AN ECONOMIC COMPARISON OF ALTERNATIVE IRRIGATION SYSTEMS ON SMALL AND IRREGULARLY SHAPED FIELDS

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INTRODUCTION

Economic analysis supports the idea that sprinkler irrigation systems have an economic advantage over subsurface drip irrigation (SDI) systems for fields where full size center pivots can be utilized. In these scenarios, center pivots gain important cost economies from spreading system investment costs over the maximum number of acres.

This paper considers a number of factors that affect the relative profitability of investing in center pivot and SDI systems. First, how are the cost economy advantages of center pivot systems over subsurface drip irrigation systems affected as field size decreases and field shapes change? A related question is whether there is some range in field size or group of field shapes where the relative projected profitability of SDI systems becomes comparable with center pivot systems? Important factors to consider in comparing investment in the two irrigation systems are a) variation in irrigation system investment cost economies by field size and shape (i.e, the capital or fixed cost effects), b) potential differences in crop revenue for cropping systems that fully utilize all acres in irrigated crop enterprises as opposed to those that must include nonirrigated production due to inflexible system designs, and c) comparative irrigation water application efficiencies for center pivot and SDI systems (i.e., the variable or operating cost effects).

The starting point for this analysis is the assumption that a field exists that is currently being flood irrigated, but is to be transformed into either a center pivot or SDI irrigation system. It is also assumed that the existing well is centrally located at the edge of the field, is fully depreciated out, but not yet in need of replacement. From this starting point, cost estimates for alternative irrigation systems together with Extension crop enterprise budgets for irrigated corn and summer fallow wheat in western Kansas will be used to project annual profitability for the alternative irrigation and cropping systems. An objective of this paper is to compare the "proportional adjustability" of center pivot and SDI system costs per acre for a number of smaller and irregularly shaped fields.

FACTORS AFFECTING THE CHOICE OF IRRIGATION SYSTEM

One of the primary factors affecting a farmer's choice of irrigation system are the cost economies involved. Center pivot irrigation systems have a cost advantage over SDI systems on large land tracts (i.e. 1/4 sections) where per acre investment costs can be lowered by spreading them out over a large number of acres. However, center pivot investment costs may tend to be “chunky” or “sticky” as acreage decreases for less than 125 acre center pivots or for irregularly shaped fields. Some “sticky” center pivot cost factors may include the following items: the pivot pad, the underground pipe from the well to the pivot system, installation labor, generator and electric wiring, etc.

The expected life of an irrigation system is another concern. In this paper a center pivot is assumed to have a 20 year life, with a range of from 15 to 25 years. An SDI system is assumed to have a 10 year life, with a range of from 5 to 15 years. Life of the system has a major impact on the profitability of investing in either system, as the initial investment cost per acre is amortized out over the expected life of the system. This is especially critical for SDI systems, where uncertainty about expected system life can dramatically impact the annual system cost per acre a farmer is willing to budget for.

The replacement cost or salvage value of each system is another major consideration in this analysis. In these budgets, both systems are assumed to have 0% salvage value. This is a common assumption and practice in western Kansas. However, in some cases center pivots will have some salvage value after 20 years. A very important, and as yet unanswered question exists regarding the salvage value of SDI systems. For this analysis, it is assumed that at the end of 10 years, the full current cost of an SDI system will be incurred to renovate the old system, without consideration of inflation costs, etc.. Given that some of the SDI equipment could be reused at that time, such an assumption may be reasonable. More information is needed regarding the projected costs of renovateing, repairing, and/or replacing an existing SDI system with a new SDI system in the future.

Irrigation water application efficiency may effect the choice of irrigation system. In this study, it is assumed that SDI water applications are 10% more efficient than center pivot applications. Center pivot systems are assumed to apply 18 inches of water while SDI systems are assumed to apply 16 inches. Because of reduced water application, SDI systems will have lower fuel, oil, and electricity costs, and marginally lower repair and operating interest costs than center pivot systems.

There will also be revenue differences among center pivot and SDI-oriented cropping systems. The primary factor affecting relative profitability will be lower revenue produced from nonirrigated farmland in center pivot corners as compared to higher revenue on these same acres in SDI systems. The proportional adjustability of SDI systems relative to center pivots will allow for more cropland to be irrigated and cause gross revenue (as well as total expenses) to increase for the whole-field cropping systems. The deciding issue for farmers considering center pivot versus SDI will be which cropping system produces the highest net revenue.

A number of other factors are not accounted for in this analysis. Lower production and income risk for the irrigated as opposed to nonirrigated cropland in the center pivot system is not studied here, but is a factor that would be expected to favor the 100% acreage coverage available with SDI systems. There are potential irrigation water application uniformity benefits for SDI as opposed to center pivot irrigation systems which are not dealt with here. Also, with declining water tables in some local areas of western Kansas, and therefore limited irrigation time horizons, the increased efficiency of SDI systems could potentially reduce the rate of water use, lengthen the life of the local aquifer, and better match the expected investment time horizon of the irrigated enterprise in areas where declines are most precipitous.

