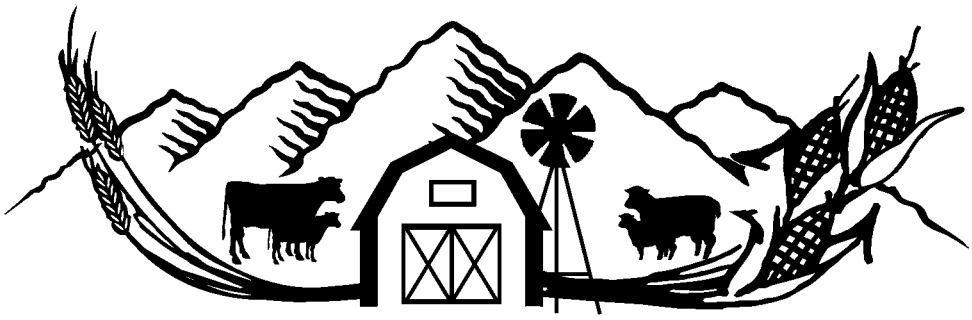

Risk and Resilience in Agriculture

Choosing the Right Enterprise Mix to Reduce Your Risk: A Case Example in Wyoming's Big Horn Basin

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While it is impossible to eliminate risk, the consequences of production risk (i.e. yield variability) may be reduced by buying insurance, diversifying among more enterprises, or selecting more stable enterprises. Producers often have a range of crop and livestock enterprises from which to choose. For example, in grazing areas, the choice may be between cattle or sheep, or some of both; and in irrigated farming areas, it may be between sugar beets, malt barley or corn. In weighing these choices, most people focus on annual profitability. This criterion--while obviously important-- is not the only one that should be used. Equally important is risk. The objective of this paper is to illustrate some contrasting approaches for incorporating the risk element into decision-making and enterprise selection. This objective is accomplished by presenting results from a case study of alternative crop combinations in Wyoming's Big Horn Basin (Jennings, 1998).

Evaluating Risk

Although most will agree that managing risk with one or a combination of selected strategies is important, there is not total agreement on how risk or its consequences should be assessed. Some analysts prefer to consider risk in terms of annual income variability, as measured by such things as a range of low to high income or gross revenue, a standard deviation, and or a coefficient of variation. The previous article, entitled "Enterprise Diversification: Will It Reduce Your Risk?," discussed how you might apply these concepts as illustrated by wheat and cattle enterprises. If risk is considered in terms of variability, diversifying among more enterprises can reduce year-to-year income or revenue variation.

Alternatively, others may argue that risk and its consequences is better measured in a downside context, in the form of the potential chance and amount of loss associated with some enterprise mix. For example, even

though diversification may reduce income variability, it may concurrently reduce the overall amount of realized income. In fact, income may be reduced to such an extent that the chances of falling below critical thresholds or target levels (necessary for meeting fixed financial obligations) may become quite large indeed. Thought of in this sense, associating lower income variability with "less risk" could be misleading at times. The effect of assessing risk in two different ways-- income variability versus "chance and amount of loss"-- will be illustrated with a case analysis of different crop rotations for a representative 720-acre irrigated farm in Wyoming's Big Horn Basis, as originally developed by a panel of farmers (Agee, 1986), and later updated by Jennings (1998).

Assessing Net Income and Its Variability Between Alternative Crops

Table 1 shows a 20-year series (1978-97) of irrigated crop yields from Big Horn County, (Wyoming Agricultural Statistics). Reported county level yields were upgraded to reflect 20-year average yields that are more consistent with yields expected for better managed operations in the region (Agee, 1986). Table 2 contains a series of prices for the selected crops over the same 20-year period (Wyoming Agricultural Statistics). To facilitate a consistent comparison with other prices and 1997 costs, annual crop prices were adjusted for inflation and converted to constant 1997 dollars, using the Gross Domestic Product implicit price deflator (Economic Report of the President). As was discussed in “Enterprise Diversification: Will It Reduce Your Risk?,” the price and yield data could be compared either separately or combined as gross revenues and compared for the different crops using a graphical method or by estimating range, standard deviation and coefficient of variation (CV). For purposes of illustrating how income variability for a whole farm might be analyzed, we will not analyze the price and yield data in that way here. It is important to remember you could very well use those techniques to get some initial ideas about the variability of the individual crops before analyzing income variability.

