Employing real options methodology to evaluate the organic agriculture scheme in Greece

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Abstract
New policy measures have studied and introduced to transform Europe’s agriculture into a more environmental friendly agriculture. Adopting environmental friendly production systems involves risk and uncertainty and to overcome this well designed policy schemes are required. This study attempts to examine the effects of income variability upon the decision on adopting or not environmental friendly production systems in order to evaluate the organic financial incentives to farmers by introducing the real options methodology. The real options procedure revealed that the investment in environmental friendly production systems must be postponed and the option of investment must be kept alive until the expected returns are high enough to offset the risk and uncertainty. Therefore, policy makers have to reconsider the current financial incentives if they want faster adoption of sustainable production systems.

Keywords: real options, uncertainty, organic agriculture, subsidies

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1 Introduction

Europe’s policy makers dispute on the future course of agriculture and they try to balance the farmers and public counterclamns. Agricultural policy makers are pressed by the public to protect the environment while on the other hand they are pressed by farmers to adopt and maintain various supporting schemes. Agriculture proved very successful in boosting food production but sometimes at the expenses of the environment. Thus, European policy makers have tried to introduce new more integrated policy measures to accomplish both environment and farm income objectives. Major agri-environmental programs have been tried and tested in the EU since the mid-1980s and special attention has been given to the environmentally sensitive areas scheme, the countryside stewardship scheme, the organic agriculture schemes, the integrated farming systems initiatives and the nitrate sensitive areas scheme.

Nevertheless, farmers face continuous changes such as a new reformed farming industry (Boehlje & Lins, 1998) a globalized and an increasingly competitive market (Harwood et al., 1999) leading to a high uncertain economic environment. In this new era, investing in agriculture turns to be a very risky business face engulfed by many constraints. Farmers will decide to invest in friendly environmental technologies and implement new practices only if the investment will be provided a profitable one. Therefore, it is required a thorough examination of the impact of adopting environmental friendly farming systems on the farmer decision. In this respect, defining the optimal timing for technological adoption and the effectiveness of environmental policies will provide essential information to the farmers and policy makers.

Farmers constantly face questions such as: whether to invest in a new production system with more environmentally sound farming practices or to continue the conventional farming without new types of risks and uncertainties. Although, the most common way to evaluate a new farming system or an investment opportunity is to use traditional discounted cash flow methods (Gittinger, 1986). Several researchers argue that net present value (NPV) does not work properly under uncertain conditions (Dixit & Pindyck, 1994; Collins & Hanf, 1998; Arman & Kutalika, 1999). To make intelligent investment choices, investors need to consider the value of keeping their options open and include the impact of various sources of uncertainty and risk attitudes. For the economic evaluation, contingent claim analysis will be used to define the optimal investment threshold under the major risks and uncertainties that farmers face from the adoption of environmental friendly production systems.

As discussed in Pindyck (1991), Dixit (1992), and Dixit & Pindyck (1994) investment with the technical and economic uncertainty resembles to financial call options. Dixit & Pindyck (1995) claimed that thinking of investments as options changes and elaborates the theory and practice of decision-making about capital investment. Real options analysis allows making better investment decisions as the value of flexibility of an investment into the initial evaluation of that investment can be incorporated. Theoretical advances in real options methodology have been rapidly formulated and assimilated in several empirical applications. Real options have been identified and valued in natural resources (Brennan & Schwartz, 1985) and a growing body of literature provides various examples of flexible investment strategies (Myers, 1987; Paddock et al., 1987; Bjerkusund & Ekern, 1990; Demers, 1991; Kemna, 1993; Amram & Kutalika 1999; Brennan & Trigeorgis, 2000).

