Adoption of Backgrounding on Cow-calf Farms

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Abstract

A discrete choice model is used to analyze the decision to feed or sell calves at weaning. After accounting for regional factors, results show that operator perceptions towards profitability, risk, and facilities as well as control over production and attention to marketing impacted retained ownership of calves. Farm size had a minimal impact.

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Introduction

Agricultural policy analysts and extension personnel are often interested in the kind of factors that drive the adoption of value-added production systems on farms. For example, why do some cattle ranchers invest in backgrounding weaned calves while others do not? Further, how can outreach efforts to encourage downstream diversification be targeted given the diversity of agricultural producers? At the heart of the decision to adopt a new farm enterprise is the profitability of the enterprise relative to other investment alternatives. Often adoption is also conditioned by factors such as perceptions of riskiness, size of operation, and the required knowledge or experience to perform the tasks involved with the enterprise.

The objective of this paper is to analyze factors that impact the decision to feed weaned calves to heavier weights as a value-added enterprise alternative on their farms. The relative importance of these factors should aid decision makers on which factors to focus. Unique survey data from a cross section of beef producers in Arkansas is available to investigate differences between operators who operate a traditional cow-calf enterprise without any downstream diversification and those that had added backgrounding to their operation.

The Backgrounding Decision

The decision to background calves is not well understood. Cow-calf operators often follow a traditional production-marketing strategy characterized by seasonal calving and subsequent sale of calves at time of weaning (Schroeder and Featherstone, 1990). However, agricultural economists frequently suggest other strategies, often with cattle backgrounding systems, that could increase profitability (Lambert, 1989; Feuz and Wagner, 1996; Johnson, Ferguson and Rawls, 1989; Pardue, Popp and Garner, 1997; Watt, Little and Petry, 1987;

Schroeder and Featherstone, 1990; Ethridge et al., 1990). Further, Young and Shumway (1991) and Biswas et al. (1984) show that rational decision making and profit motivation generally explain the behavior of cow-calf producers, particularly when they are full-time ranchers and accrue a large share of their revenue from cattle.

Why then the dichotomy between the results of research studies and the actual management practices of cow-calf producers? *First*, producers might be very risk averse (Lambert, 1989). According to Schroeder and Featherstone (1990) as well as Rawlins and Bernardo (1991) the option of calf retention involve complex, dynamic decisions that depend upon stochastic price and rangeland or pasture decisions -- the more risk averse the producers, the less attractive calf retention is as a production/marketing strategy. *Second*, cash flow and labor constraints might limit the ability to retain calves (Lambert, 1989). Also, the ability of cow-calf producers to adopt downstream value-added cattle feeding activities may be subject to the same type of complexities encountered in the literature on technology adoption in other sectors (Feder, 1982). *Third*, some production/marketing strategies depend on benefitting from price cycles and seasonal variation, often requiring complex calculations. Not everyone has the skills or managerial ability to follow these strategies (Ethridge et al., 1990).

Methodology

Most of the studies cited above derive optimal production/marketing plans and then reflect on whether those plans accurately describe the general behavior of cow-calf producers. An alternative modeling choice is the double-hurdle model (e.g. Young and Wilson, 1996; Haines et al., 1988). A double-hurdle model envisions a multi-step process where a simple discrete ("adopt or not") decision is followed by a quantitative ("how many") decision. When these two decisions

occur simultaneously and with the same explanatory variables the double-hurdle model is equivalent to a TOBIT model (Young and Wilson, 1996). We hypothesize that the two decisions involve different factors. Specifically, a farm's financial condition, its labor situation, and the risk attitude of the farm operator would significantly affect the level of adoption in any given year. Another approach, when micro-level financial, labor and risk data are not available, is to directly analyze only the first step, the discrete choice decision to retain calves, as follows:

$$(1) \quad OPT_i = a_0 + a_k X_{ki} + \epsilon_i \qquad (k = 1, 2 \ldots K;\ i=1, 2 \ldots N)$$

where OPT_i is the i^{th} producer's decision to sell calves at weaning ($OPT = 0$ for traditional cow-calf) or to keep feeding the animal ($OPT = 1$ for value-added producers), $k = 1 \ldots K$, is the number of explanatory variables (X), a_0 is a constant term, a_k are the coefficient estimates and ϵ_i is the error term for each of i = 1 ... N observations.

