CONVERTING FROM FURROW IRRIGATION TO CENTER PIVOT SPRINKLER IRRIGATION—DOES IT PAY?

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SUMMARY

An economic analysis was conducted to analyze the feasibility of converting from furrow to center pivot sprinkler irrigation for corn production in western Kansas and eastern Colorado. The analysis revealed that investing in a center pivot sprinkler system would increase returns compared to furrow irrigation. The relative profitability of the two systems was insensitive to typical pumping costs but was very sensitive to initial investment, payback period, corn yield potential, and acres irrigated. Factors affecting the economic feasibility of converting from furrow to center pivot vary considerably between producers; therefore, it is important for each producer to analyze the profitability of conversion for their operation.

INTRODUCTION

Crop production from irrigated land in the High Plains provides important contributions to the economy of the region. Irrigated crop production is the largest permitted water use in Kansas and Colorado. However, declines in groundwater resources have emphasized the need to use this limited resource in an efficient manner while still considering the economic impact on individual producers. In addition to decreasing water supplies, increasing energy costs are encouraging producers to look at methods of improving irrigation efficiency. Improvement in irrigation water use efficiency, whether through better management techniques or system efficiency improvements, may be able to accomplish partial conservation of water resources and preservation of returns to irrigation farmers.

One of the biggest improvements that can be made regarding irrigation water application efficiency is the conversion of furrow or flood irrigation to center pivot sprinkler irrigation. When managed properly, the application efficiency of a center pivot system can be significantly higher than furrow irrigation. As irrigation efficiency is increased, production per unit of water will increase indicating a more efficient use of the limited groundwater resource. However, converting to center pivot sprinkler from furrow irrigation requires a large capital investment. The production and economic benefits of center pivot systems will vary considerably among producers; thus, it is important for producers to analyze the economic feasibility of conversion before making any investment decisions.

Many producers believe that converting from furrow irrigation to a center pivot sprinkler system will decrease energy costs. Irrigation pumping costs per inch of water will not necessarily decrease with center pivot because of increased pumping pressure. The effect on total annual energy costs will depend on total water pumped. If water use per acre remains the same as furrow levels or acres irrigated increase, there may not be any total water savings associated with converting to center pivot irrigation. However, irrigation water use efficiency (production per inch of water) should be higher with center pivot because of the improved application efficiency.

ECONOMIC ANALYSIS METHODOLOGY

The economic profitability of converting from furrow to center pivot sprinkler irrigation was analyzed using partial budgeting. Partial budgeting analyzes the profitability of an investment, but unlike whole-farm budgeting, it does not indicate whether or not the farm as a whole is profitable because only income and costs directly affected by the investment are included in the analysis. This type of analysis allows the producer to see how much a new investment either needs subsidizing or contributes to the rest of the farm operation.

Because a center pivot sprinkler system is a long-term investment, the net present value of returns from the partial budget was calculated. Net present value (NPV) takes into account the time value of money because it discounts costs and returns that are realized in future years. This method is useful when there is a long payback period and in cases where income and/or costs vary from year-to-year over the investment period considered. Even though returns were considered constant from year-to-year in this analysis, NPV was used because of the long payback period assumed. From an economic standpoint, a positive NPV indicates returns will be increased by converting to center pivot. Producers may want to develop a partial budget that analyzes the cash flow consequences of converting to center pivot because the cash flow implications can be different from the long run economic potential.

Investment analyses will often calculate an after-tax return. While the tax implications of converting irrigation systems cannot be ignored, they will vary considerably among producers, so they were not included in this analysis. Therefore, all reported returns are on a before-tax basis.

The first step in the economic analysis was to determine the investment requirement of the center pivot sprinkler system (Table 1). The system investment was based on a low pressure system with drops on 5.0 foot spacings irrigating 126 acres. The investment also included 2000 feet of underground pipe and electrical wiring. It also was assumed that there would be a cost of pulling and modifying the pump. If there is furrow irrigation equipment (gated pipe, surge valves, etc.) that could be sold, the initial investment of the center pivot system could be decreased by that amount. For this analysis, it was assumed the current furrow irrigation equipment had minimal salvage value so it was not factored into the calculations.

