Assessing economic incentives for dairy sheep farmers: A real options approach

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Abstract— **New policy measures have been introduced to transform Greece's agriculture into a more modern and environmentally friendly agriculture. Adopting new technology and environmentally friendly production systems involves risk and uncertainty, which in turn stress the need for well designed policy schemes. This study attempts to examine the effects of income variability upon the decision to adopt new technology and environmentally friendly production systems by introducing the real options analysis to dairy sheep farming in Greece. The real options procedure revealed that the investment in new technology in dairy sheep farms under organic scheme is profitable. Attractive economic incentives that are offered by the applied agricultural policy to young farmers compensate for the risk and uncertainty of the activity.**

Keywords— **agricultural policy, organic sheep farming, real options**

I. INTRODUCTION

Sheep farming is one of the most important agricultural activities in Greece, since its share in the total agricultural production value and in the total animal production value, is 15% and 45%, respectively. Furthermore, its contribution to the total milk production is 34.7% and to the total meat production 16.6% [1]. Sheep farming provides income to thousands of families and it contributes highly to regional development especially in isolated and less favored areas. These areas usually have poor soil quality and lack infrastructure making it difficult for other dynamic agricultural activities to prosper. The majority of sheep farms in Greece produce both milk and meat. Approximately 56.8% of the total gross revenue comes from milk production, while the remaining 43.2% comes from meat production [2]. It should also be noted that the abundance of pastureland in semi-mountainous and mountainous areas provides a fertile ground for further expansion of the activity.

The majority of sheep farms are small, not-intensive, family farms, with a high degree of diversification in terms of herd size, capital, productivity etc. The annual cost of equipment and buildings is low, as the majority of farms are less capital-intensive. Nevertheless, in the last few years, there is a trend of establishing new, modern and intensive sheep farms in lowland areas, which produce forage and grains to cover whole or part of the animal needs and have greater amount of invested capital [3].

The productive system of sheep farming in the mountainous areas of Greece is considered to be very close to that of organic sheep farming. This fact, gives a competitive advantage to the Greek sheep farmers against their European rivals. Indeed, there is a considerable rise of organic sheep farming in Greece. During the 2002-2006 period, the number of organically bred sheep experienced a rise of about 260%, representing the 2.9% of the total sheep population in Greece and the 9% of the organic sheep population in E.U. [4].

The importance of sheep farming in Greece, the restructuring of the agricultural sector and the increasing demand for feta cheese and other sheep farming products, justify the need for development of the sector. In this sense, policy makers provide economic incentives for the establishment and the modernization of sheep farms. The high cost of the initial investment is a common inhibitory factor for the development of both organic and conventional sheep farming. Producers can benefit from the national investment incentives law and especially from the European rural development programs to overcome this difficulty. These programs offer a subsidy that ranges between 40% to 60% of the initial investment cost (buildings, equipment, animal capital etc). The percentage is higher for young farmers and in mountainous and less-favoured areas [5].

In this paper an attempt is made to evaluate the establishment of a modern dairy sheep farm in the region of Macedonia, by employing elements of the real options methodology. Two typical investment options have been evaluated, organic dairy sheep farming and conventional dairy sheep farming. To conduct the analysis we have assumed a herd size of 200 productive ewes, which is a common herd size in Greece. This study focuses on the impact of returns variability and of the available policy tools on farmers' decision on adopting new technology and non-conventional production systems. The framework of real options analysis is a more appropriate form of analysis in order to examine the investment profitability under risk and uncertainty and investigate the appropriate agricultural policy tools as well. The work consists of the following parts. First, the theoretical model and the simulation model are presented. Data and results of the empirical application to determine the optimal threshold for Greek dairy farmer investors are then presented. Finally, the paper highlights the importance of incorporating the real options approach in agricultural investment evaluations and the usefulness for policy implications.

