All regressions use White's consistent standard errors. See Table 1 for a list of the 32 states included in the regressions.

Table 2. 2SLS Beef Cow and Replacement Heifer Inventory Equations by Firm Specialization

	$Cows_{t-1}$	$Cows_{t-2}$	$Heif_{t-1}$	$Heif_{t-2}$	$Pcalf_{t-1}$	$Pcalf_{t-2}$	$Cash_t$	N	R^2
A1. Specialized Beef Cow Inventory Equations									
1966-95	0.802	-	0.272	-	-	0.332	0.545	480	0.983
	(23.32)		(2.27)			(4.74)	(3.37)		
Falling net worth	0.675	-	0.492	-	-	0.320	0.846	240	0.974
	(12.47)		(2.69)			(4.31)	(3.19)		
Rising net worth	0.862	-	0.379	-	-	0.296	0.108	240	0.992
	(29.99)		(2.65)			(3.22)	(0.72)		
A2. Non-Specialized Beef Cow Inventory Equations									
1966-95	0.675	-	0.831	-	-	0.788	0.123	480	0.990
	(11.34)		(4.34)			(5.72)	(1.80)		
Falling net worth	0.435	-	1.401	-	-	0.629	0.259	240	0.988
	(4.44)		(3.90)			(3.42)	(2.72)		
Rising net worth	0.852	-	0.735	-	-	0.763	-0.019	240	0.995
	(20.19)		(4.65)			(4.40)	(0.25)		
B1. Specialized Replacement Heifer Inventory Equations									
1966-95	-	0.033	0.722	-0.036	0.123	-	0.080	480	0.933
		(0.42)	(10.93)	(0.64)	(5.27)		(1.34)		
Falling net worth	-	0.024	0.675	0.023	0.213	-	0.014	240	0.913
		(0.60)	(7.42)	(0.27)	(3.77)		(0.13)		
Rising net worth	-	0.030	0.801	-0.006	0.072	-	-0.007	240	0.951
		(1.15)	(7.67)	(0.08)	(2.16)		(0.10)		
B2. Non-Specialized Replacement Heifer Inventory Equations									
1965-95	-	-0.011	0.655	0.070	0.434	-	-0.003	480	0.957
		(0.41)	(8.50)	(0.93)	(7.29)		(0.11)		
Falling net worth	-	-0.015	0.497	0.161	0.513	-	0.004	240	0.949
		(0.38)	(5.97)	(1.77)	(4.66)		(0.10)		
Rising net worth	-	0.021	0.954	-0.115	0.303	-	0.012	240	0.971
		(0.77)	(9.28)	(1.05)	(4.65)		(0.51)		

Notes: The dependent variable in section A is thousands of head of beef cows and in section B is thousands of head of replacement heifers. The absolute values of the asymptotic t-values are in parentheses. The period of falling net worth includes 1974-77, 1980-86, and 1992-1996. The period of rising net worth includes 1966-73, 1978-79, and 1987-91. Coefficients on state dummy variables are not reported. All regressions use White's consistent standard errors. See the Appendix for states included in each grouping.

Appendix

Table A. Conglomeration Grouping Criteria

Sample split	Mean	S.d.	High	Low
% Specialized firms	75.7	7.3	88.7	65.6
% Non-specialized firms	43.1	14.3	62.1	16.5
% Low Off-Farm Income	42.0	8.1	55.7	31.4
% High Off-Farm Income	28.9	1.9	31.0	25.2

Source: calculated by authors from 1978 Census of Agriculture.

Notes: The procedure for grouping is to first order the 32 states by the 1978 means of the pertinent conglomeration criteria and then split the ordered means at the fiftieth percentile By this method, the 32 state sample is sorted into two equal conglomeration groupings of 16. Specialized firms are the 16 states with the highest percentages of specialized breeding cattle firms. Non-specialized firms are the 16 states with the lowest percentages of specialized breeding cattle firms. Specialized breeding cattle firms are defined as those breeding cattle firms in which 50% or more of sales are from cattle except feedlots (SIC number 0212).   Specialized firm states in descending order include Nevada, New Mexico, Wyoming, Texas, Montana, Oklahoma, California, Oregon, Utah, Colorado, Louisiana, Arkansas, Florida, Mississippi, Idaho, and Virginia. Non-specialized firm states in descending order include Alabama, Washington, Tennessee, South Dakota, Missouri, North Dakota, Kansas, North Carolina, Nebraska, Georgia, Kentucky, Ohio, Minnesota, Indiana, Iowa, Illinois.

Low-off-farm income firms are the 16 states with the highest percentages of beef breeding managers who worked zero days off the farm (SIC code 0212). High-off-farm income firms are the 16 states with the lowest percentages of beef breeding firms who worked zero days off the farm. Low off-farm income states are in descending order: South Dakota, North Dakota, Montana, Nebraska, Wyoming, Nevada, Kansas, Colorado, Iowa, New Mexico, Idaho, Kentucky, Missouri, Virginia, California, and Oklahoma. High off-farm income states in descending order are: Arkansas, Utah, Oregon, Minnesota, Illinois, Georgia, Louisiana, Tennessee, North Carolina, Texas, Florida, Mississippi, Ohio, Alabama, Indiana, Washington.

References

Bierlen, Ralph, Peter J. Barry, Bruce L. Dixon, and Bruce L. Ahrendsen. "Credit Constraints, Farm Characteristics, and the Farm Economy: Differential Impacts on Feeder Cattle and Beef Cow Inventories." *The American Journal of Agricultural Economics*. (forthcoming)

Foster, Kenneth A. and Oscar R. Burt. "A Dynamic Model of Investment in the U.S. Beef-Cattle Industry." *Journal of Business and Economic Statistics*. 10(1992): 419-426.

Rosen, S., K.M. Murphy, and J. Scheinkman. " Cattle Cycles." *J. Pol. Econ.* 102(1992):468-492.

United States Department of Agriculture, National Agricultural Statistics, *Agricultural Statistics*. Washington DC, various years.

United States Department of Agriculture, Economic Research Service. *Economic Indicators of the Farm Sector: State Financial Summary*. Washington DC, various years.

United States Department of Agriculture, National Agricultural Statistics Service. *Agricultural Prices: Annual Summary*. Washington DC, various years.