Annual ownership costs of the center pivot system were calculated by amortizing the system cost over its estimated useful life of 15 years at 9 percent interest. It is very possible that a sprinkler system could have a positive salvage value at the end of 15 years. However, due to the uncertainties associated with depth to water, energy costs, and potential obsolescence at the end of the payback period, a zero salvage value was assumed for the analysis.

The second step in the economic analysis was to determine the level of three key production parameters: acres irrigated, crop yield potential, and the amount of irrigation water applied (Table 3). These figures are correlated and vary with well capacity, irrigation system, field size, soil type, and location. The center pivot sprinkler system was assumed to irrigate 126 acres of corn *versus* 80 acres with furrow irrigation. Acres not in irrigated corn production were assumed to be in a wheat/no-till corn/fallow rotation. Irrigated corn yields were initially assumed to be equal for both systems at 175 bu/ac. The amount of irrigation necessary for optimal yields will vary by year, location, management, and system. For the analysis, approximately 20-acre inches of irrigation water were used with the center pivot sprinkler system and 28-acre inches with the furrow system. These values are based on water use requirement studies conducted in Kansas and an application efficiency of 90 percent for center pivot and 60-65 percent for furrow.

Based on the production assumptions used, production expenses were approximately $30/acre higher for furrow than center pivot irrigated corn (Table 4). This was due to higher labor requirements and increased pumping costs. Income per irrigated acre was constant because yields were assumed to be equal for both systems. Government program payments were assumed to be equal for both systems so they were not included in the analysis. Machinery ownership costs (depreciation, interest, and insurance) were not included in the analysis. It was assumed there would be no difference in machinery requirements between the two systems.

RESULTS AND DISCUSSION

The center pivot sprinkler system had an annual economic advantage of $1390 ($8.68/acre) over the furrow system (Table 5). The total economic advantage over the life of the system was $20,844 with an NPV of $11,201.

In other words, the net returns of the center pivot sprinkler over the life of the system are equivalent to $11,201 today. The center pivot system irrigated more acres thereby generating significantly more gross income. However, increased total production expenses and annual ownership costs of the center pivot system offset much of this increased income. Annual ownership costs were calculated as the initial investment cost of the system ($51,500) amortized over the expected life of the system (15 years) at 9 percent interest.

The relative returns of both the center pivot sprinkler and furrow irrigation systems were very sensitive to changes in certain variables. A sensitivity analysis was done to determine how changes in major variables affected the relative returns of the two systems. Variation in the initial investment and amortization period for the center pivot sprinkler system was evaluated to determine its impact on NPV. At the base investment ($51,500), NPV was positive with a payback period greater than 10 years (Figure 1). Reducing the initial investment by 20 percent to $41,200, resulted in a positive NPV with a payback period of eight years or more. With a 20 percent increase in initial investment, NPV was slightly positive over the useful life of 15 years.

Because center pivot sprinklers are more efficient than furrow irrigation, it is expected the benefit of converting increases as irrigation pumping costs increase. However, in this analysis, NPV decreases as pumping costs increase (Figure 2). The reason for this is because more total water was pumped with center pivot compared to furrow due to increasing the amount of acres irrigated (126 *vs.* 80). However, even if pumping costs were to increase substantially, converting to center pivot was profitable. This indicates that irrigation pumping costs are not a major determinant of relative profitability of the two systems.

The sensitivity of NPV to corn yield potential also was analyzed to determine the potential income advantage the center pivot sprinkler system had over the furrow system due to more irrigated acres (126 *vs.* 80). The NPV of converting from furrow to center pivot irrigation was zero, indicating a breakeven proposition, if corn yields under center pivot decreased approximately 5 bu/ac (Figure 3). Yield/acre might decrease as a fixed amount of irrigation water is spread over additional acres. If the initial yield under furrow irrigation was 150 bu/ac, the breakeven yield for the center pivot system would be approximately 155 bu/ac. It can be seen in Figure 3 that the relative returns of the two systems (NPV) were extremely sensitive to changes in yields.