Nevertheless, only a few studies implement real options in agriculture. Purvis, et al., (1995) try to examine the technology adoption of a free-stall dairy housing under irreversibility and uncertainty and its implications in the design of environmental policies. Ekboir, (1997) through a stochastic dynamic model analyzes the investment decisions of an individual farmer under risk in the presence of irreversibility and technical change. Winter-Nelson & Amegbeto, (1998) present a model of investment under uncertainty to analyze the effect of
variability of prices on the decision to invest in conservation with application to terrace construction. Price & Wetzstein, (1999) develop a model for determining optimal entry and exit thresholds for investment in irrigation systems when there is given irreversibility and uncertain returns with price and yield as stochastic variables. Tegene et al., (1999) present a model for the investment decision to convert farmland to urban as an irreversible investment under uncertainty when use of this land is restricted by government policies so as to protect the environment. Khanna et al., (2000) analyze the impact of price uncertainty and expectations of declining fixed costs on the optimal timing in site-specific crop management.

In this paper an attempt is made to elaborate the decision process in evaluating environmental friendly production systems by employing elements of the real options methodology. It is also attempted to assess the effectiveness of investment on organic farming. Two typical investment options have been evaluated, an organic cultivation versus a conventional one. More specific we try to evaluate organic currants and organic lemons cultivation. This study focuses on the impact of returns variability and the used policy tools on farmers’ decision on adopting for non-conventional production systems. The framework of contingent claims analysis is more appropriate form of analysis in order to examine the investment profitability under risk and uncertainty and also to investigate the needs for the appropriate agri-environmental policy tools. The work consists of the following parts: first, the theoretical model and the simulation model are presented. Then, data and results of the empirical application for determining the optimal threshold for Greek organic investors are presented. Ultimately, the paper highlights the importance of incorporating the real options approach in agricultural investment evaluations and the usefulness for policy implications.

2 The theoretical model

Based on discount cash flow methodology, the net present value (NPV) criterion is used extensively in evaluating an investment opportunity (Brealey & Myers, 1991; Luehrman, 1998). The typical cost benefit model in agriculture can be represented as a choice between production “with” or “without” a specific technology. Adoption of environmental friendly production systems such as organic or integrated farming system by farmers can be considered as an investment. The choice between adopting friendly to the environment production systems or not can be based on the comparison of the incremental investment costs of the new technology $I$ and the present value of its incremental net revenue flow $V$, under certainty:

$$V = \int_{0}^{\infty} e^{-\rho t} E[(P_{f,t}Q_{f,t} + S_{f,t} - C_{f,t}) - (P_{c,t}Q_{c,t} - C_{c,t})]dt$$

(1)

where $\rho$ 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; $S$ is the subsidy; and subscripts $c$ and $f$ indicate conventional production and friendly to the environment production respectively. The acceptance rule accepts projects when 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 (Dixit & Pindyck, 1994). More specifically, 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. The standard net present value model does not allow uncertainty of returns to influence the adoption decision directly, but returns variability will affect the value of option to invest. 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 & Pindyck, 1994).
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 must not only 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 & Pindyck, 1994). Taking option values into account, one would invest in a project only if \( V \) meets or exceeds \( I \) plus the value of option to invest in the future, \( F(V) \). Under certainty, the value of option to invest in the future is equal to zero, so the decision would be not reversed if it were profitable. Under uncertainty, the value of option to invest in the future can rise so the optimal time to invest would change.

Dixit & Pindyck (1995) suggest an optimal investment trigger using the contingent claims analysis that offers a richer framework to evaluate such projects. 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). To derive \( F(V) \), we assume that the incremental net present value of the project \( V_t \), is non stationary, following a geometric Brownian motion

\[
\frac{dV}{V} = \mu \, dt + \sigma \, dz \tag{2}
\]

where \( \mu \) is the proportional growth rate parameter, \( \sigma \) is the proportional variance parameter and \( dz \) is the increment of Wiener process, \( z(t) \). The relationship between \( dz \) and \( dt \) is given by \( dz = \varepsilon \sqrt{dt} \) where \( \varepsilon \) has zero mean and unit standard deviation. Therefore, changes in \( V \) over time are a function of a known proportional growth rate parameter \( \mu \), and \( \sigma \), which is governed by the increment of Wiener process, \( dz \) (Dixit & Pindyck, 1994).

