Investment analysis in agriculture

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Loren W Tauer
Cornell University

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Loren W. Tauer

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Loren W. Tauer[*]
Cornell University

Abstract

Recent developments in investment analysis and their relevancy in agricultural investment assessment are discussed. The Net Present Value model can be modified to incorporate the value of strategic management of an investment into the initial evaluation of that investment. Since these decisions can be modeled as call and put options, the mathematics of financial options has been applied to these investment decisions, and referred to as real options analysis. It is shown how contingent claims analysis can be used to value these real options. Contingent claims analysis uses a risk-free discount rate, since risk is incorporated into option valuation using computed risk-neutral probabilities obtained from a replicating portfolio correlated to the discounted income stream. Many net returns in agricultural activities are correlated with prices of underlying agricultural commodities, suggesting the potential use of contingent claims analysis.

Introduction

In this paper, I review the recent developments in investment analysis that have occurred in recent years, and discuss the relevancy of these techniques in agricultural investment assessment. These new concepts are often referred to as <u>real options</u> or <u>contingency claims analysis</u>. They are an off-shoot of the research work on pricing financial options. An understanding of these new concepts is important to a business manager since they may allow that manager to make better investment decisions. An economist should understand these concepts to understand investment behavior. Most economists believe that man is economically rational, and even if that man is not able to perfectly replicate the results of our economic models in his daily decisions, we believe that he comes close. Our models help us to understand economic behavior.

The consensus in the investment literature is that if the objective of a firm is the maximization of profit or wealth of a business, then the Net Present Value (NPV) model is the appropriate procedure to evaluate investment decisions (Van Horne and Wachowicz). Even with multiple and possible competing goals, NPV is the preferred model to evaluate the profit or wealth effects of any investment within those various goals.

The NPV model was originally designed to evaluate the market price of a government bond. In that situation, the annual return of the coupon payment is known with certainty except for the slight probability that the government would default on the bond. In contrast, the annual returns from most investments are far from known with any level of certainty. Another important difference is that physical investments are actively managed after the investment decision is made. This active management is much different than the passive decision of purchasing a bond.

During the last 15 years, there have been significant appearances of literature on modifying or adjusting the NPV model to incorporate the value of actively managing an investment into the initial evaluation of the investment. If you are able to adjust to any adverse or favorable changes during the investment period, then the value of that opportunity should be reflected in your initial evaluation of the investment.

Very early this new literature realized that these strategic adjustments during the investment periods were similar to the concept of call and put options in finance. The call option on a stock for instance, gives the owner (buyer) of the call option the right, but not the obligation, to purchase the stock at some price (exercise price) over some specific date or time period. The owner of a call option will exercise that option if the market price of the stock exceeds the exercise price at the termination date. It is easy to visualize that the same decision process can be found in many investment decisions. A firm may make the decision to introduce some new product at a small scale, with the intent that if the product shows promise, then the investment to produce that product will be expanded at some future date. This decision can be modeled as a call option. The market value is the profits to be made from a larger plant rather than the selling price of a stock, and the exercise price is the cost of the increased investment rather than the cost of the stock.

The mathematics of financial options has been applied to investment decisions. To distinguish these applications from the option literature on financial instruments that are traded on markets, such as stocks and bonds, the literature on physical rather than financial investments is typically referred to as real options. Although the term real may be used for modeling physical investments, the mathematics used are essentially identical to that used to evaluate financial instruments. In some sense, real option models can become even more complex mathematically than the finance option models since the strategic decision of a real investment can be much more complicated than the decision of buying and selling the stock of a company.

The beauty of the real option literature is that the developers of the concept generally do not throw out the NPV model in modeling real options. Most real option researchers will state that any investment should first be evaluated using the standard NPV, with the estimated values of any options appended to this standard NPV, adjusting the assessed investment value of the investment opportunity. This approach has a number of benefits. At least two generations have been taught the usefulness and appropriateness of the NPV, and it would not be beneficial to discard that knowledge and acceptance. More importantly is that real options are strategic decisions that will be made during the investment period. It is extremely valuable to specify what these decisions may be for the

investment period, and estimate their separate values. As anyone working with decision-makers realizes, most decision-makers find the numerical estimates of investment analysis tenuous. They realize these numbers are only estimates. The process of arriving at these numbers, with the necessary assumptions, is what decision-makers find most useful. Real option analysis requires specifying what strategic decisions might exist in the future, and estimating the possible value of those decisions. Since there are numerous strategic decisions that can be made during the course of the life of any investment, that investment may be modeled as a nexus of put and call real options.

