Employing Real Options Methodology
for Decision Making in Greenhouse Technology

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ABSTRACT

Latest developments in investment analysis offer a number of valuable insights into how to evaluate investment opportunities encountering the weaknesses of net present value criterion. More specific, irreversibility, uncertainty and the choice of timing are conditions that net present value does not include but they alter the investment decision in critical way. Employing contingent claims analysis in tangible investments several assumptions made by discount cash flow method are concerned and better assessment results can be derived. In this work, an attempt is made to apply real options methodology in agricultural investments. Many agricultural investors face a growing uncertainty environment with high sunk investments and net present value criterion has been extensively used that may be lead to incorrect decisions. Both discount cash flow method and real options approach are employed to evaluate the effectiveness of a new technology project under uncertainty returns in agriculture. Discount cash flow approach indicates that the adoption of a new technology project under uncertainty is feasible while real options approach differentiates the results. The corollary is that real options approach can be proved conducive in assessing projects with uncertainty and irreversibility and it can furnish a new way of examining agricultural investment decisions.

Keywords: real options, irreversibility, option value, agriculture, investment, policy.

I. INTRODUCTION

Recent years a lot of changes are taking place in agriculture. Applied agriculture policies following the international trade agreements have changed decision-making in agriculture. Farmers have to act under a very competitive environment with less predictable consequences. A lot of uncertainties and risks about the future returns could arise from several factors such as uncertainty about output prices, yields, input prices, technology, weather conditions, and market conditions. Adoption capital agriculture investments have to evaluated regarding to various sources of uncertainty and risk attitudes. Conventional net present value formulas have been shown to be limited when the conditions of the investment require substantial commitment under uncertainty.

As discussed in Pindyck (1991), Dixit (1992), and Dixit and Pindyck (1994) investment with the above characteristics resemble financial call options. The opportunity to acquire real assets as opposed to financial assets is called a real option (Dixit and Pindyck, 1994). Real options analysis allows making better investment decisions because may incorporate the value of flexibility of an investment into the initial evaluation of that investment. Dixit and Pindyck (1995) claimed that thinking of investments as options changes and elaborate the theory and practice of decision-making about capital investment. Theoretical advances in real options methodology have formulated very rapidly and assimilated in several empirical applications. Real options have been identified and valued in natural resources (Brennan and Schwartz, 1985; Smit, 1997;) and a growing body of literature provides various examples of flexible investment strategies (Myers, 1987; Paddock et al, 1987; Bjerksund and Ekern, 1990; Demers, 1991;

Kemna, 1993; Amram and Kulatilaka (1999); Brennan and Trigeorgis, 2000). A few studies implement real options in agriculture (Purvis, et al., 1995; Ekboir, 1997; Winter-Nelson and Amegbeto, 1998; Price and Wetzstein, 1999; Tegene et al. 1999; Khanna et al., 2000; Isik et al., 2001).

In this paper mainly an attempt is made to elaborate the decision process in agriculture investment by employing elements of the real options methodology. The work consists of two parts: At first, real options approach is discussed and the faulty assumptions of net present value are presented which affect the decision making under uncertainty and irreversibility in agriculture. Then, empirical application for determining the optimal threshold for Greek greenhouse investors when future returns are uncertain has been investigated. The paper concludes with the main results and highlights the usefulness of real options approach to agricultural investments.

II. THE MODEL

Net Present Value (NPV) criterion is used extensively in evaluating an investment opportunity and is based on discount cash flow methodology (Brealey and Myers, 1991; Bierman and Smidt, 1988; Irvin, 1978; Gittinger, 1972; Luehrman, 1998). The typical cost benefit model in agriculture can be represented as a choice between production with or without a specific technology. The choice between adopting a new technology or not can be based on comparison of the incremental investment costs of the new technology I and the present value of its incremental net revenue flow, V under certainty:

$$V = \int_0^\infty e^{-\rho t} E[(P_t Q_{w,t} - C_{w,t}) - (P_t Q_{o,t} - C_{o,t})]dt \tag{1}$$

where ρ is the real discount rate; t is the time period; E is the expectations operator; P is the output price; Q is the output quantity; C is the variable costs of production; and subscripts w and o indicate production with and without the investment respectively. The acceptance rule adopts projects where incremental net revenues are greater or equal to incremental investment costs ($V \geq I$).