Initially it was assumed that there were 126 irrigated corn acres with center pivot compared to 80 under furrow irrigation. The sensitivity of NPV to varying irrigated acres under furrow was analyzed holding acres for center pivot constant at 126. If the furrow system could maintain the 175 bu/ac yield on approximately 90 acres or more, NPV was negative indicating it would not be profitable to convert to center pivot.

This analysis indicates that converting from furrow to center pivot sprinkler irrigation systems can increase returns for corn in western Kansas and eastern Colorado. However, the analysis also indicates the relative returns of the two systems as shown by NPV is fairly sensitive to variables such as initial investment and payback period. Returns were extremely sensitive to those variable that directly affect gross income such as yield and acres irrigated. Irrigation pumping costs did not impact the relative profitability of the two systems. This implies that an improvement in income is much more critical than a reduction in costs in order for conversion to be profitable.

TABLE 1. Investment information for center pivot sprinkler system.

Total investment for sprinkler system	$38,000
Pump, gearhead, and motor modification costs	$7,500
Underground pipe and electrical lines, etc.	$6,000
TOTAL INVESTMENT	$51,500
Years for payback	15
Interest rate	9.0%
Annual charge (principal and interest)	$6,389
Salvage value at end of payback period	$0

TABLE 2. Irrigation pumping and repairs information.

PUMPING INFORMATION	Furrow	Pivot
Pumping capacity (gpm)	600	600
Lift (ft)	250	250
Discharge (psi)	10	35
Energy source	Elec.	Elec.
Energy cost/unit	$0.05	$0.05
NPPPC (%)[1]	75.0	95.0
Total dynamic head (TDH)	273	331
Pumping cost/inch of water	$2.35	$2.25
IRRIGATION REPAIRS AND MAINTENANCE	$400	$1,000

[1]Percent of Nebraska Pumping Plant Performance Criteria.

TABLE 3. Crop acres, yield, and water use information.

IRRIGATED ACRES		Furrow		Pivot
Crop planted		Corn		Corn
Acres planted		80		126
Irrigation days (24 hr/d)		70		80
Total irrigation hours		1680		1920
Acres inches applied/acre		28.0		20.3
Yield/acre		175.0		175.0
Value of crop/unit		$2.35		$2.35
Sales income per acre		$411.25		$411.25
DRYLAND ACRES				
Crop planted	Wheat	NT-Corn	Wheat	NT-Corn
Acres planted	26.7	26.7	11.3	11.3
Yield/acre	35.0	65.0	35.0	65.0
Value of crop/unit	$3.20	$2.35	$3.20	$2.35
Sales income per acre	$112.00	$152.75	$112.00	$152.75
Dryland acres fallow		26.7		11.3
TOTAL ACRES		160		160

TABLE 4. Irrigated and dryland crop budgets.

IRRIGATED CORN: INPUTS AND COSTS/ACRE	Furrow	Pivot
Acres planted	80	126
Inches of water pumped/acre	28.0	20.3
Hours of labor at $8 per hour	3.50	2.50
Labor	$28.00	$20.00
Seed	30.00	30.00
Herbicide and insecticide	50.00	50.00
Fertilizer	50.00	50.00
Fuel and Oil	8.00	7.00
Machinery repairs	15.00	13.00
Pumping energy	65.80	45.71
Irrigation repairs and maintenance	5.00	7.94
Crop consulting	6.00	6.00
Miscellaneous	7.00	7.00
Operating interest at 9%	11.92	10.65
TOTAL OPERATING COST/PLANTED ACRE	$276.72	$247.30

DRYLAND WHEAT: INPUTS AND COSTS/ACRE	Furrow	Pivot
Acres planted	26.7	11.3
Hours of labor at $8 per hour	1.25	1.25
Labor	$10.00	$10.00
Seed	4.00	4.00
Herbicide	7.50	7.50
Fertilizer	6.00	6.00
Fuel and oil	7.50	7.50
Machinery repairs	12.00	12.00
Miscellaneous	5.00	5.00
Operating interest at 9%	$54.34	$54.34

