Proceedings of the 31st Annual Central Plains Irrigation Conference, Kearney, Nebraska, Feb. 26-27, 2019
Available from CPIA, 760 N. Thompson, Colby, Kansas

THE ECONOMICS OF ADOPTING TECHNOLOGY AND/OR CHANGES IN METHODS

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Introduction

Adopting, updating and/or changing irrigation technology or methods is one of the main pathways by which irrigators will meet many of their future challenges. In many instances when new methods or tools are introduced they are developed with the idea of achieving one or more physical objective, i.e. water conservation, increase productivity, environmental balance and so forth. For instance in the 2017 CPIA proceedings, page 35, an article compared Mobile Drip Irrigation (MDI) to Low Elevation Spray Application, (LESA) of a center pivot while growing corn. The stated focus of that paper was to discuss experimental effects these two methods of irrigating had on soil evaporation, corn grain productivity, water productivity, irrigation water use efficiency and seasons end soil moisture profile. Nothing was mentioned about the economics of either method which leaves adopters to do this on their own. This work is focused on helping stakeholders become familiar with two common methods of applying economics to these types of decisions.

Whether it be deciding on how to best allocate limited water, or selecting among various new tools to irrigate, the question of economics generally prevail for the individual producer who makes his living through production. How can a method or technology be expected to be useful or transformative if no one can afford to implement it.

Premise

The basic economic ideas behind these types of choices are simple and can be boiled down to three focus areas: 1) Capturing the physical effects, 2) Assigning them appropriate monetary values, and 3) Comparing the differences among them. These three focus areas are illustrated well in two methods or techniques, partial and capital budgeting.

Partial budgets are generally used to compare among choices that have a short turnaround time one or two years and relate to competing alternatives where only the expenses and benefits created by each alternative are considered leaving out all common costs or benefits. Partial budgets have many different forms and don’t require a complete costs analysis. By leaving out those costs or benefits common among alternatives they become much easier to apply. For instance a comparison among sprinkler types used on a pivot where the installation costs are the same but the head costs differ. The installation costs can be ignored while the head costs would be included. Generally each alternative has some unique costs and benefits. In the case of two alternatives alt 1 and alt 2, four categories would be considered; 1) Costs unique to alt 1, 2) Benefits unique to alt 1, 3) Costs unique to alt 2, and 4) Benefits unique to alt 2. Once each costs is subtracted from the appropriate benefit the totals are compared, with the most economic being the alternative with the most positive value or return.

Capital budgeting is for large long term structural changes or decisions such as purchasing a significant asset or choosing among alternative assets or systems such the purchase of a competing irrigation systems all of which span years in time. Both expenses and revenues are allocated to the appropriate period, year when they would occur over the expected life span of the investment. This includes all costs and revenues associated with the capital item. This method is good for changes or adoptions that require large investments, have a long period of impact on the operation. Capital budgeting can be simple or complex depending on how much detail is required to make a reasonable decision. Capital budgeting is typically used to make investment choices such as drilling an irrigation well, or in a comparative mode, choosing among the purchase of alternative center pivot systems. The results can be enlightening about the expected performance of the investment being made.

For the remainder of the discussion the use of Partial and Capital budgets will be demonstrated by using two examples. These two methods generally use relevant differences and are ideally suited to evaluate among choices or making a change in the current production system, enterprise or business. Each of the examples are created using fictional information and are purely intended to create clarity and understanding.

Partial Budget Example – Sprinkler Package Comparison

The following information, including the outcomes are captured in an excel spreadsheet which is illustrated in Figure 1. The question posed here is to either replace or repair the current sprinkler package on a center irrigation pivot that covers 130 acres. The current package, alt 2, is not as efficient as the new package, alt 1, claims to be and is expected to use at least 2% more water. With an estimated 6 acre inch annual use over its five year life, this amounts to a total of 78 ac in of saved water for alt 1. When water is valued at $3.00/ac in there is a $234 water savings over alt 1's expected life. Costs of the new sprinkler package is based on 66 new units (heads) times $22/unit, this includes installation costs, amounting to a total costs of $1452. The added efficiency of alt 1 is expected to create an added .5 bushel (bu) per acre corn grain yield. The system maintenance for alt 1 is $135 over its 5 year life and $460 for alt 2 over the same period. Using an average base yield of 220 bu/ac per year with an average expected value of $3.50/bu, total revenues are estimated to be $502,659 for alt 1 and $500,500 for alt 2. When costs are subtracted from the revenue benefits, alt 1 had $501,072 versus $500,040 for alt 2, making alt 1 $1032 higher in net income than alt 2 and the economically preferred choice.