Recent developments in investment analysis point out that NPV formulas have shown to be limited when the conditions of irreversibility and uncertainty are present. More specific, NPV rule assumes a fixed scenario in which an investor starts and completes a project and garners a cash flow during some expected lifetime without permitting the investor to react in an uncertain and irreversible environment. Contingent claim analysis offers a range of possibilities to examine: investing today, or waiting and perhaps investing later on when the conditions are more favorable (Dixit and Pindyck, 1994). It allows uncertainty to influence the adoption decision directly and incorporates an extra value into the cost benefit structure. Therefore, the simple NPV rule requires a short of modification. The present value of the expected stream of cash from a project not only must be positive but also to exceed the cost of the project by an amount at least equal to the value of keeping the investment option alive (Dixit and Pindyck, 1994).

Dixit and Pindyck (1995) suggest an optimal investment trigger using the contingent claims analysis that offers a richer framework to evaluate such projects (Smit, 1997). Capital investments or irreversible investment opportunities are like financial call options, therefore a company with an investment opportunity has the option to spend money now or in the future (the exercise price) in return for an asset of some value (the project). The value of the opportunity to invest is described by the two equations, the value of waiting (BR^β) and the value of investing ($R/\rho - K$) (Dixit, 1992) (Figure 1).

$$V(R) = \begin{cases} BR^\beta & \text{if } R \leq H \\ R/\rho - K & \text{if } R \geq H \end{cases} \tag{2}$$

where, R are the expected returns from the investment; B is a parameter equal to $(H - \rho K)/H^\beta$ (Pindyck, 1991); K is the sunk cost of initiating the investment project; ρ is the opportunity cost of capital or a risk-adjusted discount rate.

Dixit (1992) described optimal timing of an investment as a tangency between the value of investing (i_1i_2) and the value of waiting (w_1w_2) to invest. The optimal investment trigger is at H, where the expected returns from initiating the investment are sufficiently high to make it optimal to proceed. To derive the optimal investment rule, the value-matching condition and the smooth-pasting condition are satisfied simultaneously where

$$H = \frac{\beta}{\beta - 1} \rho K \tag{3}$$

where $\beta = \frac{1}{2}\left[1 + \sqrt{1 + \frac{8\rho}{\sigma^2}}\right] \succ 1$ (Dixit, 1992); ρK is the Marsallian trigger (Dixit, 1992).

The parameter β is a function of two known or estimable parameters (ρ and σ^2). As uncertainty about returns from investing increases, β gets smaller and the difference between the Marshallian trigger (M) and the optimal trigger increases. Raising the discount rate increases β and reduces the difference between the M and H.

A simulation Monte Carlo model is used to estimate the variance on the value of investing in new agriculture technology. The value of the opportunity to invest (V) is modeled as a geometric Brownian motion process

$$\frac{dV}{V} = \mu \, dt + \sigma \, dz \tag{4}$$

where σ is the proportional variance parameter and dz is the increment of Wiener process, $z(t)$.
[1]The relationship between dz and dt is given by $dz = \varepsilon_t \sqrt{dt}$ where ε_t has zero mean and unit standard deviation.

The trend (μ) of the geometric Brownian motion process was estimated by $\mu_v \approx \frac{1}{N} \sum_{j=1}^{N}\left[\Delta \ln V_j\right]$

and the variance of the value of the opportunity to invest was estimated by

$\sigma_v \approx \frac{1}{N} \sum_{j=1}^{N}\left[\Delta \ln V_j - \mu_v\right]^2$ (Purvis, et al, 1995). To calculate the statistics μ_v and σ_v from

simulation data, the mean of N simulated log differences investing in t and t+1 was calculated.