In summary, fixed or capital costs per acre will be affected by initial irrigation system costs as well as the expected life of the system and the cost to renovate it (especially for SDI systems). Variable operating costs per acre will be affected by the irrigation water application efficiencies of each system. Cropping system gross and net revenues will be affected by the number of nonirrigated acres necessary in center pivot cropping systems relative to fully irrigated SDI cropping systems.

ANALYSIS

Framework Used for Analyzing Irrigation System Economics

An enterprise budget framework is used to analyze the profitability of center pivot and SDI system investments for each field size scenario. Projected crop production system net returns to land and management are calculated as follows.

First, gross revenue is projected for each field size scenario for both a center pivot-oriented cropping system (with a combination of irrigated corn and non-irrigated summer fallow wheat acreage) and an SDI-oriented cropping system (with 100% irrigated corn acreage). Differences in crop returns will show the effect upon total and net revenue per acre of combined irrigated / dryland cropping systems for center pivots and irrigated acres-only cropping systems for SDI. Then, variable costs of production for the irrigated and non-irrigated acres are subtracted from gross revenue for each cropping system, with all variable costs being accounted for except management charges. While a labor charge is paid, a cost for the responsibility of making management decisions is not explicitly included. Differences in the non-management variable costs will indicate the affect of potential irrigation water application efficiencies upon variable (direct) irrigated operating costs per acre as well as the impact of including non-irrigated acres in the center pivot-oriented systems. Following the variable cost adjustment, fixed costs are subtracted. All fixed costs are accounted for except land opportunity costs, or, alternatively, land rental costs. While real estate taxes are included, land opportunity or rental costs are not estimated in order to avoid the difficult task of determining fair opportunity cost returns or fair rental values for farmland. Differences in total fixed non-land costs between the two alternative cropping systems are the result of two factors. First, differences exist in per acre irrigation system capital investment costs for center pivots and SDI systems. Second, the inclusion of nonirrigated acreage in pivot-oriented cropping systems lowers the average fixed cost per acre across all acres in that cropping system.

The net revenue remaining after variable and fixed costs are subtracted represents the net returns to land and management for each cropping system. Projected yields, prices, variable costs, and all fixed costs other than for the irrigation system are based on 1995 KSU Extension Farm Management Enterprise Budget projections and recommendations of KSU Extension specialists. Center pivot and SDI irrigation system investment costs were formulated by KSU agricultural engineers using past and current industry survey results together with personal knowledge of item costs, and are not readily available in any KSU Extension or Research publication.

Alternative Field Scenarios

Six field scenarios are examined in this paper. As previously stated, it is assumed that the square or rectangle field being examined has been in a flood irrigation system, with an existing well located centrally at the edge of the field. In each scenario, projected production, returns, variable costs, fixed costs, as well as projected net returns from both a center pivot and an SDI cropping system are calculated and analyzed. It is assumed that corn will be produced on all the irrigated acres. On the nonirrigated acres summer fallow wheat will be grown in a two year wheat - fallow rotation. The center pivot cropping systems irrigated and nonirrigated acreages are given in Table 1, and the SDI cropping system irrigated acreages are given in Table 2.

Scenario O is the base scenario for a full 160 acre field. For a center pivot cropping system, there would be 125 acres of irrigated and 35 acres of nonirrigated cropland, with a full circle allowed for the pivot. For an SDI cropping system, all 160 acres would be irrigated. For Scenario A, a 127 acre field will be considered. For a shortened center pivot, the cropping system would include 100 acres of irrigated cropland and 27 acres of nonirrigated. With SDI, all 127 acres are irrigated. Scenario B portrays a 95 acre field. In this field the further shortened center pivot would provide for 75 acres of irrigated cropland, and 20 acres of nonirrigated. All 95 acres are assumed to be irrigated in an SDI cropping system. Scenario C represents a field of 64 acres. In the center pivot cropping system, there would be 50 irrigated acres and 14 nonirrigated acres. All 64 acres would be irrigated in the SDI cropping system. The smallest field examined is in Scenario D, with 32 total acres. In this small field scenario, the center pivot irrigation system covers 25 acres, leaving 7 acres of nonirrigated cropland. As in the other scenarios, the SDI system allows for all 32 acres to be irrigated. The final scenario examined is the 80 acre scenario, where a half circle pivot or "wiper" system (i.e., the "Wiper" Scenario in Table 1) is used for sprinkler irrigation, as compared to coverage of the full acreage with SDI irrigation (i.e., Scenario E in Table 2). The Wiper pivot system scenario results in 64 irrigated and 16 nonirrigated acres. It is also assumed that no underground pipe is needed for the Wiper system scenario, since the existing well is already located centrally at the edge of the field, at the same location as the Wiper system pivot point.

Center Pivot and SDI System Designs and Costs

Center pivot system capital requirements for the alternative field scenarios are given in Table 1. The center pivot system costs in Table 1 were estimated using private industry cost figures and input from agricultural engineers. Field radius is calculated to estimate the length of underground pipe needed to the pivot point from the edge of the field. Worksheets presented in the KSU Extension publication, Irrigation Capital Requirements and Energy Costs, MF-836, are used as a framework by which to calculate center pivot capital investment costs per irrigated acre. Further explanation is given in footnotes to Table 1.