The value of the investment opportunity \( F(V) \) is equal to max of its expected present value when the payoff from investing at time \( t \) is \( V_t - I \):

\[
F(V) = \max \left( E \left[ (V_T - I) e^{-\rho T} \right] \right) \tag{3}
\]

where \( E \) is the expectation, \( T \) is the unknown future time that the investment is made, \( \rho \) is a discount rate and \( \mu < \rho \) and the maximization is subject to equation (2) for \( V \). Under uncertainty \( (\sigma > 0) \), the optimal to invest \( I \) in return for an asset worth \( V \) is a critical value \( \bar{V} \) such that \( V \geq \bar{V} \). The critical value \( \bar{V} \) is the full cost of making the investment, direct cost plus opportunity cost \((\bar{V} = I + F(V))\).

According to Dixit & Pindyck (1994) the optimal investment rule demonstrate that

\[
F(V) = AV^\beta \tag{4}
\]

where,

\[
A = \frac{(V^* - I)}{(V^*)^\beta} \tag{5}
\]

\[
V^* = \frac{\beta}{\beta - 1} I \tag{6}
\]

\[
\beta = \frac{1}{2} - \frac{\mu}{\sigma^2} + \sqrt{\left( \frac{\mu}{\sigma^2} - \frac{1}{2} \right)^2 + 2\frac{\rho}{\sigma^2}} \tag{7}
\]
The parameter $\beta$ is a function of three known or estimable parameters ($\mu$, $\rho$ and $\sigma^2$). As uncertainty about returns from investing increases, $\beta$ gets smaller and the difference between $I$ and $V^*$ increases. Raising the discount rate increases $\beta$ and reduces the difference between $I$ and $V^*$.

3 Simulations

A simulation Monte Carlo model is used to estimate the growth rate and the variance on the value of investing in organic agriculture. The incremental net present value of the investment ($V_t$) is non-stationary and following a geometric Brownian motion (see equation 2). It is modeled as the discounted sum of random draws from the distribution of expected returns from investing ($R$), annualized and projected into perpetuity. More specifically, the opportunity to invest for time $t$ ($V_t$) is equal to equation (8) and for a period hence is ($V_{t+1}$) is equal to equation (9) (Dixit & Pindyck, 1994; Purvis et al., 1995).

$$V_t = \left(1 - \frac{\rho}{\ln(1+\rho)^n - t}\right)^{PV_t}$$  \hspace{1cm} (8)

$$V_{t+1} = \left(1 - \frac{\rho}{\ln(1+\rho)^{n+1} - t - 1}\right)^{PV_{t+1}}$$  \hspace{1cm} (9)

where, $PV_t = \sum_{i=0}^{n} \frac{R_{t+i}}{(1+\rho)^i}$, $PV_{t+1} = \sum_{i=1}^{n+1} \frac{R_{t+i}}{(1+\rho)^{i-1}}$, $R$= expected returns from investing, $\rho$ is a discount rate, $t$ is the time period of the investment.

The first difference of the natural log of $V_t$ is calculated to estimate the average growth rate ($\mu_v$) and the variance ($\sigma_v$) of the growth rate. The trend ($\mu_v$) of the geometric Brownian motion process was estimated by $\mu_v \approx \frac{1}{N} \sum_{j=1}^{N} \ln V_j$ and the variance of the value of the opportunity to invest was estimated by $\sigma_v \approx \frac{1}{N} \sum_{j=1}^{N} \left[ \ln V_j - \mu_v \right]^2$.

To calculate the statistics $\mu_v$ and $\sigma_v$ from simulation data, the mean of $N$ simulated log differences investing in $t$ and $t+1$ was calculated. The difference between natural logarithms of $V_t$ 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 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.

4 Data

European trade and growth of organic products started in 1993 following the implementation of EU Regulation 2091/91 for organic crop production and with EC Regulation 1804/99 for the organic livestock sector. Organic production methods covered just over 4,4 million hectares by the end of 1999 in the EU, which means that nearly 3.51% of the agricultural land in the EU as a whole was farmed organically. In Greece, up to the mid of 1990s the
The Greek organic sector has had a rapid growth, since the demand for healthy products with fewer chemicals is showing an upward trend; premium prices for organic produce offer an attractive alternative to farmers facing declining producer prices (Fotopoulos & Pantzios, 1998). The Greek Organic Aid Scheme provides financial assistance to farmers, for five sequence years on land undergoing conversion.