Partial Budget	Sprinkler Package Example CPIA		Feb. 1, 2019
Most Economic Choice			
Estimated Difference	$1,032.00	**Alternative 1 (New sprinkler package)**	

Alternative 1 (New sprinkler package)		**Alternative 2 (Current sprinkler package)**	
Benefits		***Benefits***	
Total water savings	$234.00	Value of Crop Production	$500,500.00
Value of Crop Production	$502,425.00		
Total Benefits	**$502,659.00**	***Total Benefits***	**$500,500.00**
Costs		***Costs***	
Sprinkler Installation	$1,452.00	No installation costs	$0.00
Maintenance costs	$135.00	Maintenance costs	$460.00
Total Costs	**$1,587.00**	***Total Costs***	**$460.00**

Net Income of Alternative 1	**$501,072.00**	**Change in Net Income**	**$1,032.00**
Net Income of Alternative 2	**$500,040.00**		

Capital Budgets – Center Pivot Comparison

The capital budgeting process is initiated by separating the proposed investments into annual outflows and inflows of capital (costs and revenue streams). Each year's costs and incomes are discounted into present value terms. If a 4% discount rate, 10 years into the future is used the formulation for the net present value (NPV) factor is equal to one divided by the sum of one plus the discount rate (4%)) all taken to the power of t, where t equals the number of years in the future, 10. Mathematically the formula would be $(1/1.04)^{10} = .73$. This means that an expense ten years in the future of $1000 is valued at 73% or the $1000 making its net present value (NPV) $730. This formulation accounts for the difference in the value of money streams over time, also known as the time value of money.

Using this idea of NPV, a simple capital budget will be created illustrating how it might be used to compare the purchase of one of two center pivot systems. Pivot A is a low price high maintenance system with an initial costs of $38,500. Pivot B is a top of the line low maintenance unit with an initial purchase price of $50,000. Pivot A has a limited warrantee and Pivot B has a five year no repair costs warrantee. It is expected that the useful life of either system is 15 years. The expected salvage value for Pivot A is $3000 versus Pivot B at $10,000. Table 1 shows the purchase cost of both pivots in Year 0, which is in present day value. Four annual expenses are listed in the following tables for years 1 – 15. For simplicity purposes income was omitted since it is unaffected or changed by either system. However if it were included it would show the value of investing in a pivot irrigation system, which would be invaluable in making the choice to move forward with such a large investment. In this example the decision is not whether to purchase but rather which to purchase.

The four annual expenses included were opportunity costs (OC), repair costs (RC), insurance costs (IC) and a total costs (TC). OC relates to the expected return from the investment of the capital in each pivot and is calculated as 4% of its current value (initial value – depreciation expense). RC are formulated based on individual unit type and age, and increase over time. IC is a constant annual expense based on the original value of the pivot and is only affected by the discount rate. TC is simply a sum of the other three costs.

The NPV's for Year 1 (Table 1) had a discount factor of 97%: Pivot A had an OC of $1272.62, RC of $929.95, IC of $193.24 making a TC of $2395.81 versus Pivot B which had an OC of $1769.73, no (RC), IC was $265.70 making a TC of $2035.43. TC for Pivot A is greater than for Pivot B due to higher repair costs.

Table 1	Center Pivot A		Center Pivot B	
	Year 0	Year 1	Year 0	Year 1
Purchase Value	$38,500.00		$50,000.00	
Opportunity Costs on Capital (OC)		$ 1,272.62		$ 1,769.73
Repair Costs (RC)	$ -	$ 929.95		$ -
Insurance Costs (IC)		$ 193.24		$ 265.70
Total Annual Discounted Costs (TC)	$38,500.00	$ 2,395.81	$50,000.00	$ 2,035.43

The NPV's for Year 2 (Table 2) had a discount factor of 93%: Pivot A had an OC of $1152.26, RC of $1078.20, IC of $186.70, making a TC of $2417.17 versus Pivot B which had an OC of $1622.75, no (RC), IC was $256.72, making a TC of $1879.47. Again TC for Pivot A is greater than for Pivot B due to higher repair costs.

The NPV's for Year 3 (Table 2) had a discount factor of 90%: Pivot A had an OC of $1038.59, RC of $1128.56, IC of $180.39, making a TC of $2347.53 versus Pivot B which had an OC of $1483.70, no (RC), IC was $248.03, making a TC of $1731.73. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

Table 2	Center Pivot A		Center Pivot B	
	Year 2	Year 3	Year 2	Year 3
Purchase Value				
Opportunity Costs on Capital (OC)	$ 1,152.26	$ 1,038.59	$ 1,622.75	$ 1,483.70
Repair Costs (RC)	$ 1,078.20	$ 1,128.56	$ -	$ -
Insurance Costs (IC)	$ 186.70	$ 180.39	$ 256.72	$ 248.03
Total Annual Discounted Costs (TC)	$ 2,417.17	$ 2,347.53	$ 1,879.47	$ 1,731.73