Table 3 shows a 20-year (1978-97) series of per acre net returns for each of the designated crops. Annual net returns are calculated by subtracting per acre variable cash costs for sugar beets ($550), malt barley ($190); corn ($266); dry beans ($254); and alfalfa ($189)-- from respective gross returns. Gross returns for respective crops are calculated by multiplying annual crop yields (Table 1) times their respective prices (Table 2). Net return in this case is equivalent to returns over variable costs, and therefore represent the residual return to unpaid fixed resources, including machinery and real estate.

During this selected 20-year period, crops differed considerably in terms of their earning potential and net income variability. Income-wise, sugar beets dominated other crops, showing a much higher net return ($442 / acre), with dry beans running a distant second ($244 /acre). It is also noted that compared to other crops, sugar beets and dry beans show greater year-to-year income variability in terms of higher standard deviations ($216 and $151 / acre respectively). This suggests that crop rotations containing larger proportions of these crops will not only exhibit higher returns, but more overall income variability as well.

Net Income Correlation

Besides income variability of individual crops, the movement of crop returns with each other is yet another factor that can influence annual stability of whole-farm income. This concept of correlation relates to how closely these crops move up and down together. In this case, we are comparing the movement of annual income. This is the same concept we

used in the previous article when we compared the highs and lows in the graph for wheat and cattle ("Enterprise Diversification: Will It Reduce Your Risk?"). Instead of a graph, we will use a statistical measure for this analysis called a correlation coefficient. This is easily calculated in most spreadsheet programs, but it is not easily calculated by hand. If you do not have a computer, a graph of the enterprises will allow you to do much the same thing a correlation coefficient does. Crops which are inversely related have a negative correlation coefficient, i.e., the highs for one enterprise tend to occur during the lows for the other enterprise, and would be most preferred in stabilizing income, since below average returns from one would be associated with above average returns from the other. The closer to one the correlation coefficient is, the more likely the one crop or enterprise has highs and lows the same time the other crop or enterprise does. Conversely, the closer to zero the correlation coefficient is the less likely one crop's highs and lows occur at the same time the other crop's highs and lows occur.

Knowing the concept of correlation, or how crops move together in terms of ups or downs in revenue, can help identify enterprises that will reduce income variability. More stable income may be achieved by growing a combination of crops whose returns do not always move together in the same direction. An ideal situation is diversifying between crops generating returns, which generally move in opposite directions or have a negative or inverse correlation. Then a year of below average income from one is offset by a year of above average income from the other. However, crop yields as well as crop prices tend to be positively correlated to various degrees, since biological and/or economic forces frequently affect alternative crops in similar manners. As a result, it is less common (although not impossible) to observe negative correlation between crops with respect to net returns.

Table 4 shows net return correlation coefficients between designated crops. In most instances, net returns from Big Horn Basin crops moved together (positively correlated) to varying degrees. However, a rather weak degree of negative correlation is observed between malt barley versus dry beans (-0.281) and alfalfa (-0.040), indicating those crops to be good diversification companions with malt barley. Realizing that lower (versus higher) positive correlation is preferred for effective diversification, coefficients in Table 4 indicate that better income stability could be achieved by diversifying malt barley and sugar beets (0.293) versus dry beans and sugar beets (0.492). The advantage of combining sugar beets and malt barley (versus sugar beets and dry beans) is further supported by noting that malt barley in itself is a much more stable crop with less income variability (standard deviation =$35 / acre) than dry beans (standard deviation =$151/ acre).

