RURAL ECONOMY

RISK AND RETURN DIMENSIONS:
COW-CALF AND GRAIN ENTERPRISE COMBINATIONS

Leonard Bauer[1] and Frank Novak[2]

Project Report 93-11

Farming for the Future Project 92-0186

PROJECT REPORT

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ABSTRACT

The majority of calf production in Alberta occurs in conjunction with grain growing enterprises. This study hypothesized that a major reason for this occurrence is the risk reduction opportunities which arise from on farm "portfolios" of grain and cattle. Annual rates of return were calculated over an 11 year period (1979-1989) for a 100 head cow herd in east central Alberta, and then compared to the performance of investments in grain growing land over the same period. The returns from cow-calf production were found to be uncorrelated with the returns from investment in grain growing land. In order to improve the length of the data series, correlations were also computed between the revenue from cattle and grain production, over an 18 year period (1974-1991). Revenues from grain and cattle were similarly found to be uncorrelated with each other, leading to the conclusion that joint production of grain and cattle does, significantly, reduce the degree of risk exposure.

INTRODUCTION

Surveys of the beef industry in Alberta conclude that over 80% of calf production originates from mixed beef-grain farms [Basarab and Zobell, 1989]. From a financial management perspective, these farm businesses can be described in terms of a diversified cattle-grain portfolio. It is generally acknowledged that returns from both cow-calf production and grain production are highly variable. The degree of variation, and the sources of the underlying risk are however, not well understood. Empirical investigation into the area is only in its infancy; information about the co-variability of returns between beef and grain enterprises is virtually non existent. Policy directions enunciated by governments stress more market responsiveness and greater self reliance by farmers. Greater self reliance and market responsiveness requires better financial information upon which producers

can base their decisions. This research examines the level of risk in cow-calf enterprises and the degree to which it is correlated with risk in grain growing enterprises. It endeavors to construct risk efficient portfolios of cattle and grain.

The common approach to estimating profitability in an agricultural enterprise, for example a cow-calf enterprise, is to conduct farm level surveys. Throughout the past several decades there have been numerous surveys and cost of production studies on a variety of situations and commodities [Bauer, 1966; Pattison, 1980; Ross et al, 1988]. While this approach provides some good benchmark information for a single year, it is fraught with a number of problems. These include problems of aggregation, sample bias and respondent error [Bauer, 1990]. The approach in this study is to specify the profit or return function based upon production coefficients derived from published biological research and then to measure profitability through the application of market prices for inputs and outputs.

THE PORTFOLIO MODEL OF INVESTMENT

Management decisions facing farmers can be analyzed in the context of a portfolio; a mix or combination of investments. Generally speaking investors, farmers included, prefer investments which promise a high rate of return and exhibit a low degree of risk. The rate of return is the profit earned during a period expressed as the ratio of funds recovered to those invested. Profit is the difference between the funds placed into a project at the start of (or during) a period and the funds recovered during (or at the end of) the same period. Risk is measured by the variance, or degree to which the actual return earned from the investment is likely to deviate from that which was expected.

By combining a number of investments into a portfolio the investor is able to "average out" risk exposure. The portfolio model indicates how different combinations of investments or activities may alter an investor's risk-return opportunities compared to those of a single investment. The traditional portfolio model defines a risk efficient set as the combination of risky assets (investments or activities) that minimize variance for a given level of expected returns [Barry, 1984]. In agriculture, these risky assets are expressed as alternatives in production, marketing and investment.

To illustrate the basic risk-return character of a portfolio consider a simple single period situation where there are two investment opportunities; asset 1 and asset 2 (beef cows and grain farming for example). The important attributes of the two assets are described by their respective expected returns, μ_1 and μ_1, and their standard deviations, σ_1 and σ_2. An investor must decide what proportion of the available investment funds should be placed into each of the two assets.

If proportion p is invested in the first asset, proportion $1-p$ will remain for investment in the second. The resulting portfolio will have a blend of the expected returns of the two individual assets. Its expected return μ will be:

$$\mu = p\mu_1 + [1-p]\mu_2$$

Its standard deviation σ is a blend of the two individual standard deviations σ_1 and σ_2, and the asset proportion p. In addition, the standard deviation of the portfolio depends upon ρ, the coefficient of correlation between the individual assets:

$$\sigma = \sqrt{p^2\sigma_1^2 + 2p(1-p)\rho\sigma_1\sigma_2 + (1-p)^2\sigma_2^2}$$

The portfolio model can be generalized to include any number of assets, for example K assets, where the expected returns and standard deviation are:

$$\mu = \sum_{k=1}^{K} p_k\mu_k$$

and:

$$\sigma = \sqrt{\Sigma_{k=1}^{K} p_k^2\sigma_k^2 + 2\Sigma_{k=1}^{K}\Sigma_{j<k}^{J} p_k p_j \rho_{kj}\sigma_k\sigma_j}$$

with:

$$\Sigma_{k=1}^{K} p_k = 1$$

The model illustrates that the standard deviation of returns faced by an investor is affected by the number of assets held, the standard deviation of each asset, the proportion invested in each asset and the co-variance or correlation of returns between the assets. The standard deviation minimizing proportion of asset 1 in a two asset portfolio is p^* when $\sigma_1 > \sigma_2$:

$$p^* = \frac{\sigma_2^2 - \rho\sigma_1\sigma_2}{\sigma_1^2 - 2\rho\sigma_1\sigma_2 + \sigma_2^2}$$

Diversification among two assets will reduce the minimum attainable standard deviation if the correlation coefficient is less than the ratio of the smaller standard deviation to the larger one (Levy and Sarnat). This is to say p^* will be positive but less than 1.0 when the correlation coefficient is

less than this ratio. If the correlation coefficient is greater than this ratio there will be no benefit from diversification; the lowest portfolio standard deviation will be obtained by specialization in the least risky asset, namely the one with the lowest standard deviation.