The NPV's for Year 4 (Table 3) had a discount factor of 87%: Pivot A had an OC of $931.28, RC of $1174.27, IC of $174.29, making a TC of $2279.84 versus Pivot B which had an OC of $1352.29, no (RC), IC was $239.65, making a TC of $1591.83. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

The NPV's for Year 5 (Table 3) had a discount factor of 84%: Pivot A had an OC of $830.05, RC of $1215.60, IC of $168.39, making a TC of $2214.04 versus Pivot B which had an OC of $1352.19, no (RC), IC was $231.54, making a TC of $1459.42. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

Table 3	Center Pivot A		Center Pivot B	
	Year 4	Year 5	Year 4	Year 5
Purchase Value				
Opportunity Costs on Capital (OC)	$ 931.28	$ 830.05	$ 1,352.19	$ 1,227.88
Repair Costs (RC)	$ 1,174.27	$ 1,215.60	$ -	$ -
Insurance Costs (IC)	$ 174.29	$ 168.39	$ 239.65	$ 231.54
Total Annual Discounted Costs (TC)	$ 2,279.84	$ 2,214.04	$ 1,591.83	$ 1,459.42

The NPV's for Year 6 (Table 4) had a discount factor of 81%: Pivot A had an OC of $734.59, RC of $1252.79, IC of $162.79, making a TC of $2150.28 versus Pivot B which had an OC of $1110.43, (RC) of $711.81, IC was $223.71, making a TC of $2045.95. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

The NPV's for Year 7 (Table 4) had a discount factor of 79%: Pivot A had an OC of $644.64, RC of $1310.29, IC of $157.20, making a TC of $2112.13 versus Pivot B which had an OC of $999.52, (RC) of $785.99, IC was $216.15, making a TC of $2001.66. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

Table 4	Center Pivot A		Center Pivot B	
	Year 6	Year 7	Year 6	Year 7
Purchase Value				
Opportunity Costs on Capital (OC)	$ 734.59	$ 644.64	$ 1,110.43	$ 999.52
Repair Costs (RC)	$ 1,252.79	$ 1,310.29	$ 711.81	$ 785.99
Insurance Costs (IC)	$ 162.70	$ 157.20	$ 223.71	$ 216.15
Total Annual Discounted Costs (TC)	$ 2,150.08	$ 2,112.13	$ 2,045.95	$ 2,001.66

The NPV's for Year 8 (Table 5) had a discount factor of 76%: Pivot A had an OC of $559.94, RC of $1365.38, IC of $151.88, making a TC of $2077.21 versus Pivot B which had an OC of $894.84, (RC) of $854.34, IC was $208.84, making a TC of $1958.02. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

The NPV's for Year 9 (Table 5) had a discount factor of 73%: Pivot A had an OC of $480.23, RC of $1412.43, IC of $146.75, making a TC of $2077.21 versus Pivot B which had an OC of $894.84, (RC) of 854.34, IC was $208.84, making a TC of $1915.04. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

Table 5	Center Pivot A		Center Pivot B	
	Year 8	Year 9	Year 8	Year 9
Purchase Value				
Opportunity Costs on Capital (OC)	$ 559.94	$ 480.23	$ 894.84	$ 796.10
Repair Costs (RC)	$ 1,365.38	$ 1,412.43	$ 854.34	$ 917.16
Insurance Costs (IC)	$ 151.88	$ 146.75	$ 208.84	$ 201.78
Total Annual Discounted Costs (TC)	$ 2,077.21	$ 2,039.41	$ 1,958.02	$ 1,915.04

The NPV's for Year 10 (Table 6) had a discount factor of 71%: Pivot A had an OC of $405.27, RC of $1454.74, IC of $141.78, making a TC of $2001.79 versus Pivot B which had an OC of $703.01, (RC) of $974.76, IC was $194.95, making a TC of $1872.73. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

The NPV's for Year 11 (Table 6) had a discount factor of 68%: Pivot A had an OC of $334.82, RC of $1495.20, IC of $136.99, making a TC of $1967.02 versus Pivot B which had an OC of $615.31, (RC) of 1027.42, IC was $188.36, making a TC of $1831.09. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

Table 6	Center Pivot A		Center Pivot B	
	Year 10	Year 11	Year 10	Year 11
Purchase Value				
Opportunity Costs on Capital (OC)	$ 405.27	$ 334.82	$ 703.01	$ 615.31
Repair Costs (RC)	$ 1,454.74	$ 1,495.20	$ 974.76	$ 1,027.42
Insurance Costs (IC)	$ 141.78	$ 136.99	$ 194.95	$ 188.36
Total Annual Discounted Costs (TC)	$ 2,001.79	$ 1,967.02	$ 1,872.73	$ 1,831.09