The Total Cost Per Acre column in Table 1 illustrates that diminishing cost economies (i.e., higher capital cost per acre for smaller irrigated acreages) exist in this example as center

Table 1. Center Pivot System Capital Requirements for Alternative Field Sizes

Center Pivot Field				Center Pivot System Cost Per Irrigated Acre				
Field Scenario	No. Pivot Acres	Dryland Corner Acres	Total Acres	Pivot System Cost	Field Radius	Pipe, Wiring, Electric*	Total Cost	Total Cost / Acre**
Full Pivot Circle O	125 ac	35 ac	160 ac	$30,000	1320 ft	$9,282	$39,282	$314/ac
A	100 ac	27 ac	127 ac	$28,000	1177 ft	$8,548	$36,548	$365/ac
B	75 ac	20 ac	95 ac	$25,500	1020 ft	$7,752	$33,252	$443/ac
C	50 ac	14 ac	64 ac	$22,000	832 ft	$6,809	$28,809	$576/ac
D	25 ac	7 ac	32 ac	$18,000	589 ft	$5,559	$23,559	$942/ac
"Wiper" System	64 ac	16 ac	80 ac	$30,000	1320 ft	$2,550	$32,550	$509/ac

* 8" Underground pipe @ $3/ft, connectors @ $350, electric wiring @ $2.10/ft, 12 KVA generator @ $2,200
** No interest cost included. Calculated on a per irrigated acre basis.

pivots are placed on successively smaller fields. For base scenario O (i.e., full pivot circle), total irrigation system investment cost is $314 per acre. Total cost per acre increases to $365 per acre in scenario A (100 irrigated acres), $443 per acre in scenario B (75 irrigated acres), $576 in scenario C (50 irrigated acres), and $942 in scenario D (25 irrigated acres). These figures indicate that center pivot investment costs increase 300% when irrigated acreage decreases by 80%. The Wiper system cost is $509 per acre for 64 irrigated acres, which is comparable to the costs for the centrally located pivots in scenarios B ($443 per acre on 75 acres) and C ($576 per acre on 50 acres).

SDI system capital requirements for the alternative field scenarios are given in Table 2. As in Table 1, the SDI system costs in Table 2 were estimated using private industry cost figures and input from agricultural engineers. A KSU Extension publication, Irrigation Capital Requirements and Energy Costs, MF-836, is used to calculate SDI capital investment costs per irrigated acre. Farm labor and tractor services were estimated using formulas based on total SDI area, trench length, driptape connector length, and total PVC pipe length. Actual formulas are available from the authors upon request.

In Table 2, the results in the last row for Total Cost Per Acre do not indicate the same degree of diminishing cost economies (i.e., higher capital cost per acre for smaller fields) in this example for SDI irrigation systems as exists for center pivot systems (see Table 1). Although initial SDI irrigation system costs begin at a higher level than pivot systems for the full 160 acre scenario O ($539 per acre for SDI vs $314 per acre for pivot systems), per acre investment costs do not dramatically change as field size diminishes. Costs move moderately higher ($568 and $571 per acre for scenarios A and B, respectively) to moderately lower ($544 for scenario C), before noticably increasing to $644 per acre for the smallest field in scenario D. This amounts to 19% cost increase for an 80% decrease in field size from scenario O to scenario D. Investment cost for

Table 2, Subsurface Drip Irrigation System Capital Requirements for Alternative Field Sizes

Item	$/Unit	Subsurface Drip Irrigation System Scenarios					
		Base (O)	A	B	C	D	E
Number of SDI Acres		160 acres	127 acres	95 acres	64 acres	32 acres	80 acres
8" Mainline pipe	$1.30/ft	$6,006	$2,293	$1,763	$1,086	$761	
6" Lateral / submain pipe	$0.70/ft	952	3,293	2,848	1,169	410	$3,234
4" Flushlines	$0.61/ft	7,222	5,739	3,722	2,037	1,440	3,221
Drip tape	$0.03/ft	41,976	33,193	24,829	16,733	8,354	20,909
Drip tape connectors	$0.75/ft	3,168	2,820	1,829	1,002	708	1,584
8x8x8x8 Cross	$200/cross	400					
8x8x6x6 Cross	$200/cross		200				
8x8x8 T	$340/T						
8x6 Reducing coupling	$25/coupling	100	25		25	25	
8x8x6 T	$340/T			340			
8" Pressure control valve	$440/valve	1760				440	
6x6x6 T	$145/T		145	145	145		435
6" Endcaps	$45/cap		180	270	90	45	180
6" Valves	$375/valve		1,500	1,125			
6" Elbows	$95/elbow			95			190
6"x 4" Reducing couplings	$20/cplg	80					
4" Elbows	$30/elbow	360	480	300	240	120	480
4" Valves	$375/valve						1,500
4" x 2" Reducing bushing	$18/bushng	216	288	180	144	72	288
2" Plugs	$6/plug	72	96	60	48	24	96
Air vents	$25/vent	350	350	350	350	150	350
PVC glue		250	250	200	200	200	250
Trenching	$0.68/ft	10,322	9,196	6,455	3,975	2,400	5,384
Filter		4,500	4,500	4,500	4,500	4,500	2,200
Pressure gauges	$20/gauge	360	360	280	280	140	360
Producer labor (installation)	$8/labor hr	7,200	6,376	4,360	2,384	1,240	3,792
Tractor use (installation)	$7/tractor hr	966	833	595	378	217	525
Total Costs		$86,261	$72,117	$54,246	$34,786	$21,245	$41,111
System Costs / Irrigated Acre		$539 /acre	$568 /acre	$571 /acre	$544 /acre	$664 /acre	$568 /acre

