Risk Analysis for Off-season Greenhouse Tomato Production

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Abstract

An economic analysis of new greenhouse investment technologies in Greece is conducted by this study. The data used in the analysis were obtained from greenhouse enterprises, farm surveys and were supplemented with secondary data. Risk analysis techniques are used to take account of the uncertainties regarding the yield and the price variability of protected tomato cultivation. The financial analysis reveals that the adoption of new technology for off-season tomato production is feasible provided that there are subsidies for the initial investment cost. In Greece, off-season vegetable production indicates different degrees of risk; south areas run less risk in contrast to areas in the north. Therefore the government policy to subsidize greenhouse investments had positive results. In order to ensure further development in the sector, the state has to keep granting these incentives for the implementation of new technology in greenhouse enterprises.

Résumé

Cette étude présente une analyse économique sur les technologies introduites dans les serres en Grèce. Les données utilisées ont été obtenues à travers des enquêtes concernant les serres et les exploitations agricoles. L'analyse du risque permet de prendre en compte les incertitudes liées au rendement et à la variabilité des prix des tomates cultivées sous serre. L'analyse financière révèle que l'adoption de nouvelles technologies pour la production de tomates hors de saison est possible pourvu que le coût d'investissement initial soit subventionné. En Grèce, la production de cultures maraîchères hors de saison pose un différent degré de risque; les risques étant moins importants dans le sud que dans les régions du nord. La politique gouvernementale de subventions des investissements pour les serres a produit des résultats positifs. Le développement de ce secteur peut être assuré par l'état à travers des primes qui encouragent l'application des nouvelles technologies sous serre.

1. Introduction

Protected cultivations are among the most intensive farms and contribute significantly both to the agricultural and national income. Greek farmers expect to garner the highest income returns cultivating horticultural crops in greenhouses (Mattas et al., 1990; Mattas et al., 1997; Grafiadellis et al., 2000). Today, the sector of greenhouse enterprises seems to have bright opportunities because of the enlargement of the European market and the development of international trade. Also, the increased consumers' demand for fresh vegetables creates the appropriate incentives to develop this sector and attracts the interest of farmers. Protected cultivation was introduced into the Greek agriculture in the early sixties with great expectations. In the following decades while the total area of protected cultivation increased significantly, several financial problems halted the expansion of the greenhouse sector (Tzouramani et al., 1995). Throughout the last decade, an attempt to reverse this situation was undertaken by the EU to implement a new supporting government program (Reg.2328/91). It aims at introducing new technologies in greenhouse enterprises to improve both the greenhouse economic effectiveness and the quality of off-season agricultural products. The implementation of the above-mentioned supporting-framework offers the Greek greenhouse farmers a set of investment choices but some risks as well.

The changes that are taking place in agricultural policies following the conclusion of international trade agreements can be expected to lead to competitive market forces with less predictable consequences. However, there is no doubt that decisions on purchasing and adopting technologies in greenhouses always bear risks and uncertainty and must be considered with much care and awareness. The economic performance is very important, notably in a world where funds available for agricultural investment are also extremely limited. Considering the numerous investment options available and the differences in cost, the modern greenhouse operator has to study the available information and perform the appropriate economic analysis before financing any of his decisions.

In this work an attempt was made to assess the effectiveness of the adoption of new technology in Greek greenhouses under risk and uncertainty. The most common dilemma that most farmers face is whether to invest in a modern (expensive) greenhouse or in a traditional (cheap) one. Decisions on greenhouse investment are influenced by several uncertain factors. Thus, enforcing changing options and through financial and risk analysis the investment in new greenhouse technology is assessed for two main greenhouse-producing areas of Greece.

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Table 1. *Investment and variable cost ($) for off-season tomato production in main greenhouse producing areas in Greece (1996-97, 0.4ha)*

	Crete		Northern Greece	
	Modern	*Traditional*	*Modern*	*Traditional*
Structure & Cover	88,387	32,258	89,677	32,258
Heating	45,162	-	45,162	-
Irrigation – Fertilization	2,419	2,419	2,419	2,419
Cooling	5,806	-	5,806	-
Shading	7,258	-	7,258	-
Auto net	20,968	-	20,968	-
Total Investment cost	170,000	34,677	171,290	34,677
Seeds - Fertilizers Chemicals - Fuel	10,484	9,101	14,106	12,493
Labour	12,323	12,323	10,613	10,613
Insurance	205	65	205	65
Maintenance	3,268	331	3,268	331
Total Variable cost	26,280	21,820	28,192	23,502

2. Materials and Methods

2.1. Procedure

Several types of greenhouse constructions and various types of applied technology for off-season greenhouse production may be identified. The total investment cost of greenhouse construction plays an important role in the decision of an investor (Tzouramani et al., 1995). Construction expenses constitute a very significant part of the greenhouse production cost, influencing the financial effectiveness of a greenhouse enterprise. Nowadays, greenhouse constructions have improved significantly providing higher yields and better product quality but at the same time the expenses and risks for the initial investment are higher.