In the rest of this paper I will specify the basic NPV model and contrast it with other investment criteria. Then the concept of options will be introduced and how real options can be appended to the basic NPV model. Numerically simple examples of real options will be introduced to show the potential value of including real options in investment analysis. The use of contingent claims analysis to value real options will be illustrated. Potential applications to agriculture investments will be discussed.

Net Present Value Analysis

The preferred approach to evaluate investments is to use the Net Present Value (NPV) model. For an investment of T periods that is written as:

$$NPV = \Sigma \ C_t/(1+r)^t - I$$

Where the summation is from t=1 to T representing time periods, C_t is the net cash flow for period t, r is the discount rate, and I is the initial investment period 0.

For much of the examples illustrated later, only one or two periods will be specified. This simplifies exposition without much lost of generality to T periods.

Accounting procedures differ across countries and it is sometimes debated how that impacts the computation of NPV. For instance, some countries allow an investment to be deducted from taxable income the year the investment is made, while other countries require that investment be deducted against taxable income over a specified number of years. In all cases, however, the cost of the investment is included as cash flow in NPV the year that investment is made (usually the first year). What differs is that the net taxes from writing off the investment as a cost may be different from country to country. The Net Return (NR) in any year should simply be the cash inflow and outflow that year resulting from the investment, regardless of what the accountants or tax collectors state is allowed to be deducted as an expense or included as income in any year.

As the NPV model was first being used to evaluate investment decisions it became obvious that the net return for any year was not known with certainty, and discussion arose as to how this uncertainly should be handled. Alternative proposals surfaced but the winner was that it would be best to incorporate uncertainty into the evaluation by adjusting the discount rate upward so that it consisted of a risk-free rate (in most countries the interest rate on short-term government bills) plus a risk premium. In

practice the discount rate should be the weighted average of the cost of equity and debt to a company, but those costs include the risk premium.

The cost of debt to a company is the interest rate it must pay for debt, either privately or publicly held. The cost of equity can be determined by using the Capital Asset Pricing Model (CAPM), where the risk of a company's stock is measured relative to the risk of a diversified portfolio. What is important is the variability of the price of a stock relative to the variability to the market portfolio. The concept is to let the market evaluate the riskiness of any investment by the market's evaluation of the past investments of the company.

This approach has two limitations. The first is that the company must be publicly traded in an efficient market where information about the company is readily available. That may not always be the case. The company may not even be publicly traded. Second is that the type of investment being evaluated must be similar to previous investments which the company has made, since the risk of dissimilar investments would not be reflected in the price of a company's stock. Small companies especially may consider investments much different than they have previously made. There are research opportunities for both US and CEEC researchers to determine how the cost of equity may best be determined when these conditions are not met. In the U.S. many agricultural firms are not publicly traded, and there is no apparent consensus as to how the cost of equity should be computed for those firms. As will be seen, the inability to derive a risk-adjusted discount rate may be an attraction of using real options in evaluating agricultural investments because the explicit discount rate used is the risk-free rate.

Business decision-makers are notorious for asking "what if" questions. This is especially the case when presented with a NPV analysis report. The NPV will either be positive, in which case the investment should be made, or the NPV will be negative and the investment should not be made. This implies that there is no decision for the decision-maker to make. That is not a wise situation for an analyst to present to her boss. Although NPV is computed from the expectation of net returns, those net returns have an underlying probability distribution, and the analyst can statistically draw from those distributions and illustrate the impact on NPV of various possible occurrences. This approach done by simulation is typically referred to as sensitivity analysis.