an 80 acre SDI system ($568 per acre) are comparable to those for a Wiper system ($509 per acre, Table 1).

The per acre capital requirements for SDI systems in Table 2 imply a higher degree of proportional adjustability to changes in field size than do center pivot irrigation system costs in Table 1. As field size diminishes in these scenarios, the SDI system costs are more nearly stable on a per acre basis than are those for center pivot irrigation systems. These results indicate that as field size decreases, at some point SDI systems may become cost competitive with pivot systems with regard to their fixed investment costs per acre.

Crop Enterprise Budget Framework

A crop enterprise budgeting framework is used to calculate the projected net revenue of alternative cropping systems utilizing center pivot and SDI irrigation technologies. The differing enterprise acreages, variable costs and fixed costs of each cropping system are examined within the framework of two KSU Farm Management crop enterprise budgets. The net revenue from irrigated acres is estimated using a 190 bushel per acre yield scenario, together with prices and costs for irrigated corn production in western Kansas as represented in the 1995 version of <u>MF-585, Center Pivot Irrigated Corn</u>. Table 3 is the modified version of MF-585 used in this analysis. The net revenue from non-irrigated acres is estimated using the 35 bushel per acre yield scenario from <u>MF-257, Summer Fallow Wheat in Western Kansas</u>. Table 4 is a modified version of the summer fallow wheat budget used in this analysis for nonirrigated acreage in the pivot-oriented cropping systems.

Tables 3 and 4 represent the irrigated corn and dryland wheat cost-return budgets used in scenario O (Full Circle Center Pivot). The only changes for other pivot irrigation scenarios would occur due to different pivot investment costs per acre (lines 21-22 in Table 3). These changes would correspond with the total investment costs per acre indicated in the last column in Table 1. For comparative SDI scenarios, the pivot investment costs would differ from lines 21-22 in Table 3 in accordance with results in the last row of Table 2. An additional change for SDI would occur in the variable cost of irrigation water applied (lines 7, 9, and 15), since it is assumed that 18 inches of water is applied per acre with pivots and 16 inches (a 10% efficiency increase) is applied with SDI systems. Note that no opportunity interest costs to land or land rental costs are included in these budgets. Also, no management charges are included. Therefore, the net returns calculated will represent net returns to both land and management.

The differences in costs (variable and fixed), revenue, and net returns between the irrigated corn enterprise in Table 3 and the nonirrigated summer fallow wheat enterprise in Table 4 will impact the comparison of overall net revenue between the pivot and SDI-oriented cropping systems. They will result in lower gross revenue and variable costs for pivot-oriented cropping systems relative to SDI-oriented cropping systems. However, relative capital or fixed costs between pivots and SDI as presented in Table 1 and Table 2 will be key determinants of the relative profitability of these two cropping systems.