II. MATERIALS AND METHODS

A. Methodology

The Net Present Value (NPV) criterion is used extensively in evaluating an investment opportunity and is based on discount cash flow methodology [6, 7, 8]. The typical cost benefit model in agriculture can be represented as a choice between adopting a new technology or not. The adoption of a project can be based on comparison of the investment costs of the new technology *I* to the present value of its net revenue flow, *V* under certainty:

$$V = \int_0^\infty e^{-\rho t} E[(P_t Q_t - C_t + S_t)]dt \qquad (1)$$

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; S is subsidies. The project is adopted if net revenues are greater or equal to investment costs (V ≥ *I*).

Recent developments in investment analysis point out that the adequacy of NPV formulas appear to be limited when the conditions of irreversibility and uncertainty are present. More specifically, the NPV rule assumes a fixed scenario in which an investor starts and completes a project and garners a cash flow during an expected lifetime without allowing the investor to react in an uncertain and irreversible environment. On the other hand, real options analysis offers a range of possibilities to examine: investing today, or waiting and perhaps investing later on when the conditions are more [9]. 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 has to be positive but it should also exceed the cost of the project by an amount at least equal to the value of keeping the investment option alive [9]. Taking option values into account, one would invest in a project only if V_t meets or exceeds *I* plus the value of option to invest in the future, F(V).

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 [10] and a growing body of literature provides various examples of flexible investment strategies [11, 12, 13, 14, 15, 16, 17]. A few studies, also, implement real options in agriculture. Among them, Purvis, *et al.,* [18] 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, [19] 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, [20] present a model of investment under uncertainty to analyze the effect of the variability of prices on the decision to invest in conservation with application to terrace construction. Price & Wetzstein, [21] develop a model for determining optimal entry and exit thresholds for investments in irrigation systems when irreversibility and uncertain returns are given, with price and yield as stochastic variables. Khanna *et al.,* [22] analyze the impact of price uncertainty and expectations of declining fixed costs on the optimal timing in site-specific crop management. Hyde *et al.* [23] present the optimal investment in an automatic milking system. Tauer [24] tried to find when to get in and out of dairy farming and Rahim *et al.* [25] tried to analyze farmers' economic incentives for abandoning or expanding gum Arabic production.

Dixit and Pindyck [26] suggest that 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/ñ-K) [27].

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

where, R equals the expected uncertain returns from the investment; B is a parameter equal to $(H - \rho K)/H^{\beta}$ [28]; K is the sunk cost of initiating the investment project; ρ is the opportunity cost of capital or a risk-adjusted discount rate.

Dixit [27] described optimal timing of an investment as a tangency between the value of investing and the value of waiting 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. The optimal investment derives from the real options analysis, if the value-matching condition and the smooth-pasting condition are simultaneously satisfied [27]

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

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

The parameter β is a function of two known or estimable parameters (ρ and σ^2). As uncertainty of 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 Marshallian trigger (M) and the optimal investment trigger (H).

A Monte Carlo simulation model is used to estimate the variance of the value of investing in new dairy sheep 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, $z(t)$. The relationship between dz and dt is given by $dz = \varepsilon_t \sqrt{dt}$ where ε_t has zero mean and unit standard deviation. Therefore, changes in V over time are a function of a known proportional growth rate parameter μ, and σ, which is governed by the increment of Weiner process, dz [9]. 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 estimated by equation (5) and for a period hence (V_{t+1}) is estimated by equation (6) [9, 18].

$$V_t = \frac{\left[\frac{\rho}{1 - \left(\frac{1}{(1+\rho)^{n-t}}\right)} PV_t\right]}{\rho} \tag{5}$$

$$V_{t+1} = \frac{\left[\frac{\rho}{1 - \left(\frac{1}{(1+\rho)^{n-t-1}}\right)} PV_{t+1}\right]}{\rho} \tag{6}$$

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

R= expected returns from investing, ρ is a discount rate, t is the time period of the investment.

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 $\sigma_v \approx \frac{1}{N}\sum_{j=1}^{N}\left[\Delta \ln V_j - \mu_v\right]^2$. 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 and of V_{t+1} gives a discrete estimate of the change in the value of the investment opportunity, as occurring over an increment of a geometric Brownian motion process. The estimate of this discrete difference was simulated over 10,000 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 and irreversibility.