The risk reducing character of portfolios are illustrated in Figure 1 where the standard deviations for a two asset portfolio are graphed for different correlation coefficients. In this graph the standard deviations of assets 1 and 2 are 30 and 15 respectively. The benefits from diversification can be identified by considering the minimum attainable standard deviations for each correlation level.

With correlations of 1 and 0.5, the lowest possible standard deviation is 10, produced by investing all of the funds in asset 2.[3] A correlation coefficient of zero produces a minimum standard deviation of 13.42 when 20% of the portfolio is invested in asset 1 and 80% remains in asset 2. A correlation of -0.5 requires an investment of 28.57% in asset 1 and 71.43% in asset 2 for a minimum standard deviation of 9.82. A correlation coefficient of -1.00 produces a risk free portfolio with a standard deviation of zero when 33.33% of the investment is in asset 1 and 66.67% in asset 2.

The risk reduction benefits from diversification improve as the correlation between assets becomes smaller, that is less positive. Consequently, diversification strategies which seek out investment options with lower coefficients of correlation will encounter reduced variability.

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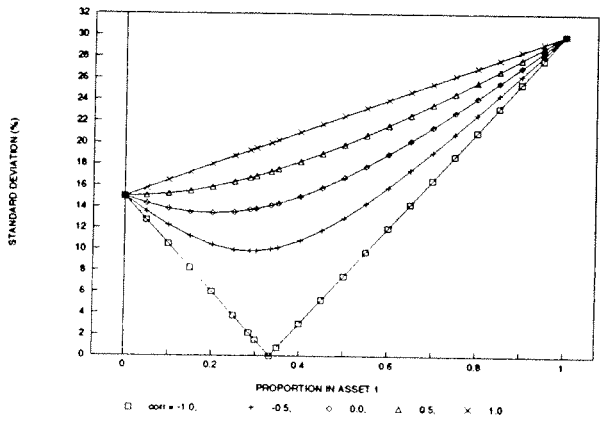
3 The ratio of the standard deviation of asset 2 to that of asset 1 is 15/30 or 0.5. Hence a coefficient of correlation greater than 0.5 requires complete specialization in asset 2 to attain minimum standard deviation.

Figure 1

Standard Deviations for 2 Asset Portfolios



RATE OF RETURN AND RISK

Annual Rate of Return

The rate of return is the profit earned during a period of time expressed as a ratio of the funds invested. Profit is the difference between the funds placed into a project at the start of (or during) a period and the funds recovered during (or at the end of) the same period. The production period for a cow-calf enterprise is typically one year; the period extending from one breeding season to the next, one calving season to the next, or one weaning period to the next. The production period for grain can also be defined over a one year period; from one seeding period to the next, or for the calendar year.

Cow-calf returns

For purposes of this study, the production period for the cow-calf enterprise begins on November 1, just after weaning, and concludes the following October 31. Calves are born in spring (April) and, except for those heifer calves retained as replacement stock, are sold on October 31. Cull cows are also sold on October 31.

The annual rate of return is calculated as the annualized internal rate of return earned over the twelve month period. The value of the basic herd on the first day of the beginning month, for example November 1, represents an investment of funds into the process. The various expenses such as feed, pasture, supplies, veterinary attention and replacement bulls are outflows of cash during the period which constitute additional investment. Revenue components such as sale of calves and cull breeding stock constitute inflows of cash. Inflows and outflows of cash are presumed to occur at the end of the relevant month. The value of the breeding herd at the end of the final month constitutes the terminal value of the investment.

The monthly rate of return is determined by solving the following equation for m_t, the monthly rate of return in year t of the data series.

$$NPV_t = -H_{t,0} + \sum_{j=1}^{12}\left[\frac{R_{t,j} - C_{t,j}}{(1+m_t)^j}\right] + \frac{H_{t,12}}{(1+m_t)^{12}} = 0$$

In the above formulation, $H_{t,0}$ represents the initial value of the basic herd and $H_{t,12}$ its terminal value. The variables $R_{t,j}$ and $C_{t,j}$ respectively represent revenues and expenses in year t at the end of month j. Net present value, which is set equal to zero to determine m_t (the monthly rate of return) is represented by NPV_t.

The annual rate of return $r_{c,t}$, earned by the cow-calf enterprise in year t is:

$$r_{c,t} = (1+m_t)^{12} - 1$$

The annual rate of return calculated in this manner represents the time weighted percentage earned on the funds invested in the cow-calf enterprise.

Farmland investment returns

The determination of annual returns from crop production was not directly part of this study; instead the returns obtained from holding farmland was taken as a proxy for grain production activities. The information used was taken from Phillips et al, "Returns to Farmland Investment in Alberta, 1964-89. Only the basic method used for calculating returns is reproduced here; the reader is directed to the original study for details.

The returns from holding farmland are composed of two parts; a capital change (gain or loss) component and an operating income component. The capital component consisted of the difference between ending land value V_t and beginning land value V_{t-1}. The operating income component I_t was determined as crop share rental income which in turn was calculated from reported crop yields and prices. The per cent return for farmland investment, $r_{l,t}$, was based on beginning value:

$$r_{l,t} = \frac{(V_t - V_{t-1}) + I_t}{V_{t-1}}$$

Expected Return and Degree of Risk

Expected annual return, $\bar{r}$, an estimate of μ, is calculated as the arithmetic average of actual annual returns experienced over the T years of the data series:

$$\bar{r} = \frac{1}{T}\Sigma_{t=1}^{T} r_t$$

The standard deviation of return, s, an estimate of σ represents the degree of risk:

$$s = \sqrt{\frac{1}{T-1}\Sigma_{t=1}^{T}(r_t - \bar{r})^2}$$

The coefficient of correlation, $\hat{\rho}_{c,l}$, an estimate of $\rho_{c,l}$, represents the degree of association between two return series, in this case cow-calf and farmland:

$$\hat{\rho}_{c,l} = \frac{1}{T-1}\Sigma_{t=1}^{T}\left(\frac{r_{c,t} - \bar{r}_c}{s_c}\right)\left(\frac{r_{l,t} - \bar{r}_l}{s_l}\right)$$

The empirical results of measuring the rate of return and risk, and the degree of association between cow-calf enterprises and grain growing activities are explored in the following section.