NPV versus Internal Rate of Return

An alternative evaluation technique when it is a challenge to determine the cost of capital for a discount rate is to compute the Internal Rate of Return. This is computed by setting the NPV equal to zero and solving for the discount rate such that the discounted net returns sum to the initial cost of the investment. The reasoning is that if the initial investment is made then it will generate net returns each year of the interest rate computed (geometric mean). This gives the rate of return generated by the investment. For businesses that do not know their cost of capital, or where the cost of capital can vary considerably by year, the Internal Rate of Return procedure can be attractive.

Opponents do not favor the IRR technique because with borrowed funds, it does not necessarily lead to maximization of the firm's wealth. They support it only if there are adverse selection problems or other capital market inefficiencies. The IRR is appropriate, however, if the firm only uses equity funds to fund an investment. This is illustrated in figure 1 where a one-period investment opportunity is graphed. The horizontal axis is the amount of capital invested, either equity or debt source, and the vertical axis is the net return (or profit) that would be generated. Production economists will recognize this as a single-period production function with first increasing and then decreasing returns to scale.

Applying the NPV criterion would result in an investment amount at point a where the marginal return from the investment is equal to the price of capital divided by the price of the product produced. The NPV amount would be the height from the origin to point A. Again production economists will realize that this height is the maximization of profit discounted to the initial time from using the optimal amount of capital (owned and borrowed) at a price of r. In contrast the IRR amount of capital to use would be at point b. Net Return (or profit) would be zero, because the IRR is computed such that the NPV is zero. However, if all the capital used is owned by the firm, then using the IRR will generate the highest return to that owned capital. That is accomplished by finding the amount of capital that maximized the average return to that capital. This concept is analogous to previous comparisons of worker-owned firms and manager-owned firms that employ labor. The worker-owned firm should operate at point b that maximizes return per worker. The manager-owned firm will operate at point a such that the marginal return to profit from the last worker is equal to the market wage rate paid that worker.

Figure 1. Comparison of Net Present Value with Internal Rate of Return with Capital Invested Period 0 and Return Received Period 1.
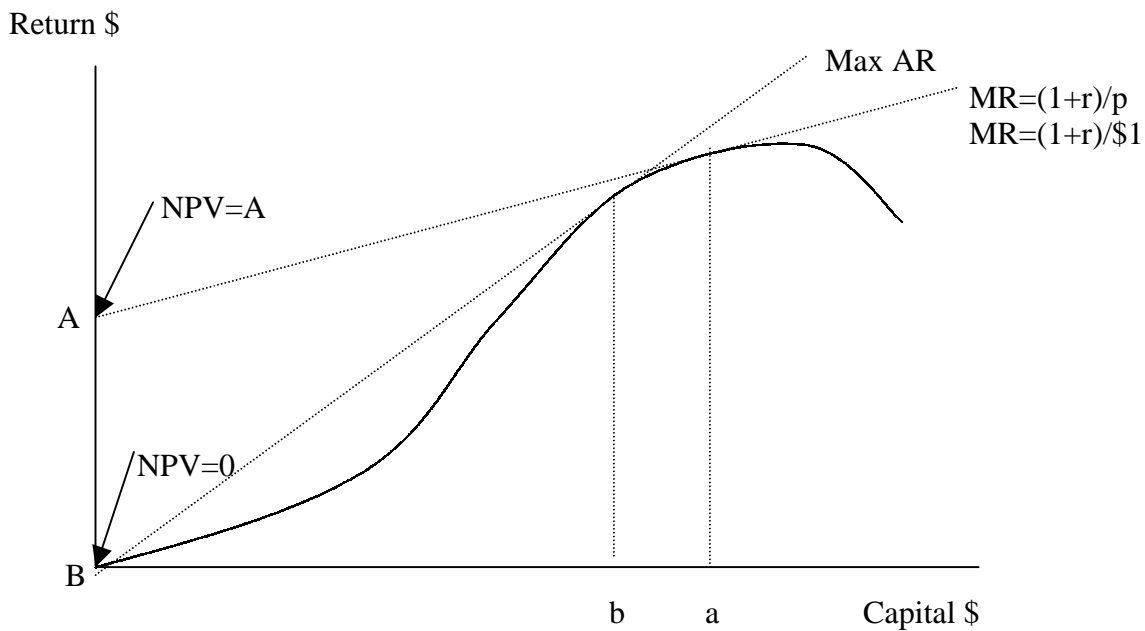
Another analysis technique is the Payback Period (PBP) which computes the number of years of net returns required to match the initial investment. Under conditions of high uncertainty, it would obviously be preferred to have your initial investment paid back quickly. Additional returns after the payback of the investment would be add-ons. The problem with the PBP is that many of the best investments do not really begin to produce until the operation is running smoothly, and that may take a year or two longer than investments which perform well at first but then show diminished potential. Most finance economists consider the PBP only appropriate for a child who asks to borrow money to engage in a social activity, and the parent asks, "when will the money be paid back?".