B. Data

The annual operating cost (200 productive ewes) for both organic and conventional sheep farming is presented in Table 1. To build the annual operating cost, we have used the deterministic enterprise budgets evaluated by Tzouramani *et al.* [29]. The data used for the deterministic enterprise budgets comes from 24 selected farms in the region of Macedonia and is part of a broader data collection survey on organic and conventional sheep farming in North Greece, which is still in progress [30]. Following Kerselaers *et al.* [31], Lien *et al.* [32] and Ribera *et al.* [33], the data was supplemented with information from the literature and expert knowledge [34, 35, 2, 36, 1].

The main factors that affect the expected returns of dairy sheep farming are milk price and yield. Milk yield and price uncertainties were modeled as stochastic variables. In the case of the gross production value of meat, the uncertainty arises mainly from the fluctuation of price, which is incorporated through the use of a stochastic price variable. The gross production value from ewe meat (non-productive ewes) contributes less to the total gross production value of the farm. Moreover, the replacement rate of ewes is common between farms while the market price of ewe meat is almost stable. Therefore, the uncertainty that comes from the fluctuation of yield and price of ewe meat is not considered in this study. It should also be noted that feed requirements are recalculated as the milk yield is simulated [37].

In this study we have used the milk yield and price distributions estimated by Tzouramani *et al*. [29]. For conventional milk the above distributions were built using historical data (1999-2003) from 22 farms from the Greek FADN sample, in the region of Macedonia. The yield and price distributions for conventional milk are normal. The stochastic milk yield and milk price variables were simulated by 1,000 Monte Carlo iterations. Hypothesis tests were performed to determine whether the simulated stochastic variables reproduced the detrended historical data. The performed tests failed to reject the null hypothesis that the simulated means and variances are statistically equal to the detrended historical data at a 95% confidence level. In addition, milk yield and price data were tested and no correlation between them appeared.

Milk yield and price distributions for organic farming are represented by Triangle distributions, due to lack of historical data [29]. The maximum, minimum and mode milk yield of organic sheep farming is 135kg, 50kg and 84.4kg respectively, while the minimum, maximum and mode for milk price are 0.75€, 1.1€ and 0.91€ respectively. Lamb meat prices for organic farming, as well as lamb meat price for conventional farming are also stochastic and are represented using the Triangle Distribution.

For organic lamb meat price, the minimum, maximum and mode are 3.5€, 5.5€ and 4.5€ respectively and for conventional meat price 3€, 5€ and 4.1€.

Table 1 Annual Operating Cost of the Flock for Conventional and Organic Sheep Farming

	Conventional		**Organic**	
	€	**% of Total Cost**	**€**	**% of Total Cost**
Land	640	*2.37*	1,082	*5.14*
Labour	6,024	*22.28*	7,962	*3781*
Variable Cost	19,946	*73.79*	11,748	*55.79*
Feed Cost	17,676	*65.39*	10,018	*47.58*
Purchased Hay	313	*1.16*	3,506	*16.65*
Purchased Corn	3,798	*14.05*	186	*0.88*
Other Purchased Concentrates (Grains and Milk Replacers)	445	*1.65*	454	*2.16*
Produced Grains	1,352	*5.00*	1,578	*7.49*
Produced Hay	462	*1.71*	2,532	*12.03*
Salt, Mineral etc.	326	*1.21*	88	*0.42*
Other*	227	*0.84*	2,278	*10.82*
Variable Capital Interest	422	*1.56*	264	*1.25*
TOTAL OPERATING COST	27,032	*100.00*	21,056	*100.00*

* Veterinary and medicines, Fuels, Lubricants, Water, Electricity, Certification cost etc.

The above stochastic variables were simulated by 1,000 Monte Carlo iterations.

