LEASE VERSUS PURCHASE OF A CENTER-PIVOT IRRIGATION SYSTEM: A GEORGIA EXAMPLE

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Use of irrigation has been increasing rapidly in the Southeast. For example, irrigated acreage in Georgia increased by 20 percent in 1980, to 0.988 million acres (Skinner, 1981), and increased 16.5 percent in the previous year (Skinner, 1980). Research has been completed on the costs and profits of irrigated crops (Tew and Musser). However, methods of financing irrigation equipment have received limited attention. One method of acquiring use of equipment and financing in agriculture is leasing. Previous studies (Hopkin; Lins; Willett and Penland; Willett) provide insight into the lease-versus-purchase financing question. All the authors found the present value of after-tax costs for purchasing less than the costs for leasing. Hopkin and Willett and Penland used straight line depreciation and did not consider accelerated depreciation. The investment tax credit (ITC) is given to lessees in Arizona (Willett and Penland), whereas in the Southeast, the lessor retains the ITC. Lins analyzes term loans that are shorter than is common for irrigation equipment loans in the Southeast. Willet provides the most definitive study; however, he and the others assume a stable price environment. Finally, these studies do not consider the financing alternatives for the higher leverage (debt/total assets) farmer.

This paper analyzes the cost of lease and purchase options for irrigation equipment within different scenarios of economic parameters. Two criteria are used to examine these options: minimum after-tax discounted cash outflows, and minimum equity capital requirements. The second criterion is added to accommodate situations in which equity capital is limited for the farm firm. However, primary reliance is placed on standard discounted net cash outflows. Data obtained in Georgia are used to illustrate the methodology.

CONCEPTUAL FRAMEWORK

When considering whether or not to acquire an irrigation system, discounting of the anticipated cash inflows minus outflows yields net present value of the investment. If the net present value is positive, the farmer should give serious consideration to purchasing the system if no financial constraints exist. Differences in the financing method will affect cash outflows. Analysis of lease or purchase is therefore a preliminary step to the overall decision to invest in an irrigation system. Alternatively, the lease-versus-purchase decision would be of interest to a farmer who has decided to use irrigation, but is undecided on financing methods. This section first considers the application of the concept of net present value (NPV) to this decision and then considers other factors that require consideration in the analysis.

Standard analysis of leasing versus purchasing utilizes the concepts of NPV that were developed for capital budgeting (Brigham; Barry et al.). The basic input for this analysis is incremental after-tax cash flows over the planning horizon. In financing decisions for irrigation systems, many costs and revenues associated with the use of irrigation are invariant and need not be considered. Examples include increased revenues from higher yields; inputs associated with intensified crop production under irrigation; labor, fuel, and repairs to operate the irrigation system. Therefore, the NPV calculations must consider only the cash ownership costs, the lease charge, and the income tax effects of the differences in cash flows. Since almost all of these cash flows are negative, the NPV most likely will be negative. For convenience, all of the formulas are multiplied by minus one and the criterion is to minimize −NPV rather than maximize NPV. Alternatively, this approach can be thought of as minimizing the present value of costs or cash outflows.

The formula for NPV of leasing (NPV_L) is:

$$(1)\quad NPV_L = L(1-d) + \sum_{t=1}^{n-1} \frac{[[(1-d)L + i_l dL]\,(1-I_t) - dLI_t + dL]}{(1+k_e)^t} + \frac{dL + i_l dL\,(1-I_n) - LI_n}{(1+k_e)^n}$$

A list of all variables used in the analyses is presented in Table 1. The formulation in (1) assumes that the firm uses debt in its capital structure, so

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TABLE 1. Variables Used in the Present Value Analysis of Leasing or Purchasing an Irrigation System