Table 3. Irrigated Corn Cost-Returns Budget for Western Kansas

Example for Scenario O: Full Circle Center Pivot (125 acres) (Modified from 1995 KSU Farm Management Guide MF-585) VARIABLE COSTS	Budgeted 190 bu
1. Labor (2.5 hrs/acre × $9.00/hr)	$22.50
2. Seed (32 lbs/acre × $0.90/lb)	28.80
3. Herbicide	27.50
4. Insecticide	30.00
5. Fertilizer (Anhydrous: 170 lbs × $0.19/lb = $32.30)	50.25
(N Dry: 20 lbs × $0.29/lb = $5.80)	
(Phosphorous: 45 lbs × $0.27/lb = $12.15)	
6. Fuel and Oil - Crop	7.47
7. Fuel and Oil - Pumping (18 inches water applied × $2.41/inch)	43.38
8. Crop Machinery Repairs & Maintenance	23.20
9. Irrigation Equipment Repairs & Maintenance (18 in water applied × $0.30/in)	5.40
10. Crop Insurance	6.25
11. Drying ($0.10/bu × 190 bu/acre)	19.00
12. Custom Hire	0.00
13. Crop Consulting	6.50
14. Miscellaneous	6.00
15. Interest on 1/2 Variable Cost (10% operating interest)	13.81
A. Total Variable Costs (Excluding management charges or returns)	$290.06/ac
FIXED COSTS	
16. Real Estate Taxes (($605/a land + $290/a well) × 0.5%)	$4.48
17. Interest on Land and Well ($605/acre land × 0%)	0.00
18. Rent for Rented Land	0.00
19. Depreciation on Crop Machinery ($208/a investment, 35% salvage value of $73/a, 10 yr straightline depreciation)	13.52
20. Interest on Crop Machinery (10% interest on average machinery value: (($208 + $73) ÷ 2) × 10%)	14.04
21. Depreciation on Irrigation Equipment (Power+Motor = $50/a, 7 yrs, 0% slvg; Irrigation System = $314/a, 20 years, 0% slvg; 0% deprec for Well)	22.84
22. Interest on Irrigation Equipment & Well (10% int. on avg irrig. equip. value: (($50 + $314) ÷ 2) × 10%)	18.20
23. Insurance on Crop & Irrigation Equipment (0.25% × ($208 + $50 + $314))	1.43
B. Total Fixed Costs (Excluding land opportunity interest or rent)	$74.51/ac
C. TOTAL COSTS (Excluding land and management costs: A + B)	$364.57/ac
D. Yield	190 bu/ac
E. Price Per Bushel	$2.50/bu
F. Net Government Payments ($0.255 deficiency payment/bu × Yield)	$48.45/ac
G. RETURNS / acre ((D x E) + F)	$523.45/ac
H. Returns Over Variable Costs / acre (Excluding management cost: G - A)	$233.39/ac
I. RETURNS OVER TOTAL COSTS / acre (Excluding land and management costs: G - C)	$158.88/ac

Table 4. Summer Fallow Wheat Cost-Returns Budget for Western Kansas

Example for Use in Pivot Cropping System Scenarios (Modified from 1995 KSU Farm Management Guide MF-257) VARIABLE COSTS	Budgeted Yield/Acre 35 bu
1. Labor (1.2 hrs/acre × \$9.00/hr)	\$10.80
2. Seed (40 lbs/acre × \$0.22/lb)	8.80
3. Herbicide	14.60
4. Insecticide	0.00
5. Fertilizer (Anhydrous: 40 lbs × \$0.19/lb = \$7.60)	7.60
6. Fuel and Oil	4.97
7. Crop Machinery Repairs & Maintenance	10.92
8. Crop Insurance	6.25
9. Drying	0.00
10. Custom Hire	0.00
11. Crop Consulting	6.50
12. Miscellaneous	5.00
13. Interest on 1/2 Variable Cost (10% operating interest)	3.45
A. Total Variable Costs (Excluding returns to management)	\$72.38/ac
FIXED COSTS	
14. Real Estate Taxes ((\$490/a land ÷ 2 year rotation) × 0.5%)	\$4.48
15. Interest on Land ((\$490/a land ÷ 2 year rotation) × 0%)	0.00
16. Rent for Rented Land	0.00
17. Depreciation on Crop Machinery (\$190/a investment, 35% salvage value of \$66/a, 10 yr straightline depreciation)	13.52
18. Interest on Crop Machinery (10% interest on average machinery value: ((\$190 + \$66) ÷ 2) × 10%)	12.79
19. Insurance on Crop Machinery (0.25% × \$190)	0.47
B. Total Fixed Costs (Excluding land opportunity interest or rent)	\$30.49/ac
C. TOTAL COSTS (Excluding land and management: A + B)	\$102.87/ac
D. Yield	35 bu/ac
E. Price Per Bushel	\$3.90/bu
F. Net Government Payments (\$0.10 deficiency payment/bu × 30 bu FSA Yield)	\$3.00/ac
G. RETURNS / acre ((D x E) + F)	\$139.50/ac
H. Returns Over Variable Costs / acre (Excluding management cost: G - A)	\$67.12/ac
I. RETURNS OVER TOTAL COSTS / acre (Excluding land and management costs: G - C)	\$36.63/ac

RESULTS

The results of the comparison of net returns for pivot and SDI-oriented cropping systems across alternative field size scenarios are presented in Table 5. Table 5 indicates that pivot-oriented cropping systems have a marked net revenue advantage over SDI cropping systems for large fields, such as for the 160 and 127 acre fields in scenarios O and A. The net return advantage of the pivot cropping system over the SDI cropping system in scenario O is $14 per acre over all irrigated and nonirrigated acreage as indicated in the "Pivot > SDI Returns / Acre" row in the Net Returns to Land and Management section of Table 5. As total acreage decreases to 127 acres in scenario A and 95 acres in scenario B, the pivot-oriented cropping system still has a net returns advantage over the SDI-oriented system (i.e., $15 and $9 per acre, respectively). As field size diminishes further in scenario C to 64 acres and in scenario D to 32 acres, SDI-oriented cropping systems gain a net returns advantage over the pivot-oriented cropping systems (i.e, $7 and $18 per acre, respectively). In the 80 acre Wiper scenario, the pivot-oriented cropping system has a relatively small $5 advantage per acre over the SDI-oriented cropping system.