The difference between natural logarithms of $V_t{}^2$ and of V_{t+1} gives a discrete estimate of the change in the value of investment opportunity, as occurring over an increment of a geometric Brownian motion process. The estimate of this discrete difference was simulated over 25,000 iterations, in each iteration, estimating equations of present value[3] required n and n+1 draws, respectively, with draw representing an observation of annual returns from investing. The evaluation of variance of the opportunity to invest was used to estimate the optimum investment trigger under uncertainty and irreversibility.

III. GREENHOUSE TECHNOLOGY EVALUATION

Agricultural farmers can met a set of investment choices with attractive incentives. In most cases the applied technology in agriculture has very strict use and the capital investment has irreversible character. A most common paradigm is greenhouse constructions. Several types of greenhouse constructions varying significant in terms of initial investment value, are at the disposal of any farmer, and he is able to select the most appropriate one for his enterprise. All these constructions can be easily classified according to their technical and financial characteristics into broad categories, traditional constructions that are cheap and can be build by farmers and modern expensive constructions can be sold either by local or foreign manufacturers (Tzouramani, et al., 1995).

There is no doubt that decisions on the exact type of greenhouse bear risks and uncertainty and must be considered with much care and awareness. The initial investment cost plays an important role in the investor's decision, as construction and equipment expenses constitute a very significant part of the greenhouse production cost. The economic performance is very important, notably in a world where funds available for agricultural investment are greatly limited. Two typical investment options were evaluated, a modern greenhouse versus a traditional one by applying discount cash flow and real options approach.

Discount cash flow approach under certainty, without considering the stochastic nature of price and yield, the irreversibility of the investment decision, or the possibility to delay the decision was applied and revealed positive results. The NPV was applied for ten years productive life of the investment with 10% discount rate. The NPV is equal to $26,554 and suggests that investment in a modern greenhouse versus a traditional one is feasible. It is important to mention that the project is not feasible (NPV is equal to $-37,613) if the investors deprived the initial subsidy given by the government.

Real options approach is applied utilizing the same as above data in greenhouse enterprises to investigate the role of stochastic factors encounter irreversibility and uncertainty. Monte Carlo simulation was used to determine the mean and the variance of net annual returns of the project. Net annual returns of a modern greenhouse investment versus a traditional one were determined by 15,000 Monte Carlo iterations through @RISK software (Palisade 1992). Yield was modeled as normal distribution and the selling price of tomato was modeled as triangular distribution. Net annual returns [E(R)] have an expected mean $16,298 with a standard deviation $14,559.

The average investment cost of a modern greenhouse for 1996-97 was about $176,667. The annuity is calculated through long-run loan, of 10 years' duration and rate of interest 10%. The

annual amount of outlay for the investment can be reduced by 50%, if the investment project benefits from 2328/91 EU Regulation. The Marshallian trigger (M) is $8,571 and $22,974 with and without subsidy of the initial cost respectively (Table 1). The net annual returns of the investment have to be 1.9526 times greater of the corresponding Marshallian trigger, which means that the net annual returns have to be greater than $16,736. Therefore according to the NPV criterion the investment in a modern greenhouse versus a traditional one is feasible, however under the conditions of irreversibility and uncertainty the investment is not feasible. The simulated expected annual returns [E(R)] have to be greater than $16,736 according to optimal investment trigger (H) while they are equal to $16,298. Conclusively, real options procedure revealed that [H>E(R)], the investment in new technology should be recommended to postpone, to keep alive the option of investment in new agriculture technology.

IV. CONCLUSIONS

The application of discount cash flow approach in agriculture is not always the appropriate way to decide if an investment project is feasible or not as uncertainty and irreversible conditions significantly influence the net income. Real options approach can be proved as a more powerful method since uncertain and irreversible environment can be better encounter. In this work an attempt was made to employ both methods in agricultural greenhouse enterprises and to compare the results. Considering price and yield uncertainty, empirical results revealed that according to the NPV criterion, a new technology investment project versus a traditional one is feasible. However, the application of real options approach does not generate the same results and this obviously indicates the need for elaborating the NPV criterion in agricultural investments. Thus, while the NPV criterion is positive, the real option approach rejects the new technology investment project and suggests postponing it.