Variable	Definition
d	ratio of debt to assets for the firm
L	annual lease payment
i_{ℓ}	interest rate on debt associated with leasing
I_t	marginal income tax rate in year t
k_e	after tax cost of equity capital
0_t	cash ownership cost, such as taxes and insurance, not paid by lessee assumed to be paid at the beginning of each period in year t
i_p	interest charge on debt associated with purchasing
D_t	depreciation charge on system in year t
N_t	principal payment on irrigation system loan in year t
A_t	interest payment on irrigation system loan in year t
ITC	investment tax credit
S_n	market salvage value at the end of planning horizon
Itt	income tax liability from S_n
C_0	retail cost for the system
n	number of years in the planning horizon

that part of L represents equity $(1-d)L$, and part debt dL. At the beginning of the planning horizon, a lease payment is due, which results in an equity cash outflow as represented in the first term of (1). From the second year through the end of the $n-1$ year in an n year planning horizon, an additional lease payment plus interest on the debt to finance the lease is paid, as reflected in the second term of (1). Also, dL is the principal paid in year t on debt financed in year $t-1$. Note that the annual lease payment, both debt and equity portions, and interest payments are a tax deductible expense. In the final year, an interest and principal payment is made; and the tax saving for the final lease payment is received in the nth year.

The NPV of costs for the purchasing alternative (NPV_P) can be specified as follows:

$$(2)\quad NPV_P = (1-d)\,C_0 + (1-d)\,0_0 - \frac{ITC}{(1+k_e)} + \sum_{t=1}^{n-1} \frac{[d0_{t-1} + (1-d)0_t + i_p d0_{t-1}(1-I_t) - I_t(D_t+0_t) + N_t + A_t(1-I_t)]}{(1+k_e)^t} + \frac{d0_{n-1} + i_p d0_{n-1}(1-I_n) - I_n(D_n+0_{n-1}) + N_n + A_n(1-I_n) - S_n + Itt}{(1+k_e)^n}$$

The first term reflects the initial equity investment in the system, and the second, the initial equity payment of incremental ownership costs. The third term reflects the fact that the tax advantage of the investment tax credit is usually obtained in the second year of the investment for a farmer (Reid et al.). The fourth term represents the annual cash flows occurring in each year of the planning horizon from $t=1$ to $n-1$. Included are ownership costs, interest, debt repayment, depreciation, and the appropriate income tax effects. The debt to finance the irrigation system dC_0 is being repaid to reflect the depreciating value of the system. If the amortization schedule for this loan is less than n, N_t and A_t may be zero for periods in the latter part of the planning horizon. The final term reflects the terminal cash flows that include all those in the second term except for an equity payment on O_n, plus the market salvage value of the system and any income tax liabilities arising from this sale (White and Musser).

Equations (1) and (2) differ from most standard NPV formulations. In the standard case, the cash flows do not consider debt—both the initial cash outflows and the annual operating outflows correspond to actual payments, rather than to payments from equity capital. In addition, the interest and debt payment charges are not included; however, a weighted average cost of capital, rather than the cost of equity, is used for the discount rate. The formulation in this paper has been utilized by agricultural economists concerned with land prices (Lee and Rask; Plaxico and Kletke; Barry et al.). Brigham (p. 397–402) contrasts the two methods and presents a simple numerical example; while the methods do not yield equivalent calculations, they would result in similar decisions in most cases. The formulation utilized in this paper does have the intuitive advantage of explicitly accounting for all equity cash flows.

The overall treatment of debt in (1) and (2) corresponds with the standard corporate treatment. The debt-to-asset ratio d reflects the overall leverage position of the firm and is utilized wherever debt is included. This treatment results in explicitly including the effects of the debt in the overall financial structure. Farm firms may be able to obtain more debt to finance these particular investments. However, debt must then be reduced on other assets or investments to maintain d. Therefore, using the debt that could be obtained on an irrigation system would not reflect the full effect of the investment on the firm. It must be recognized that investment in irrigation may reduce business risk arising from production and allow the firm to increase its financial leverage. In this case, d may increase to reflect the new risk position of the firm.

Equations (1) and (2) are utilized for the empirical calculations in this paper. As in many capital budgeting applications in agricultural economics, many of the parameters, such as k_e, n, d, and I_t, will vary among firms. Base calculations utilize assumptions on the representative values of these parameters. However, the sensitivity of the results is evaluated with variations in some of these parameters.