A number of factors are working together to determine the relative profitability of these alternative cropping systems. First, the inclusion of nonirrigated acreage in the pivot-oriented cropping system brought about large differences in total income and expenses. However, when examined on a per cropland acre basis, this income effect was fairly consistent across scenarios. In Table 5, the "Pivot<SDI Income" row in the Crop Income section shows these differences in gross revenue brought about by including lower revenue nonirrigated acreage in the cropping system. Across all field size scenarios, the total income difference declines as acreage is reduced, but remains consistently in the $90-$99 range on a per cropland acre basis.

The second factor affecting relative net returns of these cropping systems are differences in fixed costs as indicated in the "Pivot < SDI FC" row of the Crop Cost section in Table 5. As with the revenue differences indicated in the Crop Income section, the pivot-oriented cropping systems consistently had lower total fixed costs than the SDI systems. However, unlike the income difference, the lower fixed cost advantage of the pivot-oriented system diminished on a per acre basis as field and irrigation system size decreased. Specifically, the per cropland acre "Pivot < SDI FC" advantage of the pivot-oriented system declined as follows: scenario O = $63 per acre, scenario A = $63 per acre, scenario B = $57 per acre, scenario C = $43 per acre, scenario D = $32 per acre, and the Wiper scenario = $50 per acre. These differences are driven by the irrigation system investment cost differences specified in Tables 1 and 2, and are the major reason why the SDI systems become relatively more profitable as field size decreases. While the income differences per acre remain consistently in the $90-$99 per acre range, the declining SDI fixed cost disadvantage eventually causes the SDI cropping system to become more profitable for smaller field sizes.

The third factor affecting relative net returns are differences in variable costs caused both by inclusion of lower variable cost nonirrigated acres in the cropping system, and by improved water application efficiencies with SDI systems. The total variable cost differences between the cropping systems, as indicated in the "Pivot < SDI VC" row of the Crop Cost section of Table 5, are quite pronounced, especially for the larger acreage scenarios. However, these differences remain consistently in the $45 to $49 per cropland acre range across all the field size scenarios. This result supports the idea that while variable cost differences are an important factor to consider in this comparison of net returns from alternative cropping systems, they are not the major determinant of differences in profitability between these two alternative cropping systems on a per cropland acre basis. The major determining factor in net revenue differences in this analysis are the differences in fixed investment costs between the center pivot and the SDI irrigation systems.

Table 5. Summary Income Comparison Across Crop Acreage and Irrigation System Scenarios

	Base Scenario O		Scenario A		Scenario B		Scenario C		Scenario D		"Wiper" Scenario	
	160 acres		127 acres		95 acres		64 acres		32 acres		80 acres	
Item	Pivot	SDI	Pivot	SDI	Pivot	SDI	Pivot	SDI	Pivot	SDI	Pivot	SDI
Cropping System												
Irrigated Acres	125 ac	160 ac	100 ac	127 ac	75 ac	95 ac	50 ac	64 ac	25 ac	32 ac	64 ac	80 ac
Non Irrig. Acres	35 ac	0 ac	27 ac	0 ac	20 ac	0 ac	14 ac	0 ac	7 ac	0 ac	16 ac	0 ac
A. Crop Income												
Irrigated Corn	$65,431	$83,752	$52,345	$66,478	$39,259	$49,728	$26,173	$33,501	$13,086	$16,750	$33,501	$41,876
Dryland Wheat	$2,441		$1,883		$1,395		$977		$488		$1,116	
Dryland Fallow	$0	---	$0	---	$0	---	$0	---	$0	---	$0	---
Total Income	$67,873	$83,752	$54,228	$66,478	$40,654	$49,728	$27,149	$33,501	$13,575	$16,750	$34,617	$41,876
Pivot<SDI Income	$15,880		$12,250		$9,074		$6,352		$3,176		$7,259	
B. Crop Costs												
Variable Costs	$37,524	$45,499	$29,983	$36,115	$22,478	$27,015	$15,010	$18,200	$7,505	$9,100	$19,143	$22,749
Pivot < SDI VC	$7,975		$6,132		$4,537		$3,190		$1,595		$3,607	
Fixed Costs	$9,847	$19,923	$8,385	$16,376	$6,885	$12,293	$5,282	$8,018	$3,579	$4,595	$6,292	$10,315
Pivot < SDI FC	$10,076		$7,991		$5,408		$2,737		$1,016		$4,024	
Land, Mgmt Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Costs	$47,371	$65,422	$38,368	$52,491	$29,363	$39,308	$20,291	$26,218	$11,083	$13,694	$25,434	$33,065
Pivot<SDI T Cost	$18,051		$14,122		$9,945		$5,926		$2,611		$7,630	
C. Net Returns to Land & Mngmnt												
Income less Costs	$20,501	$18,330	$15,860	$13,988	$11,291	$10,420	$6,858	$7,283	$2,491	$3,056	$9,182	$8,811
Pivot > SDI Total Returns	+ $2,172		+ $1,872		+ $871		– $425		– $565		+ $371	
Pivot > SDI Returns / Acre	+ $14 /acre		+ $15 /acre		+ $9 /acre		– $7 /acre		– $18 /acre		+ $5 /acre	

Overall, the major factor that causes the relative profitability of pivot-oriented cropping systems to decline relative to SDI-oriented cropping systems is the declining fixed or investment cost advantage of center pivot irrigation systems over SDI irrigation systems as irrigated acreage declines.