The NPV's for Year 12 (Table 7) had a discount factor of 66%: Pivot A had an OC of $268.68, RC of $1528.72, IC of $132.36, making a TC of $1929.76 versus Pivot B which had an OC of $532.74, (RC) of $1075.40, IC was $181.99, making a TC of $1790.12. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

The NPV's for Year 13 (Table 7) had a discount factor of 64%: Pivot A had an OC of $206.63, RC of $1558.26, IC of $127.88, making a TC of $1929.76 versus Pivot B which had an OC of $455.04, (RC) of 1118.96, IC was $175.84, making a TC of $1749.84. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

Table 7	Center Pivot A		Center Pivot B	
	Year 12	Year 13	Year 12	Year 13
Purchase Value				
Opportunity Costs on Capital (OC)	$ 268.68	$ 206.63	$ 532.74	$ 455.04
Repair Costs (RC)	$ 1,528.72	$ 1,558.26	$ 1,075.40	$ 1,118.96
Insurance Costs (IC)	$ 132.36	$ 127.88	$ 181.99	$ 175.84
Total Annual Discounted Costs (TC)	$ 1,929.76	$ 1,892.77	$ 1,790.12	$ 1,749.84

The NPV's for Year 14 (Table 8) had a discount factor of 62%: Pivot A had an OC of $148.47, RC of $1586.43, IC of $123.56 making a TC of $1858.46 versus Pivot B which had an OC of $382.00, (RC) of $1158.34, IC was $169.89, making a TC of $1710.23. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

The NPV's for Year 15 (Table 8) had a discount factor of 60%: Pivot A had discounted salvage value of $1790.67, an OC of $94.01, RC of $1608.62, IC of $119.38, making a TC of $31.34 versus Pivot B which had a salvage value of $5968.91 an OC of $313.37, (RC) of 1193.78, IC was $164.14, making a TC of a negative $4297.61. The TC for Pivot A remains greater than for Pivot B due to higher repair costs.

Table 8	Center Pivot A		Center Pivot B	
	Year 14	Year 15	Year 14	Year 15
Salvage Value		$ 1,790.67		$ 5,968.91
Opportunity Costs on Capital	$ 148.47	$ 94.01	$ 382.00	$ 313.37
Repair Costs	$ 1,586.43	$ 1,608.62	$ 1,158.34	$ 1,193.78
Insurance Costs	$ 123.56	$ 119.38	$ 169.89	$ 164.14
Total Annual Discounted Costs	$ 1,858.46	$ 31.34	$ 1,710.23	$ (4,297.61)

By summing all the years (Table 9) Pivot A had a total NPV costs of $68.307.37 and Pivot B totaled $71,274.93 making Pivot A the economically superior choice. Pivot A was superior even with the higher annual repair costs, it was the larger upfront purchase costs due and the discounted salvage value which made the more expensive Pivot B less desirable. This point is made clear if look at the undiscounted or unadjusted comparison of costs. Under the unadjusted assumption Pivot A would have a total costs of $76,895.00, about $720 higher than Pivot B's total costs of $76,175.00. This change in total costs is the reverse of the discounted costs and now makes the more expensive Pivot B the economically preferred choice. It also is indicative of the effects of using the time value of money on the timing or flow of expenses and revenues. Expenditures or Revenues in the early life of an asset are more heavily weighted in affecting the outcome than those that occur in it later life. Therefore investments with lower costs and higher returns earlier have an advantage over those with later returns and earlier costs.

Table 9	Adjusted Costs		Unadjusted Costs	
	Pivot A	Pivot B	Pivot A	Pivot B
Total NPV	$68,307.37	$71,274.93		
Total Unadjusted Costs			$76,895.00	$76,175.00

Discussion

If the past is any indication of the adoption and development of future technology and methods in irrigation management the need for economic analysis is likely to increase. This is especially true as the need for the many environmental and human needs for increased protection and productivity become more pressing. Making sound choices about the purchase and acquisition of the ever growing opportunities requires careful thought and analysis. Both Partial and Capital budgeting techniques are adaptable and flexible and therefore have a wide range of use that works well in many of the instances where a comparison among alternatives is needed or if a new technology is economically sound. Partial budgets are good for making comparisons that are not sensitive to the effect of time as it relates to costs, and revenues. Whereas Capital budgets account for the costs and value that the time component entails. Capital budgets can also be used as a method of evaluating a single investment choice since it captures both costs and revenues for the relevant time or life of the asset or change to be made. It should be noted that understanding economics is not the only important factor in making a decision, but to ignore it is likely to result in a less than ideal outcome.