A final conceptual problem concerns the potential limitation of the NPV concept to farm investment problems. As Reid et al. stress, NPV can be the incorrect criterion in the presence of capital rationing. Inasmuch as most farm firms do not have access to external equity, the capital budget does have a finite limit so that capital rationing can exist. Resolution of the investment decision in this case requires a multiperiod model that includes future investment alternatives, such as used in firm growth research. Such a model was unavailable for this research. However, considerations of the initial investment requirements, which are $(1-d)L$ for leasing and $(1-d)C_o+(1-d)O_o$ for purchasing, along with NPV_L and NPV_P, allow identification if capital rationing is likely to affect the decision.

DATA AND METHODOLOGY

The first step in the research was to determine the lease practices utilized for irrigation systems in Georgia. Several contracts were examined, and a telephone survey of major irrigation sales and financing agencies defined prevalent leasing and purchasing terms. It was determined that irrigation lessees typically enter true leases that do not specify interest payments nor require purchase at the end of the planning horizon. Conditional sales contracts may specify interest payments and/or require purchase of the equipment, and tax treatment may not differ from a purchase (Green). Thus, of the available leasing contracts, only true leases are considered in the analysis. Leases for irrigation systems vary from typical land leases in that the lessee is responsible for part of the fixed costs of operation and all of the variable costs. For example, property taxes, insurance, development costs (water supply and field preparation), and operating expenses typically are all paid by the lessee in Georgia. Since the purchase option also results in these costs being paid by the farmer, incremental fixed and variable costs of ownership are zero, so that O_t and O_{t-1} in (2) are zero. The analysis was based on a 150-acre center-pivot sprinkler system that includes power unit, pump and gear-head, shipping, and installation. The system retailed for $61,000 in 1980 (Brown and Skinner) and was adjusted with 10 percent inflation to $67,100 for 1981.

A base scenario that reflects typical conditions was constructed for the financial analysis. A 10-year planning horizon, n, was assumed. The buyer receives a 7-year loan with 14-percent effective annual interest (i_p). Salvage value is assumed at 10 percent of retail and appreciates by a 10-percent annual inflation factor. The income received from the sale of the equipment three years after the final purchase payment is $17,404 [$S_n$ of equation (2)]. Salvaged equipment is not sold immediately after amortization, in order to maintain a consistent planning horizon for leasing and purchasing. The term Itt of equation (2) reflects the tax on the S_n sale, and can be calculated from:

$$(3) \quad Itt = (S_n - C_o + \sum_{t=1}^{n} D_t)\, I_t$$

where the variables have their previously defined meaning and S_n is less than the original retail price (White and Musser). While the Economic Recovery Tax Act of 1981 introduced the Accelerated Cost Recovery System (ACRS) method of depreciation, the traditional double declining balance method is used for the base scenario. A 10-percent investment tax credit (ITC, equation 2) of $6,710 is available in the second year of the planning horizon. By assumption, 20 percent is the cost of equity capital (k_e).[1] The initial value of the marginal tax rate (I_t) reflects a $15,000 taxable income for a married couple filing jointly with four exemptions (Internal Revenue Service). Assuming that tax rates are not indexed, taxable income is assumed to inflate 5 percent annually, so that I_t ranges from 17 percent to 27 percent over the planning horizon. The overall leverage ratio (d) is assumed to be 30 percent. The short-term interest rate (i_l) is 15 percent. The annual lease payment L is $11,114. A 10-year lease contract is assumed, and payments are made at the beginning of each production year.

While some of the parameters in the base scenario represent existing financial conditions, some of the parameters are arbitrary and reflect assumptions concerning representative value. To generalize the analysis, several of the parameters were varied separately in the analysis. The parameters that were varied and their values are listed in Table 2. The new ACRS depreciation method is tested, along with straight line and sum of the years digits. The values of I_t reflect initial taxable incomes of $6,000, $30,000, and $55,000, respectively; the taxable incomes for years after t=0 inflate at a 5-percent rate. For n=7, L_t is $13,128.[2]

[1] Following White and Musser, k_e is a nominal discount rate that reflects a 10% inflation rate utilized in the analysis. The real discount rate k_e would be determined as k'_e

$$k'_e = \frac{(1 + k_e)}{(1 + In)} - 1$$

where In = the inflation rate. In this situation, $k'_e = 9.1\%$.

