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An Economic Analysis of Underground Pipeline Irrigation Delivery System Investments: A Case Study in the Texas Rice Belt

by

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ABSTRACT

A linear programming and capital budgeting modelling framework is used to examine the economic feasibility of underground pipeline irrigation delivery system investments by Texas rice producers. Net present value of such investments for producers using groundwater are sensitive to relative delivery efficiency rates, irrigation water prices, discount rates, and marginal income tax rates, among other factors. For the case situation analyzed, efficiencies of less than 85% for existing lateral delivery systems and water prices above $20 per acre-foot are needed to justify an investment in an underground pipeline irrigation delivery system.

An Economic Analysis of Underground Pipeline Irrigation Delivery System Investments: A Case Study in the Texas Rice Belt

Introduction

United States rice producers are currently confronted with both low sales prices and high production costs. Weak export demand (related to the strong value of the U.S. dollar) and development of higher yielding, long grain varieties (Rister and Grant 1984) are contributing to the low price situation. A major component of high production costs is irrigation water.

Two types of irrigation delivery systems are currently being utilized in the Texas Rice Belt (extending along the Gulf Coast from the Texas-Louisiana border to 100 miles west of Houston): (1) conventional surface canals and (2) subsurface pipeline systems. Surface canals have been used for many years and are commonly in use today. Water losses in surface canal delivery systems, however, range from 25% to 65% (Griffin, Perry, and McCauley 1984, p. 63), thus indicating the potential advantages of a more efficient water delivery system such as an underground pipeline system.

Problem Statement

Perry, Rister, and Griffin (1984) have identified many of the benefits associated with underground pipeline investments and the effects these benefits have on the value of underground pipeline investments. Among these benefits are increased water delivery efficiencies of underground pipeline relative to surface canal delivery systems and the ability to use the underground system in delivering water to various row crops when rice is not produced. In addition, land previously used for laterals may be put into production, and labor used to maintain those laterals can be eliminated or allocated to other uses.

Although the benefits associated with underground pipeline systems can be quite substantial, the costs must also be considered. Perry, Rister, and Griffin did not analyze the associated investment and annual maintenance costs required to realize such benefits. These costs are dominated by the high initial investment. Nichols (1985) estimates purchase and installation costs could be as high as $6.58/linear foot or $34,742.40/mile. In addition, producers who rely on surface water supplies will typically have to install a pump. Because surface water is of lower quality than groundwater, the cost of pump maintenance rises. These costs, along with the predominance of flat rate water pricing by surface canal companies in the Texas Rice Belt, greatly limit the economic attractiveness of underground pipeline systems for surface water users (Griffin, Perry, and McCauley 1984, p. 66).

Although the initial investment in underground pipeline systems is quite high, the benefits received from reduced annual maintenance costs and more efficient irrigation water delivery suggest underground pipeline investments may be a viable alternative to surface canal delivery systems for groundwater users. Heretofore, the aggregate impact of the benefits and costs of investing in an underground pipeline system have not been identified. Presently, many Texas rice producers are requesting additional information regarding the profitability of such an investment.

Objectives of the Study

The primary objectives of this study are (1) to develop a methodological structure incorporating the benefits and costs associated with investing in and operating an underground pipeline irrigation delivery system, thereby assessing its overall economic feasibility, and (2) to apply this analytical framework to a representative Texas Rice Belt product situation. As a result, Texas Rice Belt producers will have preliminary information regarding the economic potential of investing in underground pipeline irrigation delivery systems. This information will also serve as a reference for producers when gathering information to conduct their own economic analyses.

Methodology

When evaluating the economic feasibility of a capital investment (such as an underground pipeline irrigation delivery system), one approach which may be used is partial budgeting applied to a representative farm situation. Partial budgeting is used to calculate the expected change in profit for a proposed change in the farm business, using only those income and expense items that will change if the proposed modification in the farm plan is implemented (Kay 1981). Linear programming and capital budgeting analyses are combined in this study to identify the net present value of the marginal net returns associated with the investment of interest.