EMPIRICAL INVESTIGATION

Returns to Cow-Calf Enterprise

A series of returns for a cow-calf enterprise with a base herd of 100 cows was constructed for the years 1979 - 1989. The study location is Census Division 10. See Figure 2, a map of Alberta

Census Divisions. Price data were obtained from Statistics Canada's Livestock Market Review for slaughter cattle and from Alberta Agriculture's Statistics Branch for breeding stock. Weights for cull animals and breeding stock were based on assumptions. Heifer and steer weanling calf weights were from the University of Alberta Ranch at Kinsella. These were 180 day adjusted weights for beef synthetic animals.

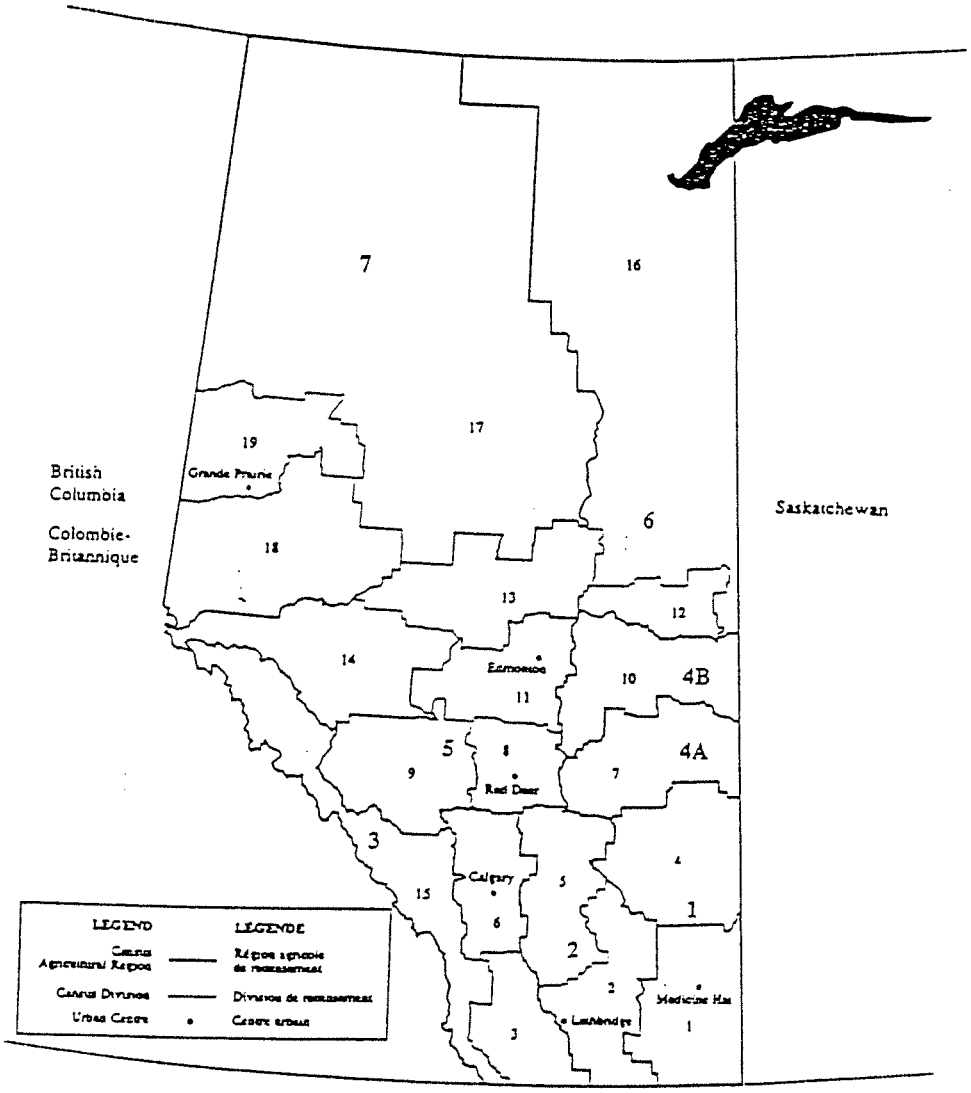
Barley and hay prices, and pasture rental charges were used to establish feed prices. These were obtained from the Statistics Branch of Alberta Agriculture. The cost of investment in land as a direct expense is not included since feed and pasture costs are charged into the cow-calf enterprise at their market values. This means that capital gains and losses in land holdings are not reflected as part of returns to the cow-calf enterprise.

Costs such as health care, marketing and transportation were included in a miscellaneous category and assumed to be $2.00 per head per month in 1989. Labour was charged in at $7.50 per hour in 1989. A fixed annual yardage charge of $4354 in 1989 was assumed to cover building, facility, machinery and equipment costs. These miscellaneous, labour and yardage costs were then indexed back over the study period using the Consumer Price Index with 1989 equal to 100. Further details of the yields, costs and prices used, and their sources are given in the appendix.

The annual return for the cow-calf enterprise was calculated as the annualized internal rate of return over the twelve month period as discussed earlier. The average, or expected, annual return was 7.04% (nominal 13.99%) with a low of -14.06% (nominal -3.25%) and a high of 29.70% (nominal 35.29%). The standard deviation of returns was 12.25% (nominal 11.91%). The real monthly cash flows and annual returns for each of the eleven years are shown in Table 1 with their nominal counterparts in Table 2. Figure 3 presents these results graphically. The real rates of return are incorporated into the portfolio analysis which follows.