[2] The telephone survey indicated that lessors set L to amortize the cost of the investment at a 13.5% rate of return for 10-year leases and at a 12% rate of return for 7-year leases. To calculate L, present value interest factors of annuities (PVIFA) for n−1 and the appropriate rate of return were utilized − L = $\frac{Co}{PVIFA+1}$.

TABLE 2. Base Values and Other Values of Parameters Varied in the Analysis

Parameter	Base Value	Other Values
Leverage Ratio (d)	0.30	0.0, 0.5, 0.7, 0.85, 1.0
Marginal Income (I_t) Tax Rate	0.17-0.27	0.12-0.15, 0.33-0.44, 0.47-0.55
Cost of Equity (k_e) Capital	0.20	0.0, 0.10, 0.32, 0.40
Depreciation Method	Double Declining Balance	Straight Line, Sum of the Years Digits, ACRS
Length of Planning (n) Horizon	10	7

RESULTS

The net present values of costs for purchasing or leasing an irrigation system for various parameters are presented in Table 3. A notable result is that leasing has an advantage over purchasing for many sets of parameters in the analysis. An exception is leverage. Also, at low values for k_e, NPV_P is less than NPV_L. When the NPV of lease and of purchase are graphed over the various values of k_e (Figure 1), the NPV of leasing becomes greater than that of purchasing as k_e drops below approximately 16 percent, given the other base parameters.

For leverage, if d is greater than approximately 45 percent, purchasing is preferred. The NPV_P declines as d increases, while NPV_L exhibits opposite behavior. In general, NPV is expected to decline as the financed portion of the purchase price increases. The preference for leasing is explained as the result of increasing interest payments as d increases. Interest payments for purchasing are deferred over a longer period than for leasing. Finally, tax deductible expense increases as d increases for purchasing, while the annual lease payment is tax deductible, irrespective of d.

TABLE 3. Net Present Value of After Tax Cash Outflows for Lease and Purchase of a 150 Acre Center-Pivot Irrigation System (in dollars)

Parameter Values [a]	Net Present Value		
	Purchase	Lease	Difference
	--------------dollars--------------		
d = leverage ratio			
0.0	51,317	45,348	5,969
0.30[b]	46,801	44,732	2,069
0.50	43,656	43,960	- 304
0.70	40,510	43,188	-2,678
0.85	38,151	42,609	-4,458
1.0	35,792	51,143	-15,351
I_t = marginal income tax rate			
.12-.15	49,972	49,074	898
.17-.27[b]	46,801	44,732	2,069
.33-.44	39,597	37,300	2,297
.47-.55	33,819	30,874	2,945
k_e = cost of equity capital			
undiscounted	43,876	70,182	-26,306
10%	46,806	53,819	-7,013
20%[b]	46,801	44,732	2,069
32%	45,887	36,951	8,936
40%	45,167	35,370	9,797
Depreciation Method			
Straight Line	47,970	44,732	3,238
Sum of the Years Digits	46,812	44,732	2,080
Double Declining Balance[b]	46,801	44,732	2,069
ACRS	45,624	44,732	892
n = length of planning horizon			
7 year	43,174	45,784	-2,610
10 year[b]	46,801	44,732	2,069

[a] Only designated parameter varies, others retain their respective base values.
[b] Base value.

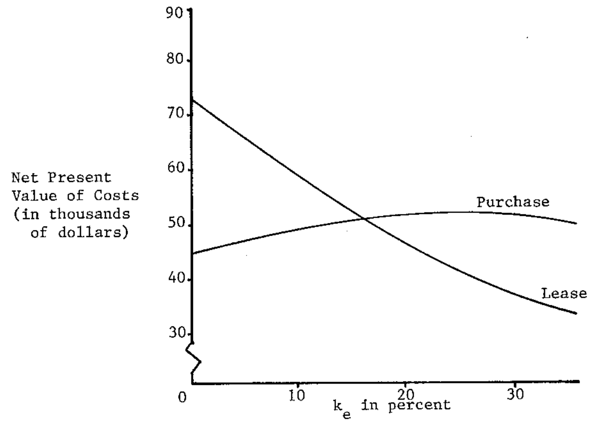

FIGURE 1. NPV of lease and purchase options for a center-pivot irrigation system for various values of k_e

As I_t increases, NPV of both options decreases, which reflects the decreasing after-tax cost of deductible interest and lease payments, and the increasing value of the depreciation tax shelter. The advantage of leasing increases slightly with higher tax rates.

