AGRIBUSINESS MANAGEMENT

EVALUATING ALTERNATIVE CAPITAL INVESTMENT PROGRAMS

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In the March 1980 issue of this publication we reviewed the procedure by which a capital investment project was assessed. The means by which a project's annual net cash flows can be calculated were discussed and illustrated. The cash flow complexities with regard to taxes, depreciation, capital gains, investment credit, and salvage values were also incorporated into the cash flow computation. Our earlier discussion did not, however, suggest a means for evaluating alternative investment projects, nor did it provide the agribusiness manager with a finite criterion by which a single project could be judged acceptable or unacceptable.

This issue shall attempt to address each of the latter two management needs. It presumes first, that the annual net cash flows attributed to each alternative capital investment project have already been computed. It presumes second, that the agribusiness manager is capable of identifying his firm's opportunity cost of capital, i.e., the true rate of return associated with investing capital in alternative projects.

Internal Rate of Return

One of the most common criteria by which alternative investment projects are compared and/or judged acceptable is known as the "internal rate of return". In technical terms, the IRR is that interest rate (annual average) that renders the sum of an investment's annual net cash flows when discounted to time period zero, equal to zero.

Expressed mathematically, the IRR is that interest rate which satisfies the following equation:

$$0 = \sum_{n=0}^{T} \frac{X_n}{(1+i)^n}$$

where:

X_n = net cash flow in year n

T = number of years of cash flow in investment's life

n = the year in which the cash flow X_n occurs

i = IRR = the internal rate of return

To simplify what appears to many to constitute a rather complex formula, let's consider an illustrious capital investment project which costs $10,000 and generates an annual net cash flow of $3,007 for each of the subsequent six years (see Table 6).

TABLE 6

End of Year	Net Cash Flows
0	-10,000
1	3,007
2	3,007
3	3,007
4	3,007
5	3,007
6	3,007

Net Annual Cash Flows ($)

By applying this stream of cash flows to our formula and solving for i we obtain:

$$0 = -10,000 + \frac{3,007}{(1+i)} + \frac{3,007}{(1+i)^2} + ... + \frac{3,007}{(1+i)^6}$$

$$= -10,000 + 3,007\,(PAi,6)\ \text{where PA = present}$$
worth factor

$$(PAi,6) = \frac{10,000}{3,007} = 3.3256$$

$i = 20\%$ as determined from a discrete compounding table where PA = 3.325 and n=6

In this illustration, of course, our analysis has been simplified by the fact that our cash flows are discrete and uniform. More commonly, however, agribusiness investments will generate annual net cash flows of unequal amounts such as those shown in Table 7.

In such cases the application of our formula becomes more complex and we are forced to approximate the IRR by a trail-and-error procedure. Typically, we would select two interest rates such that the discounted cash flows sum to a positive and negative value (see Table 8) and then approximate the IRR through linear interpolation as shown below.

Quite obviously this trial-and-error process can be both difficult and time consuming. One need not be frightened, however, as many electronic hand calculators now have built-in programs for making such IRR calculations directly.

TABLE 7

Net Annual Cash Flows ($)

End of Year	Net Cash Flows
0	-10,000
1	1,000
2	2,000
3	4,000
4	4,000
5	4,000

Accept or Reject Criteria

Now that the IRR for the capital investment project has been determined, how is it used and what does it mean?

As we noted in the March issue, most agribusiness managers have some general conception of their true cost of capital and/or their opportunity cost of capital. Given either or both of these concepts, that manager also has some policy with regard to a minimum acceptable rate of return (MARR), i.e., that rate of return on investment below which the manager or the firm is unwilling to consider as an attractive project. Given these minimum criteria, if IRR exceeds the MARR, the project is judged attractive or acceptable; if this is not the case, the project is rejected. If alternative capital investment projects are being assessed, quite obviously they may now be preferentially ranked by management in accordance with the level of IRR generated by each.

Returning to our earlier illustration (Table 6) we can further expand on the true meaning of the IRR. In Table 9 we have demonstrated an alternative meaning of IRR = 20%, where IRR is shown to be the return on unrecovered capital (allowing for the full recovery of invested capital over the investment's life). In this concept, the agribusiness firm is loaning $10,000 to the investment project and asking for a 20% rate of interest on those monies remaining unrecovered at the end of each of the six years of active life. In this case the "internal" rate of return is that return generated "internally" by the project as a result of its net cash flows.