TOTAL OPERATING COST/PLANTED ACRE	Furrow	Pivot
Acres planted	26.7	11.3
Hours of labor at $8 per hour	1.00	1.00
Labor	$8.00	$8.00
Seed	16.00	16.00
Herbicide	28.00	28.00
Fertilizer	15.00	15.00
Fuel and oil	5.00	5.00
Machinery repairs	10.00	10.00
Miscellaneous	5.00	5.00
Operating interest at 9%	3.92	3.92
TOTAL OPERATING COST/PLANTED ACRE	$90.92	$90.92

	Furrow	Pivot
TOTAL PROPERTY TAXES[1]	$1016	$1306

[1]Calculated at 1% of the value of land (irr. = $950/A and dryland = $320/A).

Table 5. Returns of center pivot sprinkler vs. furrow irrigation

Year	1	2	3	 14	15	Total
CROP INCOME[1]						
Center pivot	54,818	54,818	54,818	54,818	54,818	$822,270
Furrow	39,960	39,960	39,960	39,960	39,960	$599,400
Difference	14,858	14,858	14,858	14,858	14,858	$222,870
EXPENSES						
Center pivot	34,114	34,114	34,114	34,114	34,114	$511,710
Furrow	27,035	27,035	27,035	27,035	27,035	$405,525
Difference	7,079	7,079	7,079	7,079	7,079	$106,185
EQUIPMENT PAYMENTS						
Principal & interest	6,389	6,389	6,389	6,389	6,389	$95,835
RETURNS TO MGMT, LAND, & MACH.[2]						
Center pivot	14,315	14,315	14,315	14,315	14,315	$214,725
Furrow	12,925	12,925	12,925	12,925	12,925	$193,875
Difference	1,390	1,390	1,390	1,390	1,390	$20,850
CUMULATIVE RETURNS						
	1,390	2,780	4,170	19,460	20,850	
RETURNS TO MGMT, LAND, & MACH./ACRE						
Center pivot	$89.47	$89.47	$89.47	$89.47	$89.47	$1,342
Furrow	$80.78	$80.78	$80.78	$80.78	$80.78	$1,212
Difference	$8.69	$8.69	$8.69	$8.69	$8.69	$130
FINANCIAL MEASURES[3]						
Total Net Present Value (NPV)			11,201			
Internal Rate of Return (IRR)			12.5%			

1 Crop income does not include government payments.

2 Returns to management, land and machinery represents a return to fixed assets. (the same for center pivot and furrow irrigation)

3 Net present value (NPV) is the returns to fixed assets discounted to current dollars. A positive NPV indicates center pivot is more profitable than furrow irrigation. A negative NPV indicates furrow irrigation is more profitable.

Internal rate of return (IRR) should be compared with a minimum acceptable rate of return. If the IRR is equal to or greater than the minimum acceptable rate, center pivot would be considered a good investment.