Figure 2

Alberta Census Divisions



Source: 1991 Census of Agriculture, Agriculture Division, Statistics Canada

Table 1

Real Monthly Cash Flows for the Cow-Calf Enterprise 1979-1989

Base 89-12	79	80	81	82	83	84	85	86	87	88	89
Nov 1	-173687	-158250	-155464	-126195	-111737	-116211	-113522	-100833	-97655	-106675	-110814
Nov 30	-8156	-9103	-9010	-8456	-8027	-7919	-8388	-7787	-7056	-7117	-7210
Dec 31	-3457	-4356	-4220	-3727	-3489	-3360	-3843	-3221	-2506	-2578	-2633
Jan 31	-3795	-4696	-4534	-4068	-3856	-3697	-4183	-3560	-2856	-2928	-2978
Feb 28	-3761	-4658	-4486	-4018	-3839	-3676	-4156	-3546	-2844	-2917	-2958
Mar 31	-6044	-6967	-6444	-5771	-5568	-5357	-5776	-5103	-4483	-4537	-4507
Apr 30	-3755	-4663	-4472	-4017	-3866	-3722	-4202	-3595	-2868	-2944	-2985
May 31	-2879	-3257	-3088	-2780	-2697	-2626	-2843	-2518	-2199	-2257	-2238
Jun 30	-2030	-1883	-1714	-1581	-1520	-1529	-1484	-1455	-1541	-1586	-1513
Jul 31	-2015	-1868	-1700	-1573	-1514	-1520	-1480	-1444	-1530	-1576	-1503
Aug 31	434	258	98	8	-35	-94	-136	-50	-16	-166	-112
Sep 30	-1974	-1819	-1661	-1544	-1493	-1506	-1462	-1427	-1516	-1557	-1487
Oct 31	234906	221005	171018	155256	161457	157116	141137	147754	161396	157469	154322
Total	23787	19744	-25677	-8467	13816	5899	-10340	13216	34325	20631	13383
Percent Return	12.08%	10.65%	-14.06%	-5.62%	10.28%	4.26%	-7.48%	10.82%	29.70%	16.48%	10.32%
expected return		7.04%									
standard deviation		12.25%									

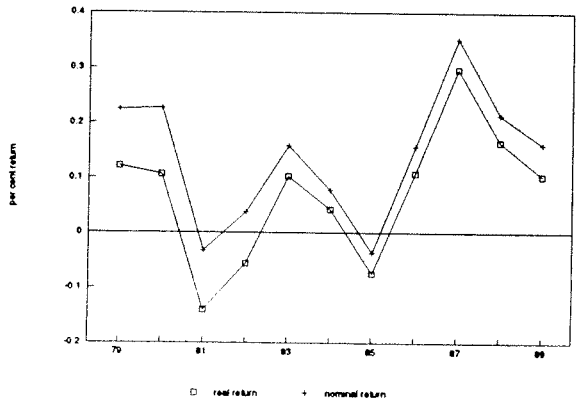
Table 2

Nominal Monthly Cash Flows for the Cow-Calf Enterprise 1979-1989

Nominal	79	80	81	82	83	84	85	86	87	88	89
Nov 1	-85600	-85204	-92813	-84869	-82639	-90185	-91054	-84290	-85194	-97091	-105115
Nov 30	-4052	-4948	-5449	-5737	-5979	-6145	-6772	-6535	-6188	-6505	-6858
Dec 31	-1722	-2382	-2566	-2540	-2599	-2616	-3105	-2715	-2201	-2358	-2504
Jan 31	-1905	-2584	-2792	-2791	-2864	-2893	-3393	-3015	-2514	-2684	-2846
Feb 28	-1905	-2584	-2792	-2791	-2864	-2893	-3393	-3015	-2514	-2684	-2846
Mar 31	-3101	-3905	-4061	-4058	-4198	-4227	-4727	-4349	-3981	-4195	-4357
Apr 30	-1938	-2629	-2841	-2840	-2914	-2944	-3453	-3068	-2558	-2731	-2896
May 31	-1501	-1857	-1979	-1993	-2038	-2080	-2341	-2159	-1973	-2107	-2193
Jun 30	-1064	-1086	-1116	-1145	-1162	-1216	-1229	-1249	-1387	-1483	-1491
Jul 31	-1064	-1086	-1116	-1145	-1162	-1216	-1229	-1249	-1387	-1483	-1491
Aug 31	230	151	65	6	-27	-75	-113	-43	-15	-156	-111
Sep 30	-1055	-1077	-1106	-1135	-1152	-1206	-1219	-1239	-1375	-1470	-1478
Oct 31	126476	131941	115014	114825	125297	126020	117981	128900	146895	149370	153920
Total	21800	22751	-3552	3786	15700	8322	-4047	15973	35610	24424	19735
Percent Return	22.43%	22.75%	-3.25%	3.73%	15.77%	7.74%	-3.64%	15.62%	35.29%	21.42%	16.04%
expected return		13.99%									
standard deviation		11.91%									

Figure 3

Real and Nominal Cow-Calf Returns (1979-1989)



Comparison of Cow-Calf and Farmland Returns

Returns to farmland investments were used as a proxy for measuring the risk and return from grain farming operations. In the farmland investment study the investor was characterized as a landlord receiving both capital gain (or loss) and rental income. This recently completed study [Phillips, et al. 1993] spanned the period 1964-1989. A sub-set of these data for census division 10, the time period 1979-1989, were used for portfolio analysis. The real return series for both investments, cow-calf and farmland, are presented in Table 3 and visually in Figure 4.

The returns for the cow-calf enterprise ranged from a low of -14.06% in 1981 to a high of 29.70% in 1987. The volatility of the farmland series was much greater with a low of -23.97% in 1983 to a high of 39.90% in 1979. The standard deviation of the farmland series, at 21.37%, was nearly twice that of the cow-calf series at 12.25%. The greater volatility in the farmland series is attributable to changes in land values, a factor not present in the cow-calf series. The mean return values for the two series were almost identical; the land investment earned an average of 6.68% and the cow-calf 7.04%.