TABLE 8

Selecting IRR Bounds

End of Year	Net Cash Flow	Discounted Cash Flows				
		PF,12%			PF,15%	
0	$-10,000	1.000	$-10,000.0	1.000	$-10,000.0
1	1,000	.8929	892.9	.8696	869.6
2	2,000	.7972	1,594.4	.7562	1,512.4
3	4,000	.7118	2,847.2	.6575	2,630.0
4	4,000	.6355	2.542.0	.5718	2,287.2
5	4,000	.5674	2,269.6	.4972	1,988.8
Sum			146.1		-712.0

$$\text{Interpolated IRR} = 12 + 3\frac{146.1 - 0}{146.1 - (-712)} = 12.51\%$$

TABLE 9

IRR as Unrecovered Capital ($)

End of Year	Net Cash Flow	(Step 3) Unrecovered Capital	(Step 1) Return on Unrecovered Capital (20%)	(Step2) Capital Recovered
0	$-10,000	-10,000		
1	3,007	$-10,000 + 1,007 = -8,993$	$.2(-10,000) = -2,000$	$3,007 - 2,000 = 1,007$
2	3,007	$-8,993 + 1,208 = -7,785$	$.2(-8,993) = -1,799$	$3,007 - 1,799 = 1,208$
3	3,007	$-7,785 + 1,450 = -6,335$	$.2(-7,785) = -1,557$	$3,007 - 1,557 = 1,450$
4	3,007	$-6,335 + 1,740 = -4,595$	$.2(-6,335) = -1,267$	$3,007 - 1,267 = 1,740$
5	3,007	$-4,595 + 2,088 = -2,507$	$.2(-4,595) = -919$	$3,007 - 919 = 2,088$
6	3,007	$-2,507 + 2,506 = 0*$	$.2(-2,507) = -501$	$3,007 - 501 = 2,506$

*=rounding error

Observing year 1 in Table 9 we see that as of the end of that period the firm expects a return of $2,000 (20%) for the project's one-year use of the $10,000 loaned it by the firm. Since the project actually returns $3,007, this reduces the balance of unrecovered capital by $1,007 such that the firm's investment in the project during the second year is $8,993, upon which a return of $1,799 (20%) is expected during the second year. Again, $3,007 is actually returned, reducing the balance of the firm's unrecovered capital from $8,993 to $7,785 for employment by the project during year 3.

Understanding of Table 9 may be aided by reviewing each row of the table via steps 1-3, in order. For those readers who enjoy the mathematical rigor associated with IRR computations, it should be noted that for certain types of cash flows, IRR either cannot be determined or the computation results in multiple solutions. For example, when all cash flows associated with a capital investment have the same sign, IRR cannot be determined. Conversely, when the signs associated with a sequence of annual net cash flows change more often than once, an algebraic phenomenon known as "Descarte's Rule of Signs" dictates that there may exist a multiple solution to the IRR computation. When this situation arises, there does exist an alternate method for determining IRR. However, such matters fall beyond the intended scope of this paper.

Net Present Value

A second common criterion by which alternative capital investment projects may be compared or judged acceptable is known as the net present value. Again, in technical terms the NPV is the sum of the annual net cash flows associated with an investment project discounted to time zero at the MARR. Mathematically it is expressed as:

$$NPV = \sum_{n=0}^{T} \frac{X_n}{(1+k)^n}$$

where k = MARR

Returning once again to our earlier example in Table 6 we find that for a MARR of 10%:

$$NPV = 10,000 + \frac{3,007}{(1+.10)^1} + \frac{3,007}{(1+.10)^2} + ... + \frac{3,007}{(1+.10)^6}$$

$$= -10,000 + 3,007 (PA,.10,6)$$

$$= -10,000 + 3,007 (4.3553)$$

$$= \$3,096$$

Given a series of net cash flows, the investment project is judged acceptable if $NPV \geq 0$, and

unacceptable otherwise. Similarly, alternative investments may be preferentially ranked in accordance with the magnitude of the NPV generated.

A better understanding of the true meaning of NPV is facilitated by Table 10. You will note the similarity between Table 10 and Table 9. They are similar in computational base except that Table 9 uses an IRR of 20% while Table 10 uses an MARR of 10%. As shown below, all capital is fully recovered in the fifth year of the investment period, with a $2,252 surplus remaining in the fifth year, plus the full cash flow of $3,007 in the sixth year. If these surplus cash flows are discounted to time zero the result is:

$$2,252 (PF,.10,5) + 3,007 (PF,.10,6)$$
$$2,252 ((.6209) + 3,007 (.5645) 3,007 = \$3,095$$

This $3,095 is identical (except for rounding error) to that solution obtained from the formula computation above.