Sensitivity Of Results To Changes in Key Factors

A series of sensitivity analysis were done to determine how sensitive these results were to changes in certain key economic factors. Changes caused in the projected net returns of scenarios O (160 acres) and D (32 acres), and the Wiper scenario (80 acres) were calculated in Tables 6, 7, and 8. These scenarios were selected because they represent the extremes in field sizes (scenarios O and D) and a difference in pivot point location (Wiper scenario).

Table 6 shows the affect of price and yield variation on projected returns from the two alternative cropping systems. Across all scenarios, as corn yields or prices decline the pivot-oriented system becomes relatively more profitable than the SDI system. For scenario O, the pivot-oriented cropping system has markedly higher net returns than the SDI-oriented cropping system over most of the range of yields and prices presented in Table 6. However, at high yield and price combinations, the SDI system becomes economically competitive. For the Wiper scenario as well, the pivot-oriented cropping system remains more profitable in all cases except for high yield and price combinations. However, the differences in net returns between the cropping systems are less for the 80 acre Wiper scenario than for the 160 acre full circle base scenario O. In small acreage scenario D, the SDI cropping system has higher net returns in all cases except

Table 6. Affect of Price and Yield Variation on Projected Returns for Center Pivot and SDI Cropping Systems (Pivot Minus SDI Cropping System Returns / Acre)

A. Base Scenario O: (125 ac. Pivot + 35 ac. W-F) vs 160 ac. SDI				
	Net Price (Cash + Program payments)			
Corn Yields	$2.45/bu	$2.60/bu	$2.75/bu*	$2.90/bu
160	$42	$37	$32	$26
175	$34	$29	$23	$17
190*	$27	$21	$14*	$8
205	$19	$12	$6	($1)
B. "Wiper" Scenario: (64 ac. Pivot + 16 ac. W-F) vs 80 ac. SDI				
Corn Yields	$2.45/bu	$2.60/bu	$2.75/bu*	$2.90/bu
160	$31	$26	$21	$17
175	$24	$18	$13	$8
190*	$16	$11	$5*	($1)
205	$9	$3	($3)	($10)
C. Scenario D: (25 ac. Pivot + 7 ac. W-F) vs 32 ac. SDI				
Corn Yields	$2.45/bu	$2.60/bu	$2.75/bu*	$2.90/bu
160	$11	$6	$1	($5)
175	$3	($3)	($8)	($14)
190*	($5)	($11)	($17)*	($24)
205	($13)	($20)	($26)	($33)

* 190 bushel per acre irrigated corn yields and $2.75 net price are the standard assumptions in the preceding analysis.

where both yields and prices are notably below the assumed averages in the preceding analysis. These results point out both the pivot cost economies impact across the scenarios, and the relative stability of the results as yields and prices change.

Table 7 shows the effect of variation in the life of both the pivot and SDI irrigation systems on projected returns from the two alternative cropping systems. Across all scenarios, it appears that changes in the life of the SDI system from 5 to 10 to 15 years has a more dramatic affect on net returns than do changes in the life of the center pivot system from 15 to 20 to 25 years. While changes in the life of a pivot from 15 to 25 years increases projected net returns per acre by $10 to $20, increases in SDI system life from 5 to 15 years increases projected net returns per acre by approximately $70 to $90. The impact is most pronounced in scenario D where a change in SDI irrigation system life from 5 to 10 years compared to a stable pivot irrigation system life of 20 years causes a change in the net returns advantage for the pivot-oriented cropping system of $49 per acre to an advantage for the SDI cropping system of $18 per acre. It should be noted for the Wiper scenario that a 15 year SDI irrigation system life gives SDI-oriented cropping systems a net returns advantage over a corresponding pivot-oriented cropping system with either a 15, 20, or 25 year life.

Table 7. Affect of Variation in Irrigation System Life on Projected Returns for Center Pivot and SDI Cropping Systems (Pivot Minus SDI Cropping System Returns / Acre)

A. Base Scenario O: (125 ac. Pivot + 35 ac. W-F) vs 160 ac. SDI			
	Center Pivot Life		
SDI System Life	15 years	20 years*	25 years
5 years	$64	$68	$71
10 years*	$10	$14*	$17
15 years	($8)	($4)	($1)
B. “Wiper” Scenario: (64 ac. Pivot + 16 ac. W-F) vs 80 ac. SDI			
SDI System Life	15 years	20 years*	25 years
5 years	$55	$61	$66
10 years*	($2)	$5*	$9
15 years	($21)	($14)	($10)
C. Scenario D: (25 ac. Pivot + 7 ac. W-F) vs 32 ac. SDI			
SDI System Life	15 years	20 years*	25 years
5 years	$36	$49	$56
10 years*	($30)	($18)*	($10)
15 years	($52)	($40)	($32)

* 20 year center pivot life and 10 year SDI system life are standard assumptions in the preceding analysis

Table 8 shows the affect of variation in SDI driptape installation cost on comparative projected returns from the two alternative cropping systems. Although drip tape costs have a major impact on the total cost of the SDI irrigation systems, for both scenario O and Scenario D, drip tape cost variation has little affect on how net returns compare between the pivot-oriented and SDI-oriented cropping systems. The pivot-oriented cropping system remains the most profitable system for scenario O across most of the range of drip tape costs considered.