An Example of an Option in Investment

The following example is from Dixit and Pindyck and illustrates the option value of waiting to invest because of net return uncertainty. It has become so commonly used as an example in any discussion of real options that I would be amiss if I did not use it. However, the original formulation of the value of waiting was McDonald and Siegel.

Assume that the cost of an investment is $1,600 and that the initial net revenue from the investment the first year will be $200, but the second year the NR will either increase to $300 and stay at $300 for perpetuity or the NR will decrease to $100 and stay at $100. The probability of each event is .5. The expected NR each year is then $200. If the discount rate is .10, then the discounted summed expected net return is $2,200 = $200 + $200/.10. Since the investment cost is $1,600, the NPV of this investment opportunity is $600 and the decision would be to invest.

However, if the firm waits just one period, then the uncertainty about whether the NR would be $300 or only $100 would be resolved. It is assumed that the investment opportunity will still exist. If the NR goes to $300, the NPV becomes $1,700 = $300 +$300/.10 - $1,600 and the firm should invest. If the NR goes to $100, the NPV becomes $-500 = $100 + $100/.10 - $1,600, and the firm should not invest.

Obviously it pays to wait as long as the investment opportunity remains open. What is the value of this option to wait? If the NR goes to $100, then there is no value to this option since the investment would not be made (the option to invest is not exercised). If the NR goes to $300, the NPV would be $1,700. The probability of this NPV of $1,700 evaluated the first year is .50 and the firm would have to wait one year to exercise so the value of this option is $772.73 = 0.50*($1,700)/(1+.10).

Should the firm invest the first year? The NPV was computed as $600. But if we subtract the option value of $772.73 from the NPV, then the Expanded (strategic) Net Present Value becomes $-172.73, and the firm should not invest the first year.

Note that in this example, irreversibility of the investment decision is implied. In contrast, if the firm could sell the investment the second year at a price of $1,600 if the net return fell to $100, then the investment would always be made the first year. But if the firm could only generate $100 the second year, then it is inconceivable that they could fine a

buyer for the investment at $1,600. Yet, as many capital investment instructors have stated, "If the market was efficient, then the original NPV should have been zero." (This statement is a variation of the economist's utterance that you do not find $20 bills lying on the sidewalk, a statement that I never use since I once did find a wad of $20 bills lying on the sidewalk at a resort in Florida.)

The example above is surprisingly simple and some would state naïve, but it does show the value of options in investment analysis. In this case, it is a call option, where you have the option to make an investment at a later date. It is easy to see that this could easily be cast in a problem with two investment decisions. Either to begin with a small scale plant to test the market and later scale up by building a larger plant, or to begin with a large scale plant immediately. The traditional NPV of first a small plant and then a larger plant would be less than the traditional NPV of constructing the large plant initially, given that you have the same expectations of market returns in both cases initially. But by computing the option value of waiting to build the large plant, the strategic NPV of the small/large plant would be greater than the NPV of only building the large plant.

Dixit generalizes the value of waiting in investment decisions for any n period investment where the uncertainty may never be resolved. After all, in an industry such as agriculture, the prices of commodities are always uncertain. The Dixit model was used by Purvis, Boggess, Moss and Holt to analyze the decision to convert from open lot to free-stall housing facilities in dairy production in Texas. Conversion would increase milk production, reduce feed cost per milk unit, and decrease pollution run-off, but conversion is costly and milk price is uncertain. They estimated that with the option value of waiting, the annual returns would have to be $106,675 or $107 per cow greater than if the investment decision was analyzed using only the standard NPV model.