Assessing Risk of Different Crop Rotations

The top of Table 5 shows six different crop rotations for the representative 720-acre farm. Farm Plan #1 yields the greatest amount of net income by concentrating its acreage between the two highest returning crops, sugar beets (33%) and dry beans (67%). Farm Plans #2 through #5 are developed on the basis of reducing sugar beet and dry bean acreage in favor of higher acreages of barley, corn and alfalfa, to the point where Farm Plan #5 eliminates sugar beets, and reduces dry beans to only 80 acres. Farm Plan #6 is a special case of a less diversified sugar beet (240 acres) and malt barley (480 acres) rotation, more typically found in Wyoming's Big Horn Basin.

Net Income Variability

The middle of Table 5 shows annual returns (1978-97), 20-year average income, as well as selected measures of variability and risk for each of the six farm plans described above. Not surprisingly, the highest return rotation (#1) comprised of sugar beets and dry beans, shows the greatest amount of income instability, having the highest standard deviation ($108,061) and 20-year range of income from low to high ($457,256). In contrast to the high income sugar and dry bean rotation (Plan #1), Farm Plan #5 generates much lower average income ($101,893 vs. $223,132), and standard deviation ($58,927 vs. $108,061), as a result of eliminating sugar beets and reducing dry bean acreage from 480 to 80 acres. The pattern of achieving lower income variability, only at the expense of reduced net returns is consistently observed, moving from Farm Plan #2 through Farm Plan #5. Also, compared to Farm Plan #1 (sugar beets and dry beans), Farm Plan #6 (sugar beets and malt barley) generates less net income ($186,518 vs. $223,132), but also much less risk in term of lower income variability as measured by the standard deviation ($58,927 vs. $108,061), and coefficient of variation (0.316 vs. 0.484). This occurs because malt barley has a lower standard deviation, and smaller correlation with sugar beets than dry beans.

These cases illustrate a general principle in risk management: reducing risk in terms of achieving more stable (or less variable) income, will generally come at the expense of earning less profit over the long run. The best choice (crop rotation is this case) depends upon each individual's attitude toward risk Specifically, what is the importance or value of lower income variability (risk) to each decision-maker, relative to the amount of income that must be sacrificed to achieve it?

To the extent that increased risk is associated with greater income variability, Farm Plan #1 could be considered the most risky of all rotations, and Farm Plan #5 the least risky of all rotations. However, for some purposes, income variability may not always be a complete or sensible way to assess the true riskiness of a crop rotation, particularly from the standpoint of downside risk.

Downside Target Risk

As an alternative to associating risk with income variability, it may be more desirable at times to consider risk in a downside context such as "chance and amount" of loss. With this approach, variation of income from extremely high to low amounts is no longer the main concern. Specifically, high income years are not considered a threat or source of risk. On the other hand, low income years are considered the problem. With respect to Table 5, attention is now shifted from the standard deviation and CV of each rotation, to instead, the worst possible net income event (minimum) that might occur with a given rotation. This is illustrated by noting the worst possible outcome for the highly variable Farm Plan #1 ($117,288) is not nearly as bad as the much lower worst outcome of the stable but low returning Farm Plan #5 ($51,962). Therefore, concern is now focused whether a given crop rotation will consistently miss the mark, by generating unacceptably low levels of income over successive years, a high percentage of the time.

To illustrate a downside target risk approach, it is necessary to establish a threshold level of target income to represent some disaster amount, below which, adverse financial consequences would occur. Selection of a specific target is somewhat arbitrary, and unique for each individual farm and its financial situation. For example, the $150,000 target selected for this analysis (bottom of Table 5), could represent the minimum

amount of net income needed to meet annual fixed cash obligations such as debt retirement or family living expenses.

The last two rows of Table 5 show risk measured from the standpoint of "frequency and amount" that annual income falls below the designated target ($150,000) over the 20-year period. It can be observed that Farm Plan #1, having highest income and associated variability, can be now considered to be least risky from a target loss standpoint. Specifically, Farm Plan #1 missed the $150,000 target in only 5 of 20 years (1985= $148,555; 1986= $123,736; 1990= $148,489; 1991= $129,307; and 1994= $117,288). In addition, Farm Plan #1 missed the $150,000 target over these five years by a total of only $82,624 (i.e., $1,445 in 1985; $26,264 in 1986; $1,511 in 1990; $20,693 in 1991; and $32,712 in 1994). Conversely, Farm Plan #5 (without sugar beets) yielding the least amount of net income and having the lowest amount of income variability, can be now considered the "most" risky of all rotations from a downside risk perspective. It misses the $150,000 target in 19 (versus 5) of 20 years, by much larger total of $990,856 (vs. $82,624).