Visual inspection of Figure 4 suggests that the two series are not closely correlated. This is borne out by the calculated coefficient of correlation of -0.02651. Statistically, this value is not significantly different from zero [Steel and Torrie, 1960 pp 189-190] and we conclude that cow-calf enterprises in Census Division 10 are uncorrelated with grain growing activities.

The substantially higher standard deviation of grain growing relative to cattle raising, and the lack of correlation between the two activities suggests that these are prime candidates to be combined in risk efficient enterprise portfolios. The proportion of grain and cattle which produces the lowest standard deviation was 25.30% in grain (farmland) and 74.70% in cattle (see Table 3 and Figure 5). The standard deviation of this combination was 10.50%, a considerable drop from that encountered in specialization.

Measured by coefficient of variation, the ratio of standard deviation to expected value, a 13.22% improvement of the portfolio over specialization in cattle (a drop from 1.74 to 1.51) is noted. A 52.81% improvement results over specialization in grain (a drop from 3.20 to 1.51).

Table 3

Real Returns for Cow-Calf and Farmland Investments (1979-1989)

	Cow-Calf	Farmland	Portfolio
79	12.08%	39.90%	
80	10.65%	22.50%	
81	-14.06%	14.19%	
82	-5.62%	14.23%	
83	10.28%	-23.97%	
84	4.26%	-5.52%	
85	-7.48%	-9.04%	
86	10.82%	-5.23%	
87	29.70%	5.14%	
88	16.48%	-17.55%	
89	10.32%	38.85%	
expected return	7.04%	6.68%	6.95
standard deviation	12.25%	21.37%	10.50
coefficient of variation	1.74	3.20	1.51
correlation coefficient			-0.0265
t-statistic[4]			-0.0796
Minimum Standard Deviation Combination	74.70%	25.30%	

4 The t-statistic is calculated to test whether the correlation coefficient is significantly different from zero.

Figure 4

Real Returns for Cow-Calf and Farmland Investments (1979-1989)

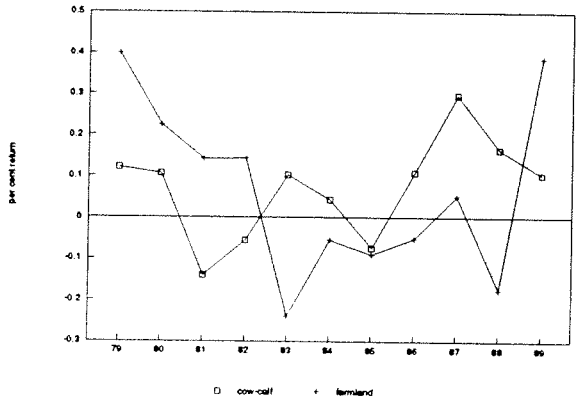
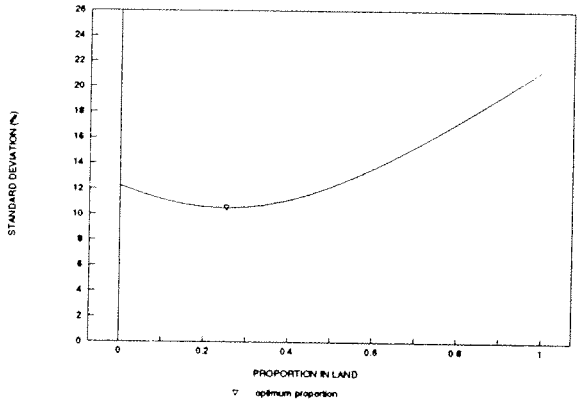


Figure 5

Standard Deviations for Cow-Calf Farmland Portfolios



Comparison of Cow-Calf and Grain Enterprise Revenues

In order to have a longer series for comparison between cow-calf and crop enterprises an analysis of revenue components was done for the period 1974 through 1991. This was necessitated because cost data for cow-calf enterprises prior to 1979 were thought to be unreliable. This detracts from the co-variance analysis in only a minor way because much of the variability arises in the revenue component. The contribution to variation by way of costs is relatively small. While the breeding herd is a capital asset in the cow-calf enterprise just as land is in the grain enterprise, capital gains and losses were not considered in the co-variance analysis.

A revenue series for a 100 cow base herd was established for the years 1974-1991. Revenue is derived from sale of culled animals and weanling calves in the fall. Revenues are expressed in real (1991) terms. Weights and prices come from the same sources as mentioned earlier for the return series. Revenue is expressed in dollars per head.

A revenue series for a grain enterprise was constructed using price and yield information from Alberta Wheat Pool grain elevators in Census Division 10 [Mumey et al, 1988 and 1992]. The grain operation is assumed to be split evenly between wheat, barley and canola production. Revenue is expressed in real (1991) terms in dollars per acre.

The results of this analysis, shown in Table 4 and in Figure 6, are not substantially different from those found by using farmland as a proxy for grain profitability. The coefficient of correlation was calculated to be -0.12737 which, in a statistical sense, is again not significantly different from zero. Consequently, we conclude that cattle and grain revenues in Census Division 10 are uncorrelated with one another. The minimum risk portfolio was composed of 72.56% cattle and 27.44% grain resulting in a minimum standard deviation of $116 (see Table 4 and Figure 7). Measured by coefficient of variation, the portfolio represents an 11.54% improvement over specialization in cattle (a drop from 0.26 to 0.23) and a 66.18% over specialization in grain (a drop from 0.68 to 0.23). These results are substantially the same as for the cow-calf and farmland analysis.