It is important to realize that the existence of uncertainty does not mean that a firm would never make an investment or that the uncertainty would have to first be resolved before an investment will be made. The existence of uncertainty only means that the expected net returns would have to be greater than without uncertainty before the investment would be made. These results apply without any appeal to risk aversion for the decision maker. All that is required is that there is a value to waiting.

Lawrence Summers surveyed business firms and discovered that computed NPV necessary for these firms to engage in an investment was much higher than expected. This high reservation NPV could be the result of investment uncertainty.

Decision Tree Analysis

About 30 years ago, investment analysts realized the shortcoming of static NPV and it's inability to incorporate the value of strategic decisions during the investment period. Decision Tree Analysis (DTA) was developed to model and accommodate those strategic decision points (Magee). The process uses a tree diagram where the initial period is the trunk, and branches occur where ever a strategic decision is made (usually represented by

a box), and to show the possible states of nature after a decision (usually represented by a circle). The technique is illustrated in many investment analysis books. At the tip of the last branches, let's say the leaves, are the payoffs if you go down the branches representing a series of decisions and a specific state of nature occurs. Each tip has one payoff. It is then a simple matter of working backwards selecting the route that keeps providing the largest payoff. It is like a child deciding to climb a tree. They first look at the highest branch strong enough to support themselves (at least a parent wishes that) and then they decide the best route backwards to get them to that branch. In advanced texts, the concept of dynamic programming is used to show how the problem can be solved.

Option Theory

The use of decision tree analysis (DTA) is better than static NPV analysis when strategic decisions are possible during the investment period. Yet DTA is still considered inferior to the use of option theory using contingent claims analysis (CCA)). With DTA the same risk adjusted discount rate is used in each period. Yet the accomplishment of DTA is to reduce the risk of the investment by truncating the lower tail of any return distribution, i.e. reduce losses. Shouldn't this truncation reduce the risk of the project and alter the risk discount rate? Contingent claims analysis does that and allows a variable risk rate, which is solved in the analysis process in the form of what is referred to as "risk neutral probabilities". These are the probabilities of specific net returns occurring adjusted for risk. A risk free rate is used for discounting to the present. The risk neutral probabilities are used to adjust for risk (Leunberger, Trigeorgis).

Cox, Ross and Rubinstein showed that the value of a financial option can be computed by the construction of a portfolio that replicates the return of the option under any state of nature. An option on a stock, for instance, can be replicated by borrowing funds and buying some of the stock (for a call option) or by lending funds and selling some of the stock (for a put option). Because of arbitrage, you can equivocate both portfolios and derive risk neutral probabilities. This approach is commonly called contingent claims valuation because the valuation of the option is contingent upon the value of the underlying asset.

To apply contingent claims evaluation to real investment analysis, it is necessary to find an asset (or groups of assets) that is correlated with the net return of the investment to be analyzed. This correlated asset has been called a "twin asset". The value of the twin asset is known at the beginning of the investment period but the value of the investment is obviously not known at the beginning since we are estimating it's value. We use the information about changes in value of the twin asset from its starting value to determine the value of the investment. This process is usually an easy task with financial options because those options are derivatives of an underlying asset, but it is often challenging to find a "twin asset" to the net returns of an investment. However, this may be easier in agriculture. Many of the net returns in an agricultural activity are highly correlated with the price of an underlying agricultural commodity.

Contingency Claims Analysis

Real options are a concept. They can be valued using contingency claims analysis. The following example from Trigeorgis shows the approach.

Assume that an investment needs to be valued where two outcomes at the end of the period are possible. The net return will be $180 or the net return will be $60. Either have a 50 percent chance of occurring. The cost of the investment is $104. A twin asset has been located which has a current value of $20 and is expected to generate either $36 or $12 of net return at the end of the period, each equally likely. The risk adjusted discount rate is then 0.20, computed from the twin security as k=(0.5*$36+0.5*$12)/$20-1.=0.20. This investment and the twin security are shown in figure 2.