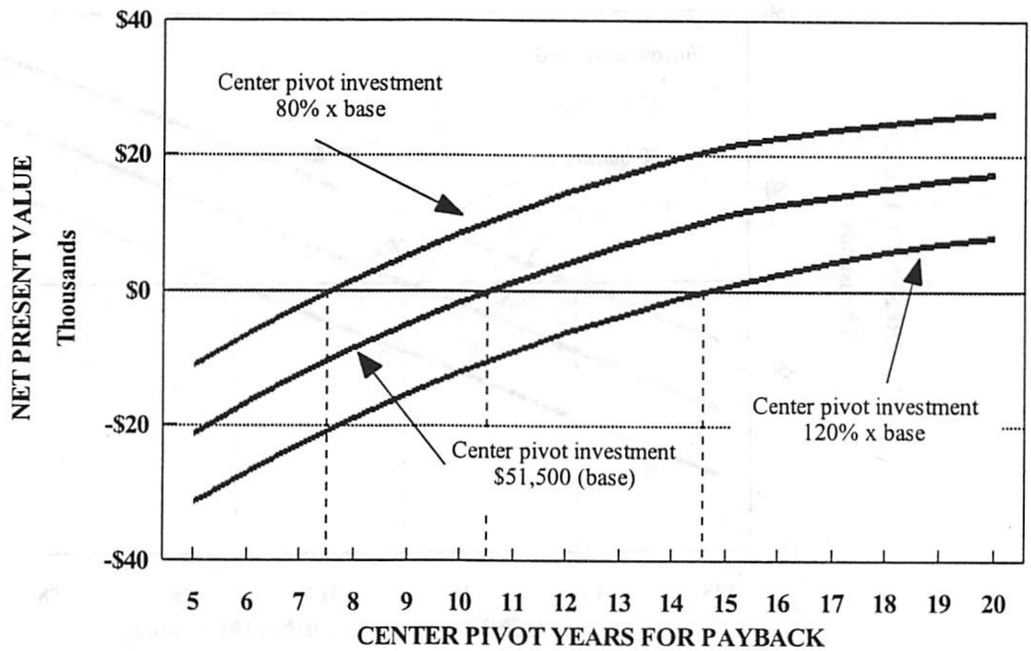

Figure 1. Net present value of converting from furrow to center pivot sprinkler irrigation vs. years for payback and total investment for center pivot sprinkler.

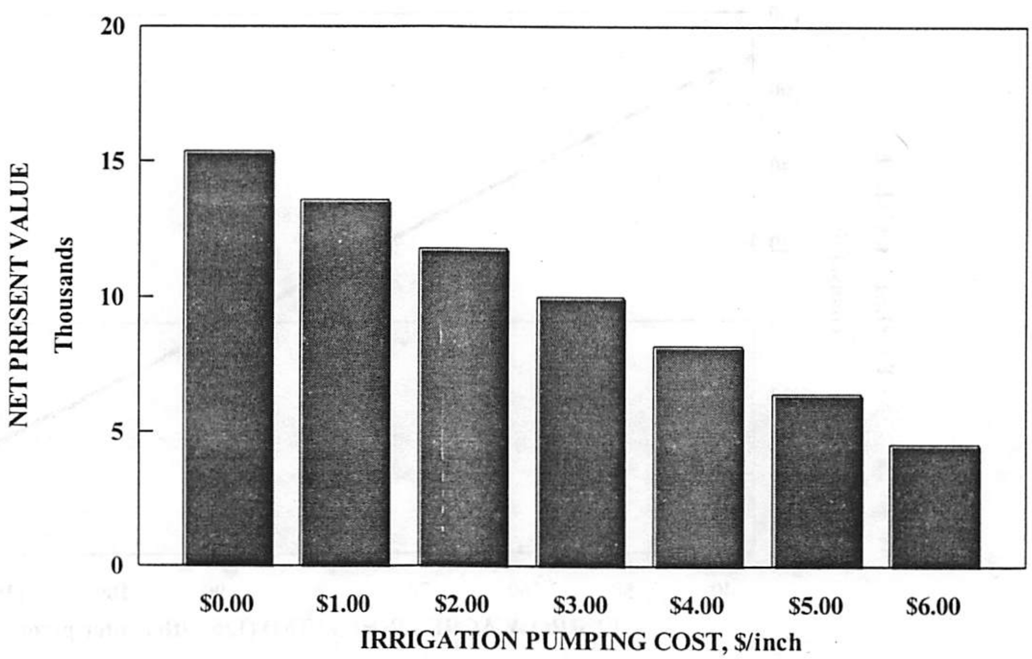

Figure 2. Net present value of converting from furrow to center pivot sprinkler irrigation vs. irrigation pumping cost.