Table 4

Revenue Series for Cattle and Grain
1974-1991

Year	Cattle $/Head	Grain $/Acre	Portfolio
1974	403	968	
1975	393	715	
1976	370	656	
1977	463	606	
1978	783	444	
1979	918	523	
1980	778	504	
1981	533	351	
1982	524	272	
1983	517	243	
1984	499	270	
1985	490	186	
1986	580	151	
1987	629	136	
1988	544	204	
1989	536	158	
1990	490	123	
1991	493	92	
Expected Gross Revenue	552	367	501
Standard deviation	143	248	117
coefficient of variation	0.26	0.68	0.23
Correlation Coefficient			-0.1274
t-statistic[5]			-0.5137
Minimum Standard Deviation Combination	72.56%	27.44%	

5 The t-statistic is calculated to test whether the correlation coefficient is significantly different from zero.

Figure 6

Revenue Series for Cattle and Grain
1974-1991

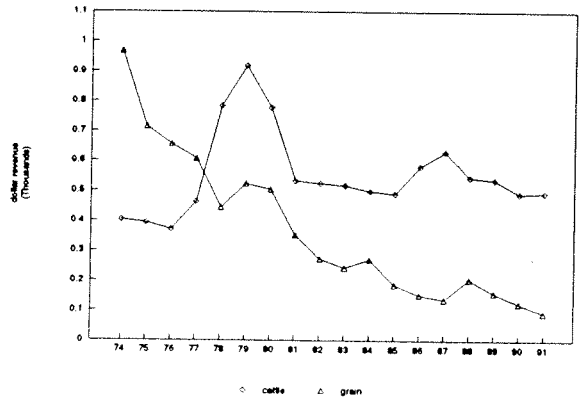
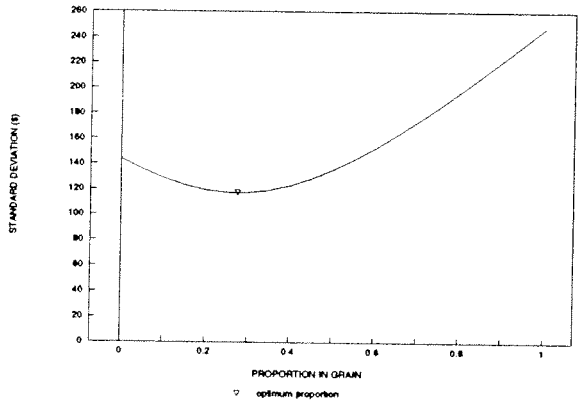


Figure 7

Standard Deviations for Cattle-Grain Portfolios



CONCLUSIONS

This analysis shows that risk can be reduced by diversifying an agricultural operation from a single commodity enterprise to one that includes both cattle and grain. The minimum variance portfolio,

which contains 70% to 75% cattle and 25% to 30% grain, reduces risk substantially. The risk minimizing portfolio reduced the coefficient of variation from complete specialization in beef by over 13% (dropping from 1.74 to 1.51). The reduction from complete specialization in grain was over 52% (dropping from 3.20 to 1.51).

Thus we conclude that, apart from other considerations such as timing of work load and resource complementarities or constraints, risk reduction is an important component in developing efficient enterprise combinations of cattle and grain. The analysis rests upon a very short data series and in only one location of the Province. Furthermore issues of resource complementarities and conflicts have not been addressed. It is important that this analysis be extended to other regions of Alberta, over a longer time span and in the context of specific investment situations, so that a more complete picture might emerge. A more thorough understanding of the risk and return patterns in these two important Alberta agricultural enterprises would be beneficial in the planning activities of farmers and in the design of agricultural policy.

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APPENDIX A. COW CALF REVENUE MODEL

The model for calculating annual rates of return, both actual and forecasted values is presented below. Data from the year ending in 1989 are used to illustrate the model. The time-line is from November 1 to October 31.

The Steady State Herd Composition

We assume that a particular herd has a planned culling rate expressed as a percentage of the breeding herd, in this case 15%. This means that for a base herd of 100 head one would expect 85 mature cows and 15 heifers to calf for the first time. The number of calves weaned is expressed as a percentage of the number of head in the base. The per cent calf crop is 90% therefore 90 calves are weaned in a 100 head herd. Of these, one half are assumed to be male calves and one half female. For odd numbers of calves born the extra calf would be assumed male. It is assumed that all male calves are sold as steers at weaning time. A certain number of heifer calves are retained in the herd for replacement breeding stock and the remainder sold at weaning time. The number retained for breeding stock is 110% of that required as replacements. This means 17 calves are kept of which 2 are culled prior to first calving. The number of bulls is expressed as a cow to bull ratio of 25, therefore the herd of 100 head has 4 bulls. One bull is culled and replaced each year. Finally it is assumed that 2% of the basic herd is lost to death each year. With 15 replacement heifers calving for the first time each year, 15 cows are removed either due to death (2 head) or due to culling (13 head). The replacement bull is purchased in March

and a cull is sold in August. All other sales are assumed to take place on October 31, at weaning time. Table 5 illustrates the herd situation emanating from the above stated conditions. Labour use data are summarized in Table 6 and the steady state herd composition in Table 7.

Table 5

Cow-Calf Model Parameters

herd size	100 cows
culling rate	15 %
cow/bull ratio	25 cows per bull
replace ratio	110 %
death rate	2 %
calf crop	90 %
pasture cost	$9.35 per aum
feed cost	$15.46 per aum
labour cost	$7.50 per hr
misc cost	$2.00 per aum
fixed yardage	$4354 per annum

Table 6

Monthly Distribution of Labour Use per Animal Unit

Month	hours
Nov	0.60
Dec	0.60
Jan	1.00
Feb	1.00
Mar	1.00
Apr	1.00
May	0.60
Jun	0.20
Jul	0.20
Aug	0.20
Sep	0.20
Oct	0.60
Total	7.20

Table 7

Steady State Cattle Numbers

description	beg	purch	births	deaths	sales	end
bulls	3	1			1	3
mature cows	85			2	13	85
bred hfrs (19mo)	15				2	15
breedng hfrs (7mo)	17					17
heifer calves			45		28	
bull calves			45		45	
Totals	120	1	90	2	89	120

The Revenue Component

Revenues are determined by multiplying animal numbers, as found in Table 7 above, by weights per head and by market prices for each of the categories and dates. The price used for the culled bull was that reported for slaughter bulls at the Edmonton Public Stock Yards in August. The price for culled cows was the average of D1,2 and D3,4 slaughter cows in October. The D1,2 slaughter cow price in October was used for the culled bred heifers. Weanling heifers, both those sold and those kept as replacements, were valued at the October price for feeder heifers between 400 and 500 pounds. Steer calves were valued at the October price for feeder steers between 500 and 600 pounds The resulting nominal values are shown in Table 8. Supporting weight and price data are in Table 9.