Figure 2: Decision Tree for an Investment Project (V) and its Twin Asset (S)
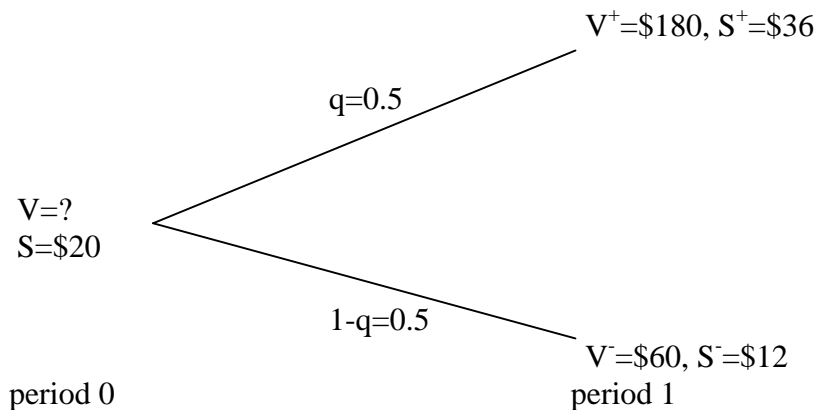
Using traditional DCF techniques the PV of the investment is:

$100 =(0.5*$180+0.5*$60)/(1.20)

The NPV is $100 - $104 = -$4 and the investment should not be made using this criterion.

Using an option-pricing hedging strategy, the firm would be indifferent between the investment and some combination of buying some of the twin security and borrowing some funds. It is necessary to determine how much of the twin security to buy and how much to borrow. If the net return of the investment is $180, then the return from the twin security must be $180 = N*$36-(1+r)*B, where N is the amount of the twin security to buy at the start of the period and B is how much money to borrow at interest rate r. If the net return of the investment is instead only $60, then the return from the twin security must be $60 = N*$12-(1+r)*B. This presents two equations and two unknowns, N and B if the interest rate is set at the riskless rate (because there is no risk in this sure arbtitrage.)

Using more general notation, the two equations become:

$$V^+ = N*S^+-(1+r)*B$$
$$V^- = N*S^--(1+r)*B$$

Solving for N and B produces:

$$N=(V^+-V^-)/(S^+-S^-)$$

And:

$$B=(V^+*S^--V^-*S^+)/((S^+-S^-)*(1+r)) = (N*S^--V^-)/(1+r)$$

The beginning value of the investment can be determined by substituting N & B into the equation V=N*S-B, resulting in

$$V=(p*V^++(1-p)*V^-)/(1+r)$$

Where p=$((1+r)*S-S^-)/(S^+-S^-)$

The expression for p is referred to as the <u>risk-neutral probabilities</u>. Notice that the value of the investment is determined by weighting the net return outcomes by this risk-neutral probability and discounting by the risk-free rate.

Inserting values for this example produces:

$$p=(1.08*\$20-\$12)/(\$36-\$12) = 0.40$$

And

$$V= (0.4*\$180+0.6*\$60)/1.08 = \$100.$$

Notice that the value of the investment is computed to be $100 using both the discounted cash flow approach discounted at the risk-adjusted rate and by using contingent valuation discounted at the risk-free rate. The risk using the contingent valuation approach is composed in the risk-neutral probabilities.

The reason the value of the investments is estimated to be identical using either approach is because no strategic decision was modeled. A simple strategic decision is the option to defer investment. This is the same management decision used in the earlier example from Dixit and Pindyck but now that option value will be computed by contingent claims analysis (which Dixit and Pindyck also do.)

The investment opportunity is assumed to remain open for one year but the cost will increase by the risk free rate from $104 to $112.32. If the return is $180 the second year,

then the option will be exercised for a net return of ($180-$112.32)=$67.68. If the net return is $60 the second year the option will not be excercised for a net return of $0.