Linear probability models (LPM) are often used to capture this type of relationship but introduce the statistical problem of heteroskedasticity (Gujarati, 1995). Logit analysis, where the logarithm of the odds ratio in favor of feeding weaned calves is used instead, removes this problem of heteroskedasticity (Gujarati, 1995; Aldrich and Nelson, 1984). The interpretation of coefficient estimates is more complex, however, as the magnitude of the effect of the explanatory variable on the dependent variable changes as follows (Aldrich and Nelson, 1984):

$$(2) \quad W_{ki} = \frac{\partial P(OPT=1)}{\partial X_k} = \frac{e^{Z_i}}{(1+e^{Z_i})^2} \cdot a_k$$

where Z_i is calculated at various levels of X_{ki} to show changes in W_{ki}, the marginal impact at various levels of the independent variables. W_k indicates the impact of a one unit change in the

explanatory variable on the likelihood that an operator chooses to background calves and the absolute value of the coefficient estimate directly measures its relative importance.

Data

All data were taken from a 1996 mail survey that was conducted on Arkansas beef cattle producers in order to determine their production and marketing practices. Independent of production region, a random sample of producers with more than 50 and less than 1,000 head of cattle was surveyed with the help of the Arkansas Agricultural Statistical Service. Operations in this size category represented approximately 40% of beef producers and nearly 80% of beef cattle in Arkansas. The mail return rate was 42.3%.

Two respondent categories were established to model the dichotomous choice of adoption of a value-added cattle feeding activity: (1) those that have not adopted value-added production are labeled "traditional cow-calf producers" and (2) those that have diversified downstream by backgrounding calves are "value-added producers".

As the literature on the "enterprise adoption/extension" decision of backgrounding is limited, we looked to the technology adoption literature where farm size, human capital (age, education, access to extension services), risk, and relative input/output prices are considered key factors in the adoption process (Feder and Slade, 1984; Caswell and Zilberman, 1985; Dorfman, 1996; Harper et al., 1990; Dinar and Yaron, 1990).

Farm Size. Farm size is usually positively related to technological adoption (Feder and Slade, 1984; Dorfman, 1996), although it may not always be significant (Harper et al., 1990). Dinar and Yaron (1990) argue that larger units are more likely to adopt a new technology, although this may depend upon the lumpiness or scale of the investment, and complementarities to

other production processes (Feder, 1982). Backgrounding of weaned calves -- which is often complementary to other farm activities -- can be undertaken on a fairly small scale and typically does not represent a particularly lumpy investment. The size of the cow herd (*SMALL* and *LARGE*) and the acreage used for cattle (*LAND*) can be used to test whether farm size is important in the adoption of backgrounding calves.

Human Capital. Higher levels of human capital (education, age and experience) generally increase the likelihood that new technologies will be adopted. Empirical results tend to be sensitive to the variable used because the impact of education can be complex (Dinar and Yaron, 1990, Rahm and Huffman, 1984). For example, higher levels of education should, *ceteris paribus*, increase the likelihood of adoption but better education is also likely to change perceptions of off-farm labor possibilities (Dorfman, 1996). Age and experience can also have intricate effects. We use a dummy variable for education by separating respondents into those having attended university (*UNIV* = 1) and those that have not (*UNIV* = 0). Age and experience in cow-calf production tend to decrease the likelihood that profit-motive is a stated goal because operators who have been in the business for a long time may have higher levels of built-up equity (Young and Shumway, 1991). As the effect of age is not expected to be constant over the entire age range, a categorical variable (default age of 61 years or older) is used. The other two age categories were *YOUNG* (< 40 years old) and *MIDDLE* (between the age of 41 and 60).

Risk and Diversification. Similar to Young and Shumway (1991) we use an opinion variable to measure attitudes toward risk. The operator's opinion regarding price risk associated with backgrounding calves is hypothesized to capture differences across the two operation types. As the *RISK* variable captured a problem with backgrounding and was scaled from 1 to 5 for

strongly agree to strongly disagree, respectively, we expect a positive coefficient on the likelihood that backgrounding will occur (see expected impacts of opinion variables in Table 1).

Another risk management strategy is business diversification through other farm enterprises (*NOTHER*). We hypothesize that operations that are already involved with value-added production on their farm may follow a similar path in their beef operation by feeding their calves to heavier weights. To test for this, the number of livestock raised commercially on farm, other than commercial beef cattle, was generated from yes/no responses on livestock categories of purebred cattle, poultry, horses, swine, dairy, and other.

Benefits and Costs of Backgrounding. Responses pertaining to producer perceptions of both benefits and costs of backgrounding were elicited (see Table 1). Benefits included access to animal performance data to adjust the breeding program in the cow herd (*BREED*) and the relatively higher average profitability of backgrounding as compared to selling calves at weaning (*PROFIT*). Costs were measured using opinion statements on the lack of feeding facilities (*FAC*) and the cost of financing (*FIN*); constraints similar to those modeled by Feder (1982).