Farmers face a dilemma should they start applying environmental friendly production systems or should they continue a conventional production system? Typical investment options were evaluated, organic currants cultivation and lemons cultivation versus the corresponding conventional. When environmental friendly production systems are employed there is an extra cost for the farmer, the sunk cost. This cost includes the lost returns from the transition period, the extra technical support cost for the applied new technology and the farmers’ education-supporting cost. The decreased yield of cultivation and the price without premium for transition period are significant factors that prevent farmers from investing on organic production. The sunk cost for organic currants and lemons were estimated to be equal to 112€ and 135€ for a 0.1ha respectively (Table 1).

Annual operating costs for organic cultivation cover organic fertilizers, labor, ecology plant protection, irrigation, marketing and transportation costs (Tzouramani et al., 2004). Operating costs for organic and conventional cultivation were estimated through a farm survey. This survey took place in Western of Greece, a major prefecture of organics, and was conducted by the Agricultural Economics and Policy Research Institute (Tzouramani et al., 2004). The expected returns for each producing system (organic and conventional) were calculated and compared. The main factors that affect the expected returns for organic cultivations are price, yield and subsidies either from Regulation (EC) 2078/93 for environmental protection or from the price support regime for currants. Yield and price uncertainties were modeled as stochastic variables, yield was modeled as normal distribution and the selling price was modeled as a triangular distribution Table 2 and Table 3. Simulated distributions of expected returns developed in an @RISK environment (Palisade, 2000). Monte Carlo simulation was used to determine the mean and the variance of net annual returns of the project. Net annual returns of organic cultivation versus a conventional one were determined by 25,000 Monte Carlo iterations. Net annual returns [E(R)] fitted in a BestFit environment (Palisade, 2000) that follow a LogNormal distribution with an expected mean equal to 9,05€ with a standard deviation 0,028€ for lemons. Net annual returns for currants follow a LogNormal distribution with an expected mean equal to 8,749€ and standard deviation 0,023€.

5 Results

Simulation results estimate the log of the variance and the parameters on the value of opportunity to invest in organic cultivations. Simulations were used to derive the parameters, $\mu_v$ and $\sigma_v$, of the growth rate for calculating the optimal investment trigger under uncertainty. The annual sunk costs for investing on organic cultivations were estimated to 34€ for lemons and 26 € for currants. The net expected annual returns of the investment on organic currants have to be 1.366 times greater of the corresponding annual sunk cost, and 1,379 times for lemons. For 5 years project life and with discount rate 5%, the optimal investment trigger ($V^*$) for organic cultivation of currants is equal to 35€ and for lemons is equal to 48€ (equation 6). This means that the expected returns from investing in organic cultivation are lower than the optimal investment trigger [$V^*>E(R)$].

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3 According to Dixit, (1992), the present value of sunk cost (or the Marsalian trigger) is equal to the annuity, $PV = CA \left[ \frac{1 - (1 + r)^{-N}}{r} \right]$, assuming a loan of 5 years' duration with a 5% rate of interest.

4 Following the EC Regulation for supporting organic agriculture with extra payments for years, we applied the same period for life span of the project.
Real options procedure revealed that the investment in organic cultivation must be postponed and the option of investment must be kept alive. This means that the potential returns from organic technology are not high enough to offset the risk and uncertainty of this production system. Therefore, policy makers have to increase the current financial incentives for organic cultivations in order to compensate the risk and uncertainty. To induce adoption, the mean subsidy from 75€/0.1ha for currants and 76€/0.1ha for lemons has to increase with the option value. This means that the difference between the optimal value to invest \( V^* \) and the sunk cost, 9€/0.1ha for currants and 13€/0.1ha for lemons have to be added to the current supporting scheme in order to compensate the profit loss for adopting the organic farming system. Therefore, the total subsidy for organic currants have to be 84€/0.1ha and 89€/0.1ha for lemons.