Using the contingent valuation formula:

$V=(p*V^++(1-p)*V^-)/(1+r)$

Where $p=((1+r)*S-S^-)/(S^+-S^-)$

Produces an option value of:

$25.07 = (0.4*\$67.68+0.6+\$0)/(1.08)$.

If that option value had been estimated using the actual probabilities and the risk-adjusted discount rate, the option value would have been:

$28.20 = (0.5*\$67.68+0.5*\$0)/(1.20)$.

The discounted cash-flow using the risk-adjusted discount rate over estimated the value of the option.

Strategic Investment Decisions Modeled as Options

Annual net returns estimated for NPV analysis are generally expected values. Around those expected values is a distribution of possible returns. The key to strategic management of investments is that actions can be taken during the investment duration that may truncate or alter the left side of those distributions and reduce the occurrence of downside risk. The value of that truncation is evaluated as a real option.

These strategic decisions might be considered decision nodes. At each decision node, a decision(s) can be made that will influence the future stream of net returns. Some decisions at these nodes may include:
1. Defer Investment
2. Temporarily shut down (and restart)
3. Expand scale of operations
4. Reduce scale of operations
5. Abandon for salvage value, or default during construction
6. Switch use (of inputs or outputs)

Readers should easily think of examples of these decisions in agricultural investments.

Further Readings

Although the investment concepts discussed here can be understood (and modeled) using discrete mathematics, much of the literature defaults to continuous specification. It does not take long reading the literature to come in contact with a Wiener process (Brownian

motion) and Ito's Lemma. That is unfortunate, because most of the concepts can be illustrated with lattice structures and discrete mathematics.

Literature on the Net Present Value model is extensive. Books on NPV in most languages have been written. That is not the case for Real Options, and much of what is available is at the advanced level. It does not appear that many undergraduate business programs teach real options to any extent in investment analysis courses except in a cursory manner. The reason may be that the mathematics can become challenging. None-the-less the concept should be introduced to students and managers.

A classic is the book by Dixit and Pindyck titled Investments Under Uncertainty. Although the concepts of options in investments is well presented, this book is more suitable for the academic economist than the professional engaged in investment analysis. The book by Lenos Trigeorgis titled Real Options is a book for those who wish to engage in using real options approaches in investment analysis. Trigeorgis has numerous short examples and the mathematics is well presented. Since option mathematics is complex a good book to help understand the mathematics at the advanced undergraduate level is the book by Leunberger titled, Investment Science.

The World Wide Web (WWW) is a good source for information. Rather than list specific cites in this article when those cites could easily change, I suggest the reader use a favorite web search engine and enter some of the key words underlined in this article.

Conclusions

This paper reviews some of the recent developments in capital investment analysis and discusses how these may be applicable to investment assessment in agriculture. Since imbedded in most investment decisions are strategic decisions that can be made during the investment period, the value of those strategic decisions should be incorporated into the value assessment of the project in the initial period. Those strategic decisions, such as expanding or contracting the size of the investment, can be modeled as options and valued using the techniques used to value financial options.

Financial options can be valued using contingent claims analysis. The value of the option is contingent upon the value of the underlying asset, and can be valued based upon the changing value of that asset. A capital investment should be valued based upon the stream of annual net returns, which can change from strategic decisions.

Traditional NPV discounts income streams using a risk-adjusted discount rate. Empirically, that risk adjusted discount rate for a firm is estimated from the market price of the stock and debt of the firm. This approach allows the market to value the riskiness of the investments made by the firm. Since many agricultural firms are not publicly traded, it is a challenge to estimate an appropriate risk adjusted-discount rate for those firms.

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Contingent claims analysis would appear to be a solution since the discount rate used then is the risk free discount rate, usually the short-term government rate. Risk is incorporated into option valuation using computed risk-neutral probabilities obtained from a replicating portfolio correlated to the discounted income stream. Essentially what is needed is a portfolio of assets correlated with the cash flow stream. In agriculture commodity prices may be highly correlated with future cash flows. However, if correlated assets to the underlying cash flows are available to compute risk-neutral probabilities, then that information can also be used to compute a risk-adjusted discount rate. The only benefit to contingent claims analysis is that it permits the risk rate to vary depending upon the strategic decision to be made.

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