Management. The number of sources -- feeder cattle futures, auction market prices, livestock reports, market trends, contracted prices or other sources -- a producer uses to forecast prices (*NPF*) is used to proxy the producer's level of attention to marketing. Innovation in the management of calving was captured with the control over calving period(s) as a management practice and the timing of production for marketing considerations. First, the *CONTROL* variable separates producers by their use of control over calving periods. Those that restrict calving periods to a single season (any single season or two adjacent seasons) as well as those that practice spring and fall calving are grouped into the category that control calving periods

(*CONTROL* = 1). The remainder are those producers that essentially practice no control over breeding. The second variable, the number of calving periods (*NSEASON*) is a direct measure of the availability of sellable calves throughout the year. It reflects the flexibility and potential profitability associated with taking advantage of seasonally high prices.

Region. Relative input/output prices and forage balances are primary components of the dynamic benefits to calf retention shown in mathematical programming models (e.g., Schroeder and Featherstone, 1990; Ethridge et al., 1990; Rawlins and Bernardo, 1991). In a cross-sectional approach, as utilized in the present study, the dynamics of input/output prices are not relevant but differing forage conditions might play a role in the decision to retain calves. Location dummies (e.g., Harper et al., 1990, Dinar and Yaron, 1990) can be used to control for spatial variation. Dummy variables are introduced to (1) reflect the potential use of pasture for crops (*PASTCROP*) as a land quality measure and (2) account for differences in topography, proximity to feedlots, etc., by differentiating across regions -- we use eight dummy variables (*D2* through *D9*) to control for differences from the NW crop reporting district in Arkansas.

Results

Table 2 shows the results of the logit estimation. The log-likelihood ratios and associated p-values indicate that all attribute categories -- with the exception of human capital and region -- were statistically significant. Likewise, the overall model was highly significant and had an overall accuracy of 85%, predicting the traditional cow-calf operation type correctly 94 % of the time and the value-added producer operation type 46% of the time.

Farm Size. As a group, the farm size variables were significant. The sign of the coefficient for the *LAND* variable was very small and positive as expected. On average, a 100

acre increase in land would lead to a 1% (100 units * W_{LAND}) increase in the likelihood that an operator will background calves. The coefficients of the *SMALL* and *LARGE* operations were insignificant. In the sense that capital investments for this type of feeding activity are not substantial, this result is similar to Feder's (1982) lumpiness of investment contentions for the likelihood of technology adoption across different size operations.

Human Capital. None of the age and education variables were statistically significant. Confounding influences in human capital variables such as off-farm employment opportunities (Dorfman, 1996) may underlie this lack of significance and justify the sign on the *UNIV* variable. Younger operators or those with a university education may view off-farm labor opportunities differently than older producers or those that are not as educated.

Risk and Diversification. The operator's opinion on the price risk associated with the backgrounding of calves was an important determinant of the likelihood that backgrounding took place on farms. Operators who reported that price risk was not a significant problem were more likely to feed than those that did. This shows that there may be important differences in the perception of price risk between the two producer categories. In addition, risk perception may include elements of an objective risk measure (price variation) *and* attitude towards risk (belief that prices change too much). In that sense, the significant coefficient for *RISK* suggests that ranchers who are optimistic -- that is, they do not perceive risk as excessive -- tend to invest in value-added cattle production. The second variable, *NOTHER*, was not significant which indicates that producers who have already diversified into other value-added enterprises are not more likely to background than those who have not. This may suggest that synergies across value-added enterprises are not important factors for investing in another value-added enterprise.

Benefits and Costs of Backgrounding. The sign of the coefficient on the *BREED* variable was not significant. It may be that cow-calf producers are more interested in other cattle characteristics such as calving ease and milking ability than the performance of their weaned calves on their own farms in choosing their breeding program (Sy et al., 1997). The opinion on profitability of the backgrounding enterprise was significant and numerically important. Results show that a producer who thinks that backgrounding is profitable is highly likely to adopt the value-added enterprise. Similar to Biswas et al. (1984) and Young and Shumway(1991), the results support that producers are motivated by profits. Among problems that producers might face when making the decision to feed weaned calves on their own farm are a lack of facilities (*FAC*) and the high cost of financing the feeding enterprise (*FIN*). A lack of facilities was a significant factor while the cost of financing was not. Access to relatively low-cost financing during the time of this survey supports that credit scarcity was not a major constraint.

Management. Both marketing (*NPF* and *NSEASON*) and production (*CONTROL*) variables were significant. The results indicate a direct relationship between the effort expended on forecasting prices and the operator's engagement in backgrounding. More importantly, by the absolute value of the coefficient, is the need to control calving periods as measured by the *CONTROL* variable. The results also indicate that additional marketing flexibility (*NSEASON*) increases the likelihood that calves are fed on farms. While there is a trade off between cost savings and production efficiencies derived from controlled breeding, the gains from additional marketing flexibility are also important. As both production control and marketing flexibility are prerequisite to backgrounding, controlled spring *and* fall calving may offer a solution to this

tradeoff as both components are present. Harper et al.'s (1990) insight on the direct relationship between adoption and the existing level of innovation in management are supported here.