Table 8. Effect of Variation in SDI Drip Tape Cost on Projected Returns for Center Pivot and SDI Cropping Systems (Pivot Minus SDI Cropping System Returns / Acre)

A. Base Scenario O: (125 ac Pivot + 35 ac W-F) vs 160 ac. SDI		
SDI Drip Tape Cost Per Foot	SDI System Costs Per Acre	CP – SDI Net Returns Per Acre
$0.02	$452	$0.30
$0.025	$495	$7
$0.03*	$539*	$14*
$0.035	$583	$20
$0.04	$627	$27
B. "Wiper" Scenario: (64 ac Pivot + 16 ac W-F) vs 80 ac. SDI		
SDI Drip Tape Cost Per Foot	SDI System Costs Per Acre	CP – SDI Net Returns Per Acre
$0.02	$481	($9)
$0.025	$524	($2)
$0.03*	$568*	$5*
$0.035	$611	$11
$0.04	$655	$18
C. Scenario D: (25 ac. Pivot + 7 ac. W-F) vs 32 ac. SDI		
SDI Drip Tape Cost Per Foot	SDI System Costs Per Acre	CP – SDI Net Returns Per Acre
$0.02	$577	($31)
$0.025	$620	($24)
$0.03*	$664*	($18)*
$0.035	$707	($11)
$0.04	$751	($4)

* The assumed drip tape cost in the preceding analysis is $0.03 per foot.

Conversely, the SDI-oriented cropping system remains most profitable system across the range of drip tape costs considered for scenario D. However, the determination of the cropping system with the highest net returns in the Wiper scenario is affected as drip tape costs change. Lower driptape costs ($0.025 per foot or less) cause the SDI-oriented cropping system to have higher net returns, while $0.03 per foot or higher driptape costs contribute to higher net returns for the pivot-oriented cropping system. It is noteworthy that even for the small acreage in scenario D where SDI systems are most competitive with pivot systems, a point is reached where increases in drip tape costs cause the relative profitabilty of the SDI system to decline to where it is nearly equal to that of a pivot-oriented cropping system.

CONCLUSIONS

This cropping system-oriented analysis demonstrates a distinct net returns advantage for pivot-oriented cropping systems over SDI-oriented cropping systems for fields of 160 acres. However, as field size decreases, the net returns advantage of pivot-oriented cropping systems over SDI systems declines to the point where SDI cropping systems returns are projected to be greater.

The primary factor affecting relative profitability is the comparative per acre investment cost required to establish either the pivot or SDI irrigation systems on the size of field in question. SDI systems have greater proportional adjustability with respect to smaller field sizes than do center pivot irrigation systems. This is illustrated by the steady, if not dramatic, increase in per acre pivot irrigation system costs as field size declines as compared to the relatively steady per acre cost levels for SDI irrigation system investment for these same declines in field size.

These comparative net returns results are most sensitive to assumptions about the life of the SDI irrigation system. Although assumed to have a 10 year life, if an SDI system only lasts 5 years, it essentially becomes non-competitive in a net returns sense with pivot-oriented cropping systems across all the field size scenarios examined in this paper. Conversely, if an SDI system has a 15 year life, it becomes relatively more profitable than a "Wiper" or full circle center pivot irrigation and cropping system with a 20 year life on an 80 acre field. Changes in prices and yields have a major impact on the projected net returns of the cropping systems considered in this paper. However, such price and yield changes do not have a noticeable impact on comparative net return results between the two cropping systems. Changes in drip tape costs do affect the relative profitability of pivot versus SDI-oriented cropping systems on an 80 acre field (i.e., the Wiper scenario).

Future research in this area should be oriented toward developing reliable information on the longevity of SDI irrigation systems and on the costs of renovating them. Also, further work is needed to document the potential water use efficiencies and uniform application benefits for SDI irrigation systems relative to center pivot irrigation systems. Additionally, an analysis is needed about how, in western Kansas, increased production risk and lower projected income for nonirrigated acres relative to irrigated acres may influence a crop producer's willingness to select irrigation systems that provide higher proportions of irrigated acreage for a given piece of farmland. From a farm financial management perspective, potential implications of placing a center pivot on a flood irrigated field may have land valuation and tax management impacts that should be understood. Finally, ongoing efforts are needed in the design and development of efficient, low cost center pivot and SDI irrigation systems.

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