A linear programming model developed by Perry, Rister, and Griffin (1984) is used to determine the annual value of the underground pipeline system in terms of returns above variable costs for a case farm situation. Linear programming is a mathematical technique generally concerned with the allocation of scarce resources in the "best" possible manner so as to minimize costs or maximize profits. Linear programming models contain three essential components: (1) an objective function, expressing what is to be optimized - total profits, returns above variable costs, etc., (2) alternative methods of achieving the objective, and (3) resource limitations (Agrawal and Heady 1972, p. 31).

Exhibit 1 illustrates the linear programming tableau developed by Perry, Rister, and Griffin (1984) to represent the decision situation. Production activities are represented by columns and the resource constraints are represented by rows. In application, the initial solution of this linear programming model assumes underground pipeline is unavailable, i.e., the "Purchase Pipe" row right hand side value is set equal to 0. Eliminating the pipe alternative forces use of surface delivery laterals (assuming the model determines production is profitable). A second solution is then obtained assuming an underground pipeline delivery system is available, i.e., the "Purchase Pipe" row right hand side value is set equal to 1. The difference between returns above variable costs using underground pipeline and returns above variable costs using surface delivery laterals represents the annual returns to the underground pipeline system. These benefits, along with the initial purchase price for the pipeline system and annual costs for maintenance, repairs, etc., are then analyzed using a capital budgeting software package developed by Pajestka, Rister, and McGrann (1983).

Capital budgeting is a technique that is used to analyze capital investment strategies. The basic idea of capital budgeting is to compare the profitability of an operation's current production strategy

ROWS \ COLUMNS	PURCHASE FC WATER	PURCHASE RC WATER	PURCHASE PIPE	FC PIPE USE	RC PIPE USE	FC DITCH USE	RC DITCH USE	AVAILABLE LABOR	SOYBEAN PRODUCTION	SORGHUM PRODUCTION	DITCH FC RICE PRODUCTION	PIPE FC RICE PRODUCTION	DITCH RC RICE PRODUCTION	PIPE RC RICE PRODUCTION	SELL FC RICE	SELL RC RICE	SELL SOYBEANS	SELL SORGHUM	CONSTRAINTS RHS
OBJECTIVE FUNCTION	-C1	-C1						-C2	-C3	-C4	-C5	-C5	-C6	-C6	+P1	+P2	+P3	+P4	
TOTAL FC WATER	+1																		≤ D1
TOTAL RC WATER		+1																	≤ D2
PIPE WATER AVAILABLE			-A	+1	+1														≤ 0
PURCHASE PIPE			+1																= 0 OR 1
TRANSFER FC WATER	-1			+1		+1													≤ 0
TRANSFER RC WATER		-1			+1		+1												≤ 0
TOTAL LABOR						+B	+B	+1											≤ 0
TOTAL LAND AVAILABLE			-E						+1	+1	+1	+1							≤ D3
FC WATER USE - PIPE				-1								+H							≤ 0
RC WATER USE - PIPE					-1									+I					≤ 0
FC WATER USE - DITCH						-J					+K								≤ 0
RC WATER USE - DITCH							-J						+L						≤ 0
TOTAL ACRES SOYBEANS			-F						+1										≤ D4
TOTAL ACRES SORGHUM			-F							+1									≤ D4
TOTAL ACRES FC RICE			-G								+1	+1							≤ D4
TSFR. FC ACG. TO RC											-M	-M	+1	+1					≤ 0
FC RICE TRANSFER											-N	-O			+1				≤ 0
RC RICE TRANSFER													-Q	-R		+1			≤ 0
SOYBEAN TRANSFER									-S								+1		≤ 0
SORGHUM TRANSFER										-T								+1	≤ 0

EXHIBIT 1.-- LINEAR-PROGRAMMING MODEL TABLEAU (PERRY, RISTER, AND GRIFFIN 1984)

with alternative strategies involving new and different capital assets. This comparison is accomplished through analysis of the additional net cash revenue flows produced by new investments over their economic life relative to the initial investment cost (Barry, Hopkin, and Baker 1979, p. 255). Several different decision criteria may be utilized. Among these criteria are: (1) internal rate of return, (2) payback method, and (3) net present value. The net present value method is used in this study.