Table 2 Initial Investment for organic and conventional farming

	Value (€)	
A. Buildings*		
1. Stable (590 m^2)	73,000	
Resting Area (450m^2)	45,000	
Milking Area (140m^2)	28,000	
2. Barn (150m^2)	13,500	
Total	86,500	
B. Equipment*		
1. Milking Machine	28,000	
2. Mill and Mixer	13,000	
3. Troughs (14)	2,800	
4. Waterers (14)	700	
5. Others	2920	
Total	47,420	
C. Animal Capital	**Organic**	**Conventional**
1. Ewes (200)	24,000	30,000
2. Rams (13)	1,755	2,145
Total	25,755	32,145
TOTAL	**159,675**	**166,065**

* We assume that the initial investment in buildings and equipment is common in conventional and in organic sheep farming

The necessary information for the estimation of the initial investment in both organic and conventional sheep farming was obtained through interviews with experts in the field (agriculturalists and entrepreneurs). The cost of the initial investment is described in Table 2 and it refers to a typical modern farm. The animal capital consists of 200 productive ewes and 13 rams. The initial investment includes the milking machine and the necessary equipment for the preparation of the ration. In this analysis we have assumed that the stable includes a resting and a milking area and is of prefabricated metallic structure, which is economical and cost effective. We have also assumed that the farm owns a barn for the storage of fodder. It should also be noted that in the case of organic farming the value of animal capital is lower as the flock consists of native races that have low milk production but are resilient to diseases and adaptive to their environment.

III. RESULTS

The initial investment cost plays an important role in the investor's decision. The economic performance is very important, especially in a world where funds available for agricultural investment are greatly limited. In this work, two investment options were evaluated by applying real options approach; a modern conventional dairy sheep farm and a modern organic dairy sheep farm.

First, a discounted cash flow approach under certainty (i.e. without considering the stochastic nature of returns and the irreversibility of the investment decision) is applied. The NPV was applied for a ten years period with 8% discount rate. Analysis yields a positive NPV equal to 36,122€ for conventional dairy sheep farm and 71,241€ for organic, suggesting that investment in dairy sheep farming is feasible under the assumption that there is either 50% or 60% subsidy for the investment cost according to the EU Rural development programs.

Then, the real options approach is applied utilizing the same data as above to investigate the role of stochastic factors, taking into account 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 conventional dairy farm and of an organic one were determined by 10,000 Monte Carlo iterations through SIMETAR software [38]. Simulated net annual returns [E(R)] from investing in a modern conventional dairy sheep farm have an expected mean equal to 10,027€ with a standard deviation of 1,289€ (Table 3). On the other hand, simulated net annual returns from investing in a modern organic dairy sheep farm have an expected mean equal to 14,481€ with a standard deviation of 3,343€.

The log of the variance and the parameters of the value of opportunity to invest in organic or conventional dairy sheep farming were determined through simulation. Ten simulations were used to evaluate the parameters, μ_v and σ_v, of the growth rate for calculating the optimal investment trigger under uncertainty by 10,000 iterations.

The annual sunk cost for investing on dairy sheep farming was estimated to 166,065€ for the conventional production system and 159,675 for the organic production system[1]. The annuity is calculated assuming a long run loan of ten years' duration and 6.35% rate of interest. The annual amount of outlay for the investment can be reduced by either 60% or

[1] According to Dixit [27], the present value of sunk cost (or the Marsallian trigger) is equal to the annuity, $PV = CA\frac{[1-(1+r)^{-N}]}{r}$, assuming a loan of 10 years' duration with a 6.35% rate of interest.

Table 3 Parameters for value of investment opportunity and value of waiting

	Organic		**Conventional**	
	With subsidy 60%	**With subsidy 50%**	**With subsidy 60%**	**With subsidy 50%**
σ^2	0.027049	0.027049	0.0127219	0.0127219
β	2.9829	2.9829	4.0814	4.0814
β/β-1	1.5026	1.5026	1.3245	1.3245
B	6.3341 E09	4.0693 E09	2.4334 E13	1.2235 E13
ρ	8%	8%	8%	8%
ρ'	12.02%	12.02%	10.60%	10.60%
M	8,822	11,028	9,175	11,469
H	13,257	16,571	12,153	15,191
E(R)	14,481	14,481	10,027	10,027

50%, if the investment is subsidized according to EU Rural development programs.