It should be emphasized that the highest income options (with highest variability) are not always the ones that will render the least amount of downside target risk (as was the case with this example). In some cases, they may turn out to be the most risky from not only the standpoint of income variability, but downside target risk as well. For example, purchased stocker ranching systems have frequently been shown to generate much higher returns along with much greater income variability, than either cow-calf or cow-yearling systems. At the same time, purchased stocker systems are also more risky from a downside context, in missing critical income targets more frequently, and by much larger amounts (Edens, Held and Feuz, 1993).

Summary and Conclusions

Reducing risk in the form of income variability generally comes at a cost of realizing lower net earnings over time. Successfully achieving reduced income variability via enterprise diversification depends on two critical factors: (1) adding one or more enterprises with relatively low income variability; and (2) finding enterprises with low, or better yet, negative correlation. Both of these factors must be considered simultaneously. For example in some cases, a beneficial correlation effect may be strong enough to offset an adverse variability component. This would imply that an operation's overall net income variability could possibly be reduced by adding a livestock enterprise, which by itself, may be highly variable, but if the livestock enterprise is also negatively correlated with crops, that effect may be more than sufficient to overcome its inherent variability, in the context of stabilizing overall farm income.

The benefit of reduced income variability from diversification can be very pronounced moving from one to two enterprises and to a lesser extent from two to three enterprises. However, as a general rule, the additional benefits of continued reductions in income variability tend to exhaust themselves quite quickly beyond four or five enterprises. Beyond benefits of reduced income variability, serious potential drawbacks should be considered from expanded diversification. These could include added investment and management costs with each new enterprise, as well as possible cost inefficiencies from a larger number but smaller sized enterprises.

Managing risk by choosing alternatives having more stable income, but at the expense of substantially lower income, may not always be the best answer. Higher income choices, in spite of being more variable, can sometimes, although not always, reduce the risk of falling

below an income target, which is critical for financial well being. If decision-makers are considering the addition of new enterprises, or expansion of existing enterprises that have unusually high net income potential, increased income instability will often be the result. However, any adverse effects of greater income variability should be weighed against potential benefits of reducing the risk of frequent annual shocks below some critical target, which is unique to that operation's financial situation. For instance, sugar beets, in spite of showing relatively high income variability over the 1978-97 period, generated very high returns compared to other crops. Therefore, although seemingly risky from a variability standpoint, they did not appear as risky from a downside target standpoint, since lower income years from sugar beets often compared favorably with average to above average income years from other crops. As a result, reductions (or elimination) of sugar beet acreage would stabilized income, but at the same time would create a greater risk falling below critical income targets.

When analyzing diversification strategies you may want to consider looking at several enterprise mix plans which vary the proportion of income from different enterprises. You will want to identify your own target income threshold and then choose an enterprise combination which reduces income variability while still meeting some acceptable level of risk associated with falling below a target income level. Your own preferences, strategic business goals and financial situation will dictate which enterprise plan offers the best balance between meeting your income target goals the most often while reducing income variability. This article and “Enterprise Diversification: Will It Reduce Your Risk?” were written to help give you the tools to develop and evaluate your own diversification strategy.