Case Farm Situation

The case farm used in this study is located in Wharton County, on the western side of the Texas Rice Belt. It is assumed the producer utilizes a rice-soybean-grain sorghum production rotation. In the base analysis, the underground pipeline irrigation system is used to irrigate the rice acreage every third year. The system is not used to irrigate either soybeans or grain sorghum. Explicit assumptions regarding other farm characteristics are identified below.

Linear Programming Model Assumptions

The representative farm is assumed to be using a surface canal delivery system with water obtained from a groundwater source. The acreage potentially affected by investing in an underground pipeline irrigation delivery system is approximately 200 acres of rice, with some potential for grain sorghum or soybeans to be grown on part of the land reclaimed from the current surface canal. All first crop rice acreage is ratoon cropped; that is, a second crop of volunteer rice is harvested.

Information pertaining to variable production costs per acre, yields and price, water requirements, delivery efficiencies, and water price are necessary requirements for solution of the linear programming model (exhibit 1; Table 1). Some increase in rice yield is assumed to occur with the installation of an underground pipeline irrigation delivery system because of better flood water control in the field.

The variable preharvest production costs are $200/acre for first crop rice, $35/acre for ratoon rice, $120/acre for soybeans, and $125/acre for grain sorghum (Texas Agricultural Extension Service 1984). Harvest variable costs are $1.23/cwt. for rice, $.46/bu. for soybeans, and $1.05/cwt. for grain sorghum, resulting in expected net selling prices of $11.04/cwt. for first crop rice, $10.18/cwt. for ratoon rice, $5.54/bu. for soybeans, and $4.36/cwt. for grain sorghum. Gross selling prices were determined using national target prices for rice and grain sorghum and the loan rate for soybeans, with adjustments for the local market basis for each respective crop. Ratoon crop rice is assumed to have a price reduction of 7% due to lower quality, thus resulting in the lower gross and net selling price.

If the surface canal is replaced by an underground pipeline system, 4.5 acres are made available for reclamation as productive land. This assumes one-half mile of 40 feet wide surface lateral area from the water source to the edge of the rice field is replaced by underground pipe. It is assumed the land in the half mile of lateral leading up to the rice field (2.3 acres) can be planted to either soybeans or grain sorghum. The lateral land adjacent to the rice field (2.2 acres) may be put into rice production.

Table 1. Base Assumptions for Linear Programming Model[a]

Variable	Description	Numeric Value	Units
A	Available Water	3,000[b]	acre-feet
B	Ditch Labor	.04	hours/acre-feet
E	Reclaimed Land	4.5	acres
F	New Land-Soy./Sorg.	2.3	acres
G	New Land-Rice	2.2	acres
H	Ditch FC Demand	1.8	acre-feet/acre
I	Ditch RC Demand	1.4	acre-feet/acre
J	Delivery Efficiency	70	percent
K	Pipe FC Demand	1.7	acre-feet/acre
L	Pipe RC Demand	1.32	acre-feet/acre
M	RC acreage	100	percent FC acreage available for RC
N	FC Rice Yield-Surf.	47	cwt./acre
O	FC Rice Yield-Pipe	48	cwt./acre
Q	RC Rice Yield-Surf.	9.7	cwt./acre
R	RC Rice Yield-Pipe	10.20	cwt./acre
S	Soybean Yield	30	bushels/acre
T	Sorghum Yield	45	cwt./acre
D1	Total FC Water	2,000[b]	acre-feet
D2	Total RC Water	1,000[b]	acre-feet
D3	Total Acreage	200	acres
D4	Max. Crop Ac.	200	acres
C1	Water Cost	25.00	dollars/acre-foot
C2	Labor Cost	5.00	dollars/hour
C3	Soy. Prod. Cost	120	dollars/acre
C4	Sorg. Prod. Cost	125	dollars/acre
C5	FC Prod. Cost	200	dollars/FC acre
C6	RC Prod. Cost	35	dollars/RC acre
P1	Rice Price-FC	11.04	dollars/cwt.
P2	Rice Price-RC	10.18	dollars/cwt.
P3	Soybean Price	5.54	dollars/bushel
P4	Sorghum Price	4.36	dollars/cwt.