6 Conclusions

In this work, an attempt was made to employ a real options approach to evaluate the effectiveness of environmental friendly production systems and especially the organic scheme in Greece. The general implication from this empirical analysis is that risk and uncertainty play an important role in farmers' decision to adopt a new organic production system. Empirical results reveal that the adoption of organic farming system versus conventional is not advisable. The best strategy for farmers is to postpone organic agriculture and to keep alive the option of adoption it. The value for the opportunity to invest in organic technology is not compensated by the expected returns of the new farming system. As uncertainty about returns from investing increases, the value of the investment opportunity increases thus it is worth postponing adoption. Moreover, the results indicate that the adoption of environmentally friendly production systems have significant constraints such as production risk and uncertainty. Policy makers in order to protect the environment, additional financial incentives are needed. New financial incentives could balance the difference between the optimal investment trigger and the sunk cost. Conclusively, real options approach can prove a very useful tool in investment evaluations since uncertain and irreversible environment can be better encountered.

Literature


### Table 1: Sunk cost and variable cost for currants and lemons

<table>
<thead>
<tr>
<th></th>
<th>Currants</th>
<th></th>
<th>Lemons</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Organic</td>
<td>Conventional</td>
<td>Organic</td>
<td>Conventional</td>
</tr>
<tr>
<td>Annual Sunk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td>112</td>
<td>-</td>
<td>112</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable cost</td>
<td>528</td>
<td>253</td>
<td>524</td>
<td>344</td>
</tr>
</tbody>
</table>

### Table 2: Triangular distributions for price parameters (€/kgr)

<table>
<thead>
<tr>
<th></th>
<th>Minimum price</th>
<th>Mean price</th>
<th>Maximum price</th>
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</thead>
<tbody>
<tr>
<td>Currants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic</td>
<td>0.58</td>
<td>0.99</td>
<td>1.17</td>
</tr>
<tr>
<td>Conventional</td>
<td>0.59</td>
<td>0.70</td>
<td>0.9</td>
</tr>
<tr>
<td>Lemons</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic</td>
<td>0.16</td>
<td>0.22</td>
<td>0.30</td>
</tr>
<tr>
<td>Conventional</td>
<td>0.12</td>
<td>0.20</td>
<td>0.21</td>
</tr>
</tbody>
</table>

### Table 3: Normal distributions for yield parameters

<table>
<thead>
<tr>
<th></th>
<th>Mean yield (kgr/0.1ha)</th>
<th>Standard deviation yield (kgr/0.1ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic</td>
<td>283.01</td>
<td>124.23</td>
</tr>
<tr>
<td>Conventional</td>
<td>287.97</td>
<td>111.75</td>
</tr>
<tr>
<td>Lemons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic</td>
<td>2005.74</td>
<td>658.78</td>
</tr>
<tr>
<td>Conventional</td>
<td>1640.66</td>
<td>907.89</td>
</tr>
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</table>

### Table 4: Parameters for value of investment opportunity, value of waiting and subsidies

<table>
<thead>
<tr>
<th></th>
<th>Currants</th>
<th></th>
<th>Lemons</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma^2$</td>
<td>0.1289</td>
<td>0.1309</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B$</td>
<td>3.73</td>
<td>3.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta/\beta-1$</td>
<td>1.366</td>
<td>1.379</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho$</td>
<td>5%</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho'$</td>
<td>14.75%</td>
<td>14.87%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>26</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H$</td>
<td>35</td>
<td>48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H-M$</td>
<td>9</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extra payment for subsidies</td>
<td>9€/0.1ha</td>
<td>13€/0.1ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing Bio-Subsidy</td>
<td>75€/0.1ha</td>
<td>76€/0.1ha</td>
<td></td>
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</tr>
<tr>
<td>Total new subsidy</td>
<td>84€/0.1ha</td>
<td>89€/0.1ha</td>
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</tbody>
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