Table 8

Nominal Values of Cattle for 1989

description	beg	purch	births	deaths	sales	end
bulls	5419	1511			1392	5419
mature cows	78625			n/a	8805	79688
bred hfrs (19mo)	12750				1119	12300
breedng hfrs (7mo)	8321					8723
heifer calves			n/a		14367	
steer calves			n/a		25428	
Totals	105115	1511			51112	106129
Value out	157241					
Value in	106626					
difference	50615					

Table 9

Weights and Nominal Prices for 1989

	weight lbs/hd	price $$/lbs	value $$/hd	Date
Bulls				
beg inventory	1800	1.00	1806.25	Nov 1
end inventory	1800	1.00	1806.25	Oct 31
purchase	1600	0.94	1511.11	Mar 31
sale	2000	0.70	1392.40	Aug 31
Mature Cows				
beg inventory	1200	0.77	925.00	Nov 1
end inventory	1200	0.78	937.50	Oct 31
sale	1300	0.52	677.30	Oct 31
bred hfrs (19mo)				
beg inventory	1000	0.85	850.00	Nov 1
end inventory	1000	0.82	820.00	Oct 31
sale	1000	0.56	559.50	Oct 31
breedng hfrs (7mo)				
beg inventory	481	1.02	489.49	Nov 1
end inventory	497	1.03	513.11	Oct 31
heifer calves				
sale	497	1.03	513.11	Oct 31
steer calves				
sale	530	1.07	565.07	Oct 31

The cost component

Costs per month depend upon number of animals in the herd. Table 10 shows the number of head in each category and the number of animal units for each month of the year. Costs per animal unit are given for each month in Table 11 and total costs for the enterprise in each month are shown in Table 12.

Table 10

Monthly Distribution of Cattle Numbers

	Bulls	Cows	Bred Hfrs	Breedng Hfrs	heifer calves	bull/str calves	AUs
Nov	3	85	15	17			114
Dec	3	85	15	17			114
Jan	3	85	15	17			114
Feb	3	85	15	17			114
Mar	3	85	15	17			114
Apr	4	98		17	45	45	116
May	4	98		17	45	45	116
Jun	4	98		17	45	45	116
Jul	4	98		17	45	45	116
Aug	4	98	17		45	45	116
Sep	3	98	17		45	45	113
Oct	3	98	17		45	45	113

Note: 1 bull equals 1.25 AUs; 1 cow-calf pair equals 1.00 AU; 1 bred heifer equals 0.80 AUs; and 1 breeding heifer equals 0.75 AUs.

Table 11

Distribution of Nominal Costs per Animal Unit for 1989

	Pasture	Feed	Labour	Other
Nov		15.46	4.50	2.00
Dec		15.46	4.50	2.00
Jan		15.46	7.50	2.00
Feb		15.46	7.50	2.00
Mar		15.46	7.50	2.00
Apr		15.46	7.50	2.00
May	4.68	7.73	4.50	2.00
Jun	9.35		1.50	2.00
Jul	9.35		1.50	2.00
Aug	9.35		1.50	2.00
Sep	9.35		1.50	2.00
Oct	4.68	7.73	4.50	2.00

Table 12

Monthly Distribution of Nominal Total Costs for 1989

	Pasture rent	Feed Cost	Labour Cost	Other Costs	Fixed Yardage	Total Costs
Nov	0	1763	513	228	4354	6858
Dec	0	1763	513	228		2504
Jan	0	1763	855	228		2846
Feb	0	1763	855	228		2846
Mar	0	1763	855	228		2846
Apr	0	1794	870	232		2896
May	542	897	522	232		2193
Jun	1085	0	174	232		1491
Jul	1085	0	174	232		1491
Aug	1094	0	176	234		1503
Sep	1075	0	173	230		1478
Oct	477	789	459	204		1929
Total	5358	12295	6138	2736	4354	30880

Net revenues and rates of return

Net revenues, more accurately called net flows of cash, are computed on a monthly basis in Table 13. The internal rate of return is then computed from these data and expressed on an annual basis.

Table 13

Monthly Distribution of Nominal Cash Flows for 1989

	Capital	Revenue	Costs	Total
Nov 1	-105115			-105115
Nov 30			-6858	-6858
Dec 31			-2504	-2504
Jan 31			-2846	-2846
Feb 28			-2846	-2846
Mar 31			-4357	-4357
Apr 30			-2896	-2896
May 31			-2193	-2193
Jun 30			-1491	-1491
Jul 31			-1491	-1491
Aug 31		1392	-1503	-111
Sep 30			-1478	-1478
Oct 31	106129	49720	-1929	153920
Total	1014	51112	-32391	19735
Percent Return				16.04%