Sources: Griffin, Perry, and McCauley (1984); Perry et al. (1985); Rister and Grant (1984); Texas Agricultural Extension Service (1984).

[a]Format for this table borrowed from Perry, Rister, and Griffin (1984).

[b]3,000 acre-feet represents an ad hoc value intended to be nonconstraining when the underground pipe system is in operation; this is a programming convention utilized to enable modelling of the availability of an underground pipe system. The 2,000 and 1,000 acre-feet assumed for first and second crop rice are similarly intended to be nonconstraining at all levels of delivery efficiency considered in the study.

Capital Budgeting Model Assumptions

In the case farm situation, it is assumed the pump is in place and is pumping water from a groundwater source. Consequently, there are no additional costs associated with this component of the underground pipeline delivery system. The line delivery section of the underground system is constructed using 12-inch, 50 pounds-per-square-inch plastic pipe with a combined materials and installation cost of $5.32/linear foot of pipe (Table 2). The line delivery section constitutes the major portion of the cost for the underground pipeline system investment and, thus, will have the greatest impact on the investment decision when different materials and installation costs are required.

It is assumed the underground pipeline irrigation system is 100% efficient. Maintenance and repair costs for the system are assumed to be zero (Nichols 1985). The underground pipeline irrigation system is installed in 1985 and has a useful life of 20 years. Because the complete system is not used for four out of five years, participation in the Soil Conservation Service's cost-sharing program on underground pipeline irrigation systems is not possible (United States Department of Agriculture-Soil Conservation Service 1985).

Eighty percent ($25,046.24) of the initial investment is financed with borrowed capital, and the remaining 20% ($6,261.56) is internally financed. The assumed interest rate is 15%, and the investment is financed over a five year period with equal annual payments.

For purposes of this study, it is assumed the producer's marginal tax rate is 30%. The assumed before-tax discount rate is 16%. This discount rate represents the return on the investment the producer would receive by investing in his/her next best alternative investment (i.e.,

Table 2. Underground Pipeline Irrigation Delivery System - Investment Components

Item	Per Unit Cost	No. of Units	Total Cost
At water source			
Pump	$ 0.00	0	$ 0.00
Pump Hook-Up	1,000.00	1	1,000.00
Draw Bands	40.00	2	80.00
Swing Check Valve	640.00	1	640.00
Pressure Relief Valve	350.00	1	350.00
Stand Pipe	500.00	1	500.00
Pipe Nipples	30.00	3	90.00
Dresser Coupler	50.00	1	50.00
Air Relief Valve	82.00	1	82.00
Subtotal			2,792.00
Line Delivery			
12" - 50 psi plastic pipe	5.32	5140'	27,344.80
Subtotal			27,344.80
Field Delivery			
Pipe Tees	100.00	2	200.00
End Caps	23.00	1	23.00
Air Relief Valve	82.00	1	82.00
Air Relief Adapter	30.00	1	30.00
Draw Bands	40.00	4	160.00
Alfalfa Valves	103.00	2	206.00
Bonnets	235.00	2	470.00
Subtotal			1,171.00
TOTAL Capital Investment			$31,307.80

Source: Burke (1984); Nichols (1985).

his/her opportunity cost) and is used in the capital budgeting model to discount all cash flows into present value terms.

An important cost associated with replacing a surface canal irrigation delivery system with an underground pipeline irrigation delivery system is the cost of reclaiming the land previously used for the surface canal in order to put that land into production. This cost includes a charge for labor, bulldozing services, land leveling, etc. In the case farm situation, the cost of land reclamation is assumed to be $2,467.20 for the 4.5 acres (Raun 1985) and is deducted from the annual net returns in the first year of the underground pipeline investment's useful life.