Table 10 shows that a $NPV > 0$ implies that all the capital is recovered over the life of the project (or a shorter period), or a return (MARR) is received each year on the unrecovered capital, and a surplus or bonus (NPV) is also received. If $NPV = 0$, this implies that MARR = IRR.

IRR and NPV Relationship

By now the reader must wonder whether or not the use of IRR or NPV would result in the same management decision regarding the acceptability of the capital investment project. In fact, for those single project assessments comprised of cash flows with no more than one sign change, either method will produce the same accept/reject decision.

The IRR and NPV relationship is diagramatically shown in Figure 1.

TABLE 10

NPVas Unrecovered Capital ($)

End of Year	Net Cash Flow	(Step 3) Unrecovered Capital	(Step 1) Return on Unrecovered Capital	(Step2) Capital Recovered
0	$-10,000	-10,000	--	--
1	3,007	$-10,000 + 2,007 = -7,993$	$.1(-10,000) = -1,000$	$3,007 - 1,000 = 2,007$
2	3,007	$-7,993 + 2,208 = -5,785$	$.1(-7,993) = -799$	$3,007 - 799 = 2,208$
3	3,007	$-5,785 + 2,428 = -3,357$	$.1(-5,785) = -557$	$3,007 - 579 = 2,428$
4	3,007	$-3,357 + 2,671 = -686$	$.1(-3,357) = -336$	$3,007 - 336 = 2,671$
5	3,007	$-686 + 2,938 = 2,252$	$.1(-686) = -.69$	$3,007 - 69 = 2,938$
6	3,007	--	--	--

Referring to Figure 1, it can be seen that if i_1 is set

Figure 1
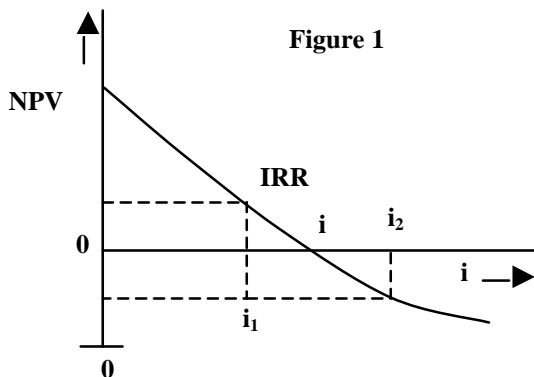
as the MARR, then NPV is greater than zero. In this situation, IRR is greater than MARR. Consequently, the cash flows are deemed to be acceptable under both NPV and IRR criteria. If i_2 is set as the MARR, then NPV is negative and IRR is less than MARR. Hence, the cash flows are judged unacceptable by both criteria. Where NPV is set as 0, then IRR = MARR and cash flows are acceptable.

The Pay-Back Period Criteria

One final criterion is sometimes applied in management's evaluation of a capital investment project. This criterion is referred to as the pay-back period and refers to the number of years required for the cash flows to completely recover the original investment. Expressed mathematically, the pay-back period (1) is:

$$0 = \sum_{n=0}^{1} X_n$$

Using those data provided in Table 11, we would calculate that the pay-back period lies somewhere between the third and fourth years, e.g.:

Third year $= -10,000 - 5,000 + 7,000 + 7,000 = -\$1,000$

Fourth year $= -10,000 - 5,000 + 7,000 + 7,000 + 7,000 = \$6,000$

Using linear interpolation, the pay-back period can be approximated as: 3 – 1,000

| 1 | 0 |

| 4 | 6,000 |

$$1 = 3 + \frac{1,000}{7,000} = 3.14 \text{ years}$$

Pay-Back Limitations

Used alone as a criterion by which to judge the acceptance or rejection of a series of cash flows, the pay-back period method has true limitations. It is not difficult to generate illustrative cash flows where the IRR and NPV criterion dictate a management decision opposite that generated by the pay-back period. This conflict results because the pay-back period ignores the magnitude of cash flows following the point of full recovery. Neither does the pay-back criterion acknowledge in any

way the time value of money. Obviously for a small agribusiness firm, the time required to recover its original investment is an important consideration. However, any attempt to base the acceptability of a series of cash flows on the pay-back period criterion alone could lead to faulty decisions.

TABLE 11

Cash Flows – Pay-Back ($)

End of Year	Net Cash Flows
0	-10,000
1	-5,000
2	7,000
3	7,000
4	7,000
5	7,000
6	7,000
7	7,000