APPENDIX B. PRICE, COST AND PRODUCTION DATA

Table 14

Nominal Prices and Yields

	79	80	81	82	83	84	85	86	87	88	89
Bulls (beg$/cwt)	79.82	79.39	87.77	84.23	84.11	88.54	88.54	88.54	88.54	97.40	100.35
Bulls (end$/cwt)	79.39	87.77	84.23	84.11	88.54	88.54	88.54	88.54	97.40	100.35	100.35
Bulls (purch$/cwt)	74.72	82.61	79.28	79.17	83.33	83.33	83.33	83.33	91.67	94.44	94.44
Bulls (cull$/cwt)	65.17	62.33	59.50	58.02	57.25	57.59	56.32	60.84	69.20	66.98	69.62
Cows (beg$/cwt)	64.33	64.29	68.12	64.50	62.50	68.75	68.75	62.50	62.08	70.63	77.08
Cows (end$/cwt)	64.29	68.12	64.50	62.50	68.75	68.75	62.50	62.08	70.63	77.08	78.13
Cows (cull$/cwt)	47.32	50.21	39.92	40.93	37.66	40.71	39.63	44.38	51.28	49.73	52.10
Bred H (beg$/cwt)	63.16	54.00	80.30	64.50	57.00	60.00	64.00	65.00	60.00	75.00	85.00
Bred H (end$/cwt)	54.00	80.30	64.50	57.00	60.00	64.00	65.00	60.00	75.00	85.00	82.00
Open H ($/cwt)	49.84	52.73	42.42	43.14	39.41	43.68	42.22	46.32	53.63	52.67	55.95
Repl H (beg$/cwt)	78.08	91.14	78.19	62.27	70.94	74.26	78.57	75.65	96.68	109.57	101.84
Repl H (end$/cwt)	91.14	78.19	62.27	70.94	74.26	78.57	75.65	96.68	109.57	101.84	103.17
H calves ($/cwt)	91.14	78.19	62.27	70.94	74.26	78.57	75.65	96.68	109.57	101.84	103.17
B/S calves ($/cwt)	100.52	87.73	70.23	75.92	81.46	84.82	84.92	102.35	119.53	104.87	106.71
Barley ($/bu)	1.39	2.20	2.93	2.44	1.93	2.48	2.72	2.11	1.51	1.27	2.49
Hay ($/ton)	47.12	60.93	74.16	68.21	73.95	73.73	86.36	91.53	62.86	58.29	67.21
Pasture ($/aum)	7.30	7.30	7.30	7.30	7.30	7.65	7.65	7.70	8.75	9.45	9.35
Repl H (beg lb/hd)	497	467	492	459	481	497	490	467	492	459	481
Repl H (end lb/hd)	467	492	459	481	497	490	467	492	459	481	497
Calf Crop (%)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
H calves (lb/hd)	467	492	459	481	497	490	467	492	459	481	497
B/S calves (lb/hd)	479	518	516	486	530	478	479	518	516	486	530
labour ($/hr)	4.01	4.42	4.97	5.51	5.82	6.08	6.32	6.58	6.87	7.14	7.50
misc ($/aum)	1.07	1.18	1.32	1.47	1.55	1.62	1.68	1.75	1.83	1.91	2.00
yardage ($/unit)	2330	2566	2883	3197	3380	3529	3666	3819	3987	4148	4354
CPI index	.5351	.5895	.6623	.7342	.7763	.8105	.8421	.8772	.9158	.9526	1.0000

Data Sources

Off Board barley prices: Statistics of Agriculture for Alberta, 1963-1970. Agricultural Statistics Yearbook, 1972-1989, Alberta Agriculture.

Good quality baled hay: Alberta Average Farm Input Prices, Agricultural Prices and Indexes, Alberta Agriculture Statistics Branch.

The CPI index was used to establish nominal costs for labour, miscellaneous and yardage rates, for the periods 1979-1988, based on 1989 costs.

Slaughter cattle prices: Livestock Market Review, Statistics Canada.

Breeding Stock: Statistics Branch, Alberta Agriculture.

Heifer and steer weanling calves weights: University of Alberta Ranch at Kinsella, 180 day adjusted weights for beef synthetic animals.

Table 15

Monthly Consumer Price Indices
(December 1989 = 1.0000)

	79	80	81	82	83	84	85	86	87	88	89
Oct (prev)	0.4928	0.5384	0.5970	0.6725	0.7396	0.7760	0.8021	0.8359	0.8724	0.9102	0.9486
Nov (prev)	0.4967	0.5436	0.6048	0.6784	0.7448	0.7760	0.8073	0.8392	0.8770	0.9141	0.9512
Dec (prev)	0.4980	0.5469	0.6081	0.6816	0.7448	0.7786	0.8079	0.8431	0.8783	0.9147	0.9512
Jan	0.5020	0.5501	0.6159	0.6862	0.7428	0.7826	0.8112	0.8470	0.8802	0.9167	0.9557
Feb	0.5065	0.5547	0.6224	0.6947	0.7461	0.7871	0.8164	0.8503	0.8841	0.9199	0.9622
Mar	0.5130	0.5605	0.6302	0.7031	0.7539	0.7891	0.8184	0.8522	0.8880	0.9245	0.9668
Apr	0.5163	0.5638	0.6354	0.7070	0.7539	0.7910	0.8216	0.8535	0.8919	0.9277	0.9701
May	0.5215	0.5703	0.6406	0.7168	0.7559	0.7923	0.8236	0.8574	0.8971	0.9336	0.9798
Jun	0.5241	0.5768	0.6510	0.7240	0.7643	0.7956	0.8281	0.8587	0.8997	0.9349	0.9850
Jul	0.5280	0.5814	0.6563	0.7279	0.7676	0.8001	0.8307	0.8652	0.9063	0.9408	0.9915
Aug	0.5299	0.5866	0.6615	0.7311	0.7715	0.8001	0.8320	0.8678	0.9069	0.9434	0.9922
Sep	0.5345	0.5918	0.6660	0.7350	0.7715	0.8008	0.8333	0.8678	0.9069	0.9440	0.9935
Oct	0.5384	0.5970	0.6725	0.7396	0.7760	0.8021	0.8359	0.8724	0.9102	0.9486	0.9974