An important consideration in determining the annual returns to the underground pipeline irrigation delivery system is the value of the grain sorghum and soybean crops produced on the reclaimed land during years in which rice is not produced. The value of this soybean and grain sorghum production is assumed to remain the same over the life of the underground pipeline investment. Returns above variable costs on the "reclaimed" soybean and grain sorghum acreage is $262/year.

Base Analysis

It is assumed in the base analysis that water price is $25/acre-foot and the delivery efficiency is 70%. The base line before-tax net present value is equal to $-5,381, and the base line after-tax net present value is equal to $1,786, indicating the underground pipeline investment is economically feasible, given the base set of assumptions.

The timing of before-and after-tax net cash flows over the life of the investment are an important consideration in the investment decision. In the first five years of the investment's life, there are negative before-and after-tax cash flows in four of the five years due to the repayment of principal and interest on the original loan. In the remaining years of the investment's life, the before-and after-tax net cash flows are positive due to principal and interest on the original financing arrangement having been repaid. The individual producer's situation will determine whether or not his/her operation will be able to sustain the negative after-tax cash flows in the first years of the capital investment's useful life.

Sensitivity Analyses

Lateral delivery efficiency and irrigation water cost are two important factors when determining annual returns to an underground pipeline delivery system investment. To examine the sensitivity of results to these parameters, three different levels of lateral delivery efficiency, 55%, 70%, and 85%, and four different levels of irrigation water cost, $15/acre-ft., $20/acre-ft., $25/acre-ft., and $30/acre-ft., are analyzed.

Results of analyzing the twelve possible combinations of these assumed delivery efficiencies and water costs are presented in Table 3. Net present values range from $-9,560 for high delivery efficiency and low water cost to $15,037 with low delivery efficiencies and high water cost.

Table 3. After-Tax Net Present Values ($) for Selected Lateral Delivery Efficiencies and Water Costs

Water Cost ($/ac. ft.)	- - - Lateral Delivery Efficiency - - - 55%	70%	85%
15	$ 3,297	$-4,508	$-9,560
20	9,013	-1,361	-8,073
25	14,564	1,786	-6,587
30	15,037	4,934	-363

Two other important factors also affect the net present value of the underground pipeline irrigation delivery system investment. These are the level of the marginal income tax rate and the discount rate. When the marginal tax rate is lowered from 30% to 15% for the base scenario assumptions of a 70% lateral delivery efficiency and a water cost of $25/acre-ft., the after-tax net present value falls from $1,786 to $-449. When the before-tax discount rate is raised from 16% to 20% (with the marginal tax rate remaining at 30%), the after-tax net present value for the base situation falls from $1,786 to $-658. These are factors that are beyond producers' control but must be taken into account when considering an investment of this magnitude.

Summary and Conclusions

Although the net present value of the underground pipeline investment under the base scenario is positive, the net present values of several different scenarios (with different water costs and lateral delivery efficiencies) are negative. These differing net present values indicate the economic feasibility of investing in such a system is highly sensitive to the effects of alternative water costs and lateral delivery efficiencies. In addition, when the marginal tax rate or before-tax discount rate is changed, the net present value of the underground pipeline investment can be substantially affected. These factors must be carefully weighed when making the investment decision.

The results of this study are contingent on several basic assumptions. First, it is assumed that there is already a pump in place on the representative farm. For surface water sources the producer must install a pump at the water withdrawal point. The investment cost of a new pump can be as high as $8,000 (Nichols 1985). This is a significant cost and, therefore, has the potential to greatly influence the investment decision. Second, it is assumed that maintenance and repair costs for the underground pipeline system are zero. The effects of poor system installation, weather damage, poor system operation (i.e., putting too much water pressure on the system), etc., are not considered.

Although this study indicates investments in underground pipeline irrigation delivery systems are economically feasible under certain conditions, the main purpose has been to provide the Texas Rice Belt producer with a methodological framework within which to evaluate his/her own personal production scenario. Each individual producer must consider his/her own lateral delivery efficiency, marginal tax bracket, opportunity cost of capital, etc., in combination with the methodological framework provided here in order to make a proper investment decision. Additional research in progress is directed towards extending the representative analyses to encompass a broader range of investment situations.

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