The remaining parameters have some interesting relationships with NPV. The ACRS accelerated depreciation method provides the lowest NPV of costs for purchasing of the four depreciation schedules. Sum of the years digits and straight line depreciation both increase the NPV of costs for the purchasing alternative over double-declining balance, which corresponds to the standard corporate finance propositions on depreciation methods (Brigham). The length of planning horizon has opposite effects on the two options—NPV_L decreases, while NPV_P increases as n increases from 7 to 10 years. For the purchase option, the only difference with a longer planning horizon is the terminal cash inflows. The cash flows have smaller current values when received in 10 years rather than 7 years, which results in NPV for 10 years being higher. In contrast, the smaller value of L for 10 years has a smaller NPV than the larger value of L for 7 years. For k_e, NPV_L decreases as k_e increases, which corresponds with expected relationships. In contrast, NPV_P first increases and then decreases as k_e increases. This unexpected pattern is caused by the terminal cash inflow, which follows cash outflows throughout the planning horizon. This pattern of cash flows has produced several unexpected relationships in capital and finance theory (Baumol).

For the situations in which $NPV_L < NPV_P$, the capital rationing criteria are consistent with the NPV criteria. The initial total cash outflow for leasing is $11,114, while the purchase cost is $67,100. No matter what value of d is utilized in the capital structure, the initial equity cash outflow will always be less for a lease. However, for situations in which NPV_P is lower than NPV_L, such as with a low k_e and higher d, the two criteria may conflict. With limited equity capital, leasing may be preferred, irrespective of its lower present value of costs.

CONCLUSIONS

The analysis in this paper demonstrates that leasing an irrigation system has a lower NPV of cash outflows that does purchasing the system under a range of parameters that are appropriate for southeastern farmers. Several differences in this investigation, compared with earlier studies and reviewed in the introduction, could have contributed to the contrasting conclusions of the other studies. Most important, development of leasing institutions to take advantage of the tax benefits of being a lessor (Brigham; Lins) may have resulted in more favorable lease payments than are currently available to farmers in Georgia on irrigation systems. Another difference cited herein is the use of a high nominal cost of equity to reflect current inflation. Hopkin noted that leasing would be favored with a high discount rate; in this paper, purchasing became more favorable than leasing as k_e approached zero. Finally, the assumptions concerning leverage relationships by the present authors, specific to the irrigation system, may have contributed to the favoring of leasing.

The base scenario uses 30-percent debt, which favors leasing. Higher leverage rates favor purchasing. If the base scenario assumed $d > 50$ percent, this may affect the decision whether to lease or purchase for the other variables. As mentioned earlier, the 30-percent assumption reflects the overall leverage position of the firm. If d increases for irrigation equipment, then d must decrease on other assets. In general, lenders will loan a high percent of the purchase cost on an irrigation system because of the perceived low risk of this investment. For example, a value of $d = 85$ percent had a NPV_P of $38,151. If the assumption is that the lease is financed 100 percent with equity, this option has a NPV_L of $45,348 (Table 2). Under this scenario, purchasing would be optimal. However, such a scenario would be inconsistent with modern financial theory—operating capital is financed in part with debt for farm firms, and the large loan for purchasing irrigation equipment is probably feasible only because $d<85$ percent for overall assets of the farm. The analysis in this paper demonstrates that at levels of d that reflect the overall leverage position of the firm, leasing is preferred.

While leasing is preferable to purchasing under the base situation and for a number of other categories, purchasing does have a lower NPV in enough situations that analysis of each particular situation appears warranted. In addition, it must be stressed that $NPV_P < NPV_L$ is not a sufficient condition for purchasing to be preferred. With severe capital rationing, the lower initial cash outflows may still make leasing more desirable.

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