Region. Land quality as measured in the *PASTCROP* variable had an insignificant impact on the likelihood of backgrounding. The regional dummy variables show some significant and large deviations from the base production district in the Northwest of Arkansas. For *D2* and *D7*, both largely forested regions, a lack of available pastures may be the cause. In the case of *D9* access to relatively cheap feed sources may be the reason for the deviation.

Conclusions

The results of this study suggest that producer perceptions about factors such as profitability, risk and facilities which enter the decision to retain calves for backgrounding are important. After controlling for farm size and human capital differences, the perceptions of producers were significant and numerically important factors in the decision to invest in downstream value-added cattle production. Generally, producers that perceive the investment as profitable, without additional price risk, and within the capacity of their physical facilities tend to invest in backgrounding. This suggests that extension efforts should be focused on price risk management, feeding technology, and how existing facilities can be converted to accommodate feeding. Benefits to feeding do not necessarily lie in superior access to performance information but rather in the belief that feeding is more profitable than selling at weaning. Contrary to popular belief, farm size and scale of cattle production have minimal impacts on the decision to invest in cattle backgrounding. Control over production and marketing flexibility were also critical to the adoption of backgrounding.

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Table 1. Description of Opinion Variables and Their Expected Sign in Results Table 2.

Variable Name	Operator Opinion[1]	Expected Sign on the Likelihood of Backgrounding
RISK	*The **problem** with feeding calves on my farm is that prices of feeder cattle change too much (too risky)*	positive
BREED	*The **benefit** of feeding calves is that I can adjust my breeding program better, because I know how well animals perform*	negative
PROFIT	*The **benefit** of feeding calves is that on average it is more profitable than selling weaned calves*	negative
FAC	*The **problem** with feeding calves on my farm is that I don't have the facilities to feed weaned calves*	positive
FIN	*The **problem** with feeding calves on my farm is that borrowing money to finance the feeding is too costly*	positive

Note:
[1] Survey respondents could choose among five levels of agreement (Strongly Agree = 1, Agree = 2, Neutral = 3, Disagree = 4, Strongly Disagree = 5).

Table 2. Summary of Statistical Results of the Logit Model.

Category	Variables	Coefficients [1] (a_k)	Standard Errors	Marginal Impact, W_k [2] (in %)	Log-Likelihood Ratios (p-value)
	Constant	-6.5953***	1.4124	-	-
Farm Size	*SMALL*	0.3413	0.4130	3.674	6.9480*
	LARGE	-0.2974	0.3304	-3.921	(0.0736)
	LAND	0.0009**	0.0004	0.010	
Human Capital	*YOUNG*	0.4328	0.4266	5.729	3.1396
	MIDDLE	0.1412	0.2880	1.449	(0.3706)
	UNIV	-0.3830	0.2623	-3.703	
Risk and Diversification	*RISK*	0.4185***	0.1469	4.311	10.3643***
	NOTHER	0.2704	0.1848	2.785	(0.0056)
Benefits and Costs of Backgrounding	*BREED*	0.2454	0.1924	2.528	100.6812***
	PROFIT	-1.0321***	0.1669	-10.633	(0.0000)
	FAC	0.6772***	0.1244	6.976	
	FIN	0.2110	0.1346	2.173	
Management	*NPF*	0.2797**	0.1101	2.882	12.1473***
	CONTROL	1.1753*	0.6502	9.916	(0.0069)
	NSEASON	0.5797**	0.2711	5.972	
Region	*PASTCROP*	0.6309	0.4803	10.594	14.0450
	D2	-0.7513*	0.4156	-7.084	(0.1207)
	D3	-0.4882	0.4613	-6.024	
	D4	-0.3867	0.3682	-3.602	
	D5	-0.1235	0.5010	-1.453	
	D6	-0.8331	0.9786	-7.559	
	D7	-0.8583**	0.4335	-6.599	
	D8	-0.3446	0.6436	-3.386	
	D9	1.2377*	0.7185	22.889	
	Log-Likelihood				-220.5989
	Restricted ($a_k = 0$) Log-Likelihood				-323.4282
	χ^2- value				205.6586
	Calculated Significance Level				0.0000
	McFadden's R^2				0.3179

Notes: There were 661 usable observations, of which 127 were value-added producers and 534 were traditional cow/calf producers.

[1] *, **, and *** imply significance at the 10%, 5%, and 1% levels, respectively.

[2] The average marginal impact, W_k, is calculated as shown in equation (2) and shows the change in the likelihood that backgrounding takes place. For the binary dummy variables, *SMALL*, *LARGE*, *YOUNG*, *MIDDLE*, *PASTCROP* and regional dummy variables *D2* ... *D9* the marginal impact is calculated at $X_{ki} = 1$ and at $X_{ki} = 0$ for *CONTROL* and *UNIV*.