Conclusively, the implementation of real options approach will be beneficial for agriculture and generally for sectors that are face high degree of uncertainty. The real options method shed new light on assessing agricultural projects and contributes significantly in casting the feasibility of investment opportunities, particularly today where investors face a high competitive environment.

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FIGURE 1

Optimal investment trigger
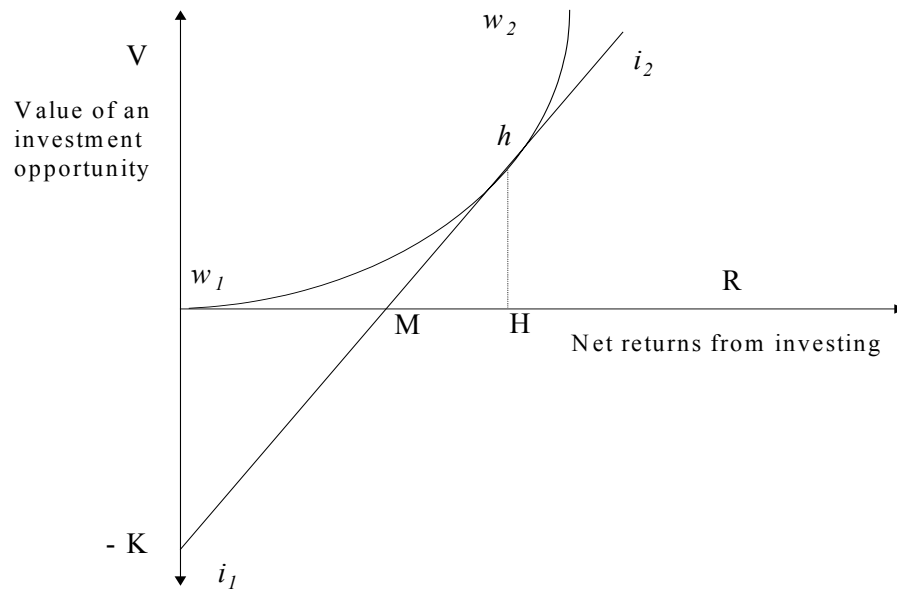
Source: Dixit, 1992

TABLE 1

Results for equations value of investing and value of waiting

	Northern Greece	
	With subsidy	Without subsidy
σ^2	0,09294815	0,09294815
β	2,0497539	2,0497539
β/β-1	1,95260418	1,95260418
B	8.769972 E08	3.115282 E08
ρ	10%	10%
ρ'	19,53%	19,53%
M	8,571	22,974
H	16,736	44,860
Q	52,000	139,833
K	65,660	176,565
H-M	8,165	21,885
ρV(R)	8,165	21,885

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[1] The relationship between dz and dt is given by $dz = \varepsilon_t \sqrt{dt}$ where ε_t has zero mean and unit standard deviation.

[2] According to Purvis et al. (1996) the present value of the investment is converted to the value of the equivalent opportunity to invest in perpetuity

$$V_t = \frac{\left[\dfrac{\rho}{1 - \left(\dfrac{1}{(1+\rho)^{n-t}}\right)} \cdot PV_t\right]}{\rho} \qquad V_{t+1} = \frac{\left[\dfrac{\rho}{1 - \left(\dfrac{1}{(1+\rho)^{n-t-1}}\right)} \cdot PV_{t+1}\right]}{\rho}.$$ The numerator of equations gives the annuity required to generate a stream benefits equivalent to the present value of the investment. Dividing this annuity by the discount rate converts the stream of benefits to the present value.

[3] The present value of the investment at time t and an instant later at t+1, are defined respectively, as

$$PV_t = \sum_{t=0}^{n} \frac{R_{t+i}}{(1+\rho)^i} \text{ and } PV_{t+1} = \sum_{t=1}^{n+1} \frac{R_{t+i}}{(1+\rho)^{i-1}}.$$

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