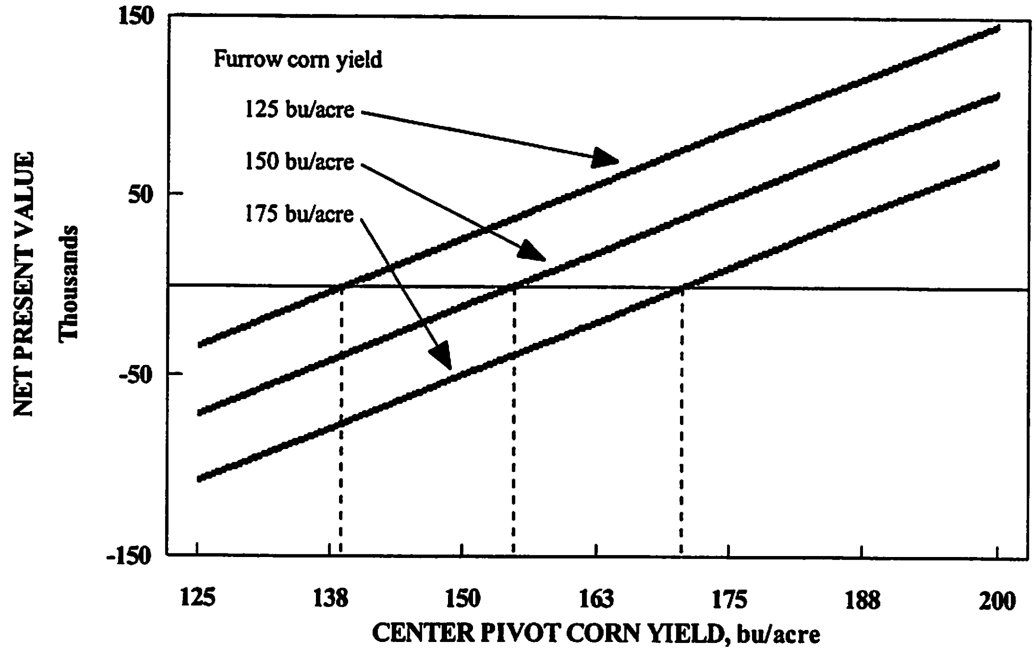

Figure 3. Net present value of converting from furrow to center pivot sprinkler irrigation vs. irrigated corn yield potential.

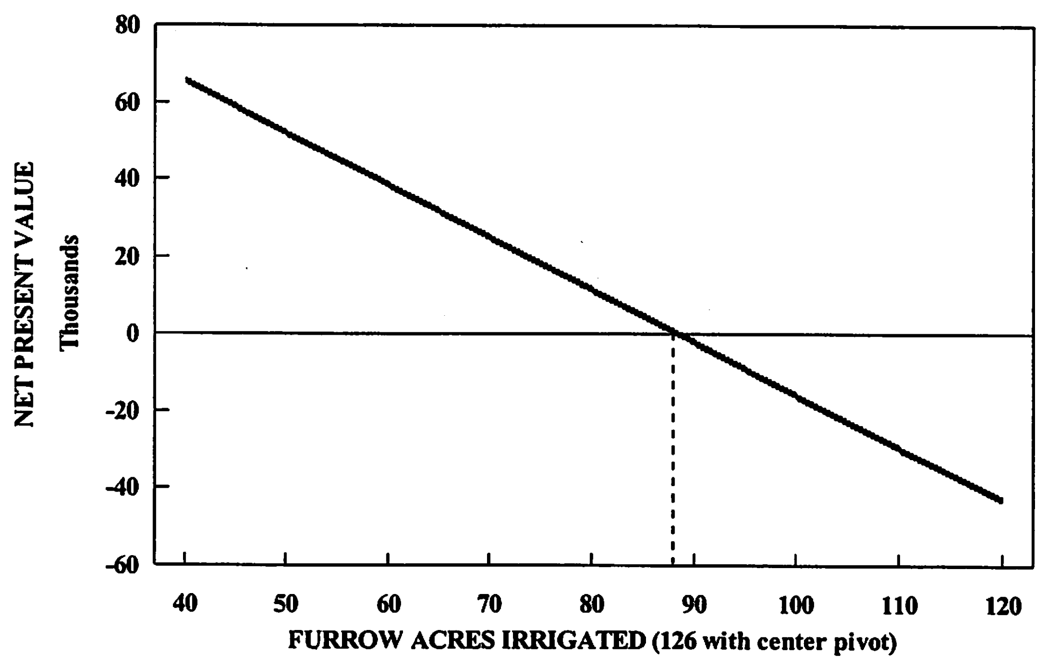

Figure 4. Net present value of converting from furrow to center pivot sprinkler irrigation vs. acres irrigated with furrow system.