Table 1. Annual and 20-year Average Crop Yields

Year	Beets (Tons / Ac.)	Barley (Bu. / Ac.)	Corn (Bu. / Ac.)	Beans (Cwt. / Ac.)	Alfalfa (Tons / Ac.)
1978	19.2	91.8	80.4	17.8	3.5
1979	19.0	84.3	107.7	22.7	3.6
1980	22.6	93.9	113.8	23.7	3.5
1981	26.1	93.9	133.6	22.0	3.5
1982	23.7	93.1	127.5	20.4	4.5
1983	21.9	87.2	109.8	19.3	4.0
1984	21.7	90.5	114.1	23.9	4.0
1985	20.8	96.1	123.2	19.9	3.6
1986	17.7	98.0	127.5	22.6	4.1
1987	22.7	94.2	123.6	23.8	3.9
1988	21.0	83.7	132.4	21.4	3.7
1989	19.2	91.8	97.9	19.5	3.6
1990	21.2	106.6	128.7	21.8	4.2
1991	22.1	110.4	141.1	23.5	4.0
1992	27.1	109.1	112.6	21.9	4.0
1993	24.1	109.1	91.6	15.2	4.2
1994	20.9	110.4	134.9	22.0	4.2
1995	23.9	125.2	125.0	25.1	4.6
1996	20.9	124.0	131.2	26.9	4.6
1997	24.1	106.6	143.5	26.5	4.7
Avg.	22.0	100.0	120.0	22.0	4.0
Std. Dev.	2.4	12.1	16.5	2.8	0.4
CV	0.108	0.121	0.137	0.129	0.094
Min.	17.7	83.7	80.4	15.2	3.5
Max.	27.1	125.2	143.5	26.9	4.7
Range	9.5	41.5	63.1	11.7	1.2

Table 2. Annual and 20-year Average Crop Prices

Year	Beets ($ / Ton)	Barley ($ / Bu.)	Corn ($ / Bu.)	Beans ($/ Cwt.)	Alfalfa ($ / Ton)
1978	$42.40	$3.52	$3.23	$24.44	$66.12
1979	$53.11	$3.58	$3.41	$34.38	$78.27
1980	$71.38	$4.07	$4.35	$38.85	$97.47
1981	$52.10	$4.28	$3.44	$23.86	$89.12
1982	$54.36	$3.94	$3.66	$16.25	$72.85
1983	$46.08	$4.43	$4.24	$24.66	$84.88
1984	$40.29	$4.34	$3.40	$19.26	$84.36
1985	$39.03	$4.02	$2.92	$21.76	$91.19
1986	$43.17	$3.82	$2.01	$17.93	$63.69
1987	$45.03	$3.68	$2.41	$17.41	$58.43
1988	$49.77	$3.70	$3.03	$32.55	$96.01
1989	$46.02	$3.48	$2.67	$31.92	$95.03
1990	$42.72	$3.68	$2.55	$17.72	$80.16
1991	$40.80	$3.63	$2.59	$14.81	$65.52
1992	$42.19	$3.56	$2.38	$19.07	$75.15
1993	$41.23	$3.14	$2.68	$26.24	$73.95
1994	$37.40	$2.92	$2.40	$17.33	$83.22
1995	$36.19	$2.59	$3.74	$20.26	$69.12
1996	$43.44	$3.03	$2.71	$20.55	$72.40
1997	$34.65	$2.97	$2.39	$17.55	$77.40
Avg.	$45.07	$3.62	$3.01	$22.84	$78.72
Std. Dev.	$8.22	$0.50	$0.65	$6.77	$11.35
CV	0.182	0.138	0.216	0.296	0.144
Min.	$34.65	$2.59	$2.01	$14.81	$58.43
Max.	$71.38	$4.43	$4.35	$38.85	$97.47
Range	$36.73	$1.84	$2.34	$24.04	$39.04

Table 3. Annual and 20-year Average Net Returns Over Variable Costs ($/Ac.) by Crop

Year	Beets	Barley	Corn	Beans	Alfalfa
1978	$266	$133	-$6	$181	$43
1979	$460	$112	$101	$528	$95
1980	$1,064	$192	$229	$665	$153
1981	$810	$212	$194	$272	$124
1982	$740	$177	$200	$78	$135
1983	$461	$196	$200	$222	$149
1984	$325	$203	$122	$206	$147
1985	$262	$197	$94	$178	$142
1986	$212	$184	-$10	$152	$72
1987	$473	$157	$31	$160	$37
1988	$497	$119	$136	$441	$171
1989	$335	$129	-$5	$369	$156
1990	$354	$203	$62	$133	$149
1991	$350	$211	$99	$95	$72
1992	$594	$198	$2	$164	$110
1993	$443	$153	-$20	$144	$123
1994	$233	$132	$58	$128	$162
1995	$313	$135	$202	$255	$127
1996	$359	$185	$89	$298	$142
1997	$284	$127	$76	$211	$174
Avg.	$442	$168	$93	$244	$124
Std. Dev.	$216	$35	$81	$151	$40
CV	0.490	0.206	0.869	0.620	0.326
Min.	$212	$112	-$20	$78	$37
Max.	$1,064	$212	$229	$665	$174
Range	$852	$100	$249	$587	$137