Under the baseline analysis, we assumed a dairy farmer could use a real discount factor of 8% on his investment. Under the real options analysis, the conventional dairy sheep farmer has to use a different discount rate than the organic dairy sheep farmer. To measure the effect of uncertainty and irreversibility on the optimal investment behavior, the organic dairy sheep farmer has to use the modified hurdle rate, which is 12.02%, while the conventional dairy sheep farmer has to use a modified hurdle rate at the levels of 10.60%. Therefore, the net expected annual returns of the investment on conventional dairy sheep have to be 1.3245 times greater than the corresponding annual sunk cost. For organic dairy sheep, the net expected annual returns have to be 1.5026 times greater than the annual sunk cost.

For 10 years project life the optimal investment trigger (H) for conventional dairy sheep farming, assuming 60% subsidy on the sunk cost, is equal to 12,153€, while assuming a 50% subsidy, the sunk cost is equal to 15,191€. This means that the expected returns from investing in conventional dairy sheep farming are lower than the optimal investment trigger [H>E(R)]. Real options procedure suggests that the investment in conventional dairy sheep farming must be postponed and the option of investment must be kept alive. This means that the potential returns from conventional dairy sheep farming are not high enough to offset the relevant risk and uncertainty. Therefore, policy makers have to increase the current financial incentives for dairy sheep farmers in order to compensate for the risk and uncertainty.

However, these results could change, if the annual amount of the investment outlay could be reduced through the EU funding programs. Thus, if the amount of subsidy were 67% of the total cost then the investment in modern conventional dairy sheep farming would be appropriate for the farmer. At present this kind of subsidy is only offered in very isolated areas in Europe and the Aegean islands and not in the area under study.

For an organic farmer the adoption of a modern dairy sheep farming investment under the prevailing conditions seems to be viable. More specifically, investing in a modern dairy sheep farm in mountainous and less favoured areas proved feasible to a young farmer, according to real options methodology. The simulated expected annual returns [E(R)] are greater than 13,257€ that correspond to the optimal investment trigger (H), assuming a 60% subsidy on the sunk cost (Table 3). The real options procedure projected that [E(R)> H], so the investment is feasible considering the stochastic nature of returns.

IV. CONCLUSIONS

In this work, an attempt was made to employ a real options approach to evaluate the effectiveness of investment in either organic or conventional dairy sheep farming. The general implication from this empirical analysis of technology adoption decision-making is that risk and uncertainty play an important role in farmers' decision to adopt a new production system. Empirical results suggest that the adoption of organic dairy sheep farming is advisable. The best strategy for farmers would be to undertake their decision to apply organic dairy sheep farming, while conventional sheep farming still remains an option that has to be kept alive. The value of the opportunity to invest in conventional dairy sheep farming is not counterbalanced by the expected returns of the new farming system. As uncertainty of returns from investing increases, the value of the investment opportunity increases, thus it is worth postponing the adoption of the project.

Moreover, the results concerning the adoption of organic dairy sheep farming indicate that the current economic incentives yield positive economic results to farmers, despite the fact that farmers have significant constraints such as production risk and uncertainty. Organic dairy sheep farming is suggested in the case of young farmers. The minimum subsidy for a young farmer is 50% and can reach 60% in mountainous and less favoured areas, where sheep farming, and especially organic sheep farming is most commonly located.

Extensive and organic production systems constitute part of the development strategy for Greek sheep farming. Nevertheless, intensive sheep farms in lowland areas can also play an important role in the development and the expansion of the activity. This analysis points out the need for further economic incentives for this development process to be accommodated and accelerated. The subsidy in lowland areas ranges between 40% to 50%, which seems to give limited motives to farmers, especially in the case of conventional sheep farming. Conventional milk price is relatively low, while the initial investment cost is higher than in the case of organic farming, explaining the need for further incentives.

This study also indicates that real options approach can prove a very useful tool in investment evaluations since uncertain and irreversible environment can be better encountered.

ACKNOWLEDGEMENT

The authors would like to thank James Richardson, Konstadinos Tsiboukas and Pavlos Karanikolas for helpful and insightful comments.

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