Table 4. Correlation of Crop Returns

	Beets	Barley	Corn	Beans	Alfalfa
Beets	1.000	0.293	0.570	0.492	0.128
Barley		1.000	0.242	-0.281	-0.040
Corn			1.000	0.367	0.392
Beans				1.000	0.270
Alfalfa					1.000

Table 5. Annual and 20-year Average Net Returns, and Measures of Risk for Six Selected Farm Plans or Enterprise Mixes.

Farm Plan	#1	#2	#3	#4	#5	#6
Beets (Ac.)	240	240	240	180	0	240
Barley (Ac.)	0	60	120	160	240	480
Corn (Ac.)	0	120	160	180	240	0
Beans (Ac.)	480	300	200	100	80	0
Alfalfa (Ac.)	0	0	0	100	160	0
Total (Ac.)	720	720	720	720	720	720
Year	**Net Returns Over Variable Costs For Each Farm Plan**					
1978	$150,620	$125,344	$115,009	$90,517	$51,962	$127,708
1979	$363,654	$287,510	$245,489	$181,142	$108,538	$163,986
1980	$574,544	$493,848	$448,026	$345,287	$178,722	$347,466
1981	$324,900	$311,915	$305,171	$254,142	$138,937	$295,921
1982	$215,175	$235,710	$246,494	$218,852	$118,281	$262,443
1983	$217,003	$212,877	$210,494	$187,435	$136,688	$204,911
1984	$176,902	$166,623	$163,083	$148,244	$118,034	$175,531
1985	$148,555	$139,501	$137,221	$127,605	$106,708	$157,413
1986	$123,736	$106,270	$101,762	$88,236	$65,407	$139,502
1987	$190,345	$174,727	$169,389	$135,580	$63,821	$188,757
1988	$331,087	$275,125	$243,599	$194,231	$123,894	$176,619
1989	$257,669	$198,417	$169,077	$132,729	$84,423	$142,590
1990	$148,489	$144,277	$145,673	$135,458	$98,071	$182,086
1991	$129,307	$136,845	$144,013	$131,188	$93,494	$185,167
1992	$221,368	$203,973	$199,522	$166,461	$78,890	$237,547
1993	$175,196	$156,077	$150,065	$127,126	$62,952	$179,531
1994	$117,288	$109,066	$106,483	$102,344	$81,640	$119,192
1995	$197,750	$184,094	$174,714	$152,484	$121,490	$139,804
1996	$229,321	$197,486	$182,359	$154,370	$112,472	$175,144
1997	$169,732	$148,429	$137,937	$123,694	$93,443	$129,049
Averages and Measures of Risk For Each Farm Plan Over 20-year Period						
Avg.	$223,132	$200,406	$189,779	$159,856	$101,893	$186,518
Std. Dev.	$108,061	$89,916	$80,436	$60,184	$30,995	$58,927
CV	0.484	0.449	0.424	0.376	0.304	0.316
Min.	$117,288	$106,270	$101,762	$88,236	$51,962	$119,192
Max.	$574,544	$493,848	$448,026	$345,287	$178,722	$347,466
Range	$457,256	$387,578	$346,264	$257,051	$126,760	$228,275
Years Out of 20 Income Fell Below Target Income of $150,000 For Each Farm Plan						
	5	7	7	11	19	6
Total Income Amount Below Target of $150,000 For Each Farm Plan Over 20-year Period						
	-$82,624	-$140,269	-$161,901	-$307,279	-$990,856	-$102,156

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