Data were gathered from two major greenhouse-producing areas in Greece, (Crete and northern Greece) to assess the effectiveness of greenhouse investments. Crete is the main greenhouse producing area that covers 44% of the total cultivated greenhouse area while northern Greece follow with 17% (Greek Ministry of Agriculture, 1997). The main difference between the two areas is the environmental conditions that affect the yield, the timing of production harvest and the production cost. Crete is located in the south part of Greece with higher average temperatures while northern Greece has lower average temperature and higher fluctuations. The most common cultivated products are tomatoes (60%) and cucumbers (21%) (Greek Ministry of Agriculture, 1997).

As mentioned before, two typical investment options were evaluated, a modern greenhouse versus a traditional one. Data were obtained from a farm survey and supplemented with data from horticultural research center of Greece and greenhouse construction enterprises. The initial investment cost of a modern greenhouse was estimated surveying greenhouse manufactures. The initial investment cost is composed of the greenhouse frame, the cover, the heating and the cooling system (Table 1).

Farm survey data show that the main factors affecting the expected greenhouse returns are price and yield variability the most common types of risks for horticulture farmers. Consequently, farm management decisions may have included price and production risk. Stochastic simulation risk analysis considers both variables, price and yield, as stochastic. More specifically, yield was modeled as following a normal distribution and the selling price of tomato was modeled as following a triangular distribution (Table 2 and Table 3). As initial investment is maintained for long period in the greenhouse production process, effectiveness should be assessed estimating all possible expenses and returns for the entire period. In this study a ten-year span-life period was chosen partly because more meaningful results can be obtained for medium intervals and partly because long run price changes cannot be precisely projected, leading to misleading results. The real discount rate used in the analysis is set at 10% reflecting the current Greek financial market (Bank of Greece, 1998). The rate of inflation is assumed to be the same both for operating incremental costs and output prices in order to leave costs and benefits constant.

Table 2. *Triangular distributions for price parameters ($/kg)*

		Minimum price	Mean price	Maximum price
Crete	*Modern*	0.310	0.468	0.877
	Traditional	0.310	0.423	0.577
Northern Greece	*Modern*	0.255	0.484	0.800
	Traditional	0.255	0.452	0.529

Table 3. *Normal distributions for yield parameters*

		Mean yield (ton/0.1ha)	Standard deviation yield (ton/0.1ha)
Crete	*Modern*	12,500	1,720
	Traditional	8,300	1,380
Northern Greece	*Modern*	11,500	1,940
	Traditional	7,700	1,200

2.2. Economic assessment

Although several approaches have been used to evaluate the adoption of a new technology, financial theory mainly indicates the concept of discounting through capital budgeting to evaluate the effectiveness of a new technology project (Bierman and Smidt, 1988; Brealey and Myers, 1991; Brigham, 1985; Bromwich, 1976). In this respect, the principle of incremental cash flows is followed which simply states that costs and benefits 'with' and 'without' the adoption of the new technology are compared in order to determine the optimal return (Pagoulatos, 1992). The assessment of the optimal return is based on the most common criteria such as net present value; internal rate of return; benefit cost ratio and profitability index.

Net present value (NPV) is the value of the expected cash flows of an investment discounted to an appropriate percentage rate and subtracted from the initial outlay of the project (Gittinger, 1972; Irvin, 1978; Brigham, 1985; Brealey and Myers, 1991). The decision criterion is to accept projects with net present value greater than zero. If mutually exclusive projects are being evaluated, the project with the largest net present value is selected.

$$NPV = -C_0 + \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t} \qquad [1]$$

where C_0 = initial cost of the project; CF_t = net cash flow in year t; r = appropriate discount rate; T = project's expected life.

The internal rate of return (IRR) of an investment project is the break-even return level that equates the project's present value of net cash flows with its initial investment (Diacogiannis, 1994). It is expressed as a percentage and it can be interpreted as the rate of return a firm is expected to earn on the project. Projects should have a required rate of return higher than the internal rate of return. Profitability index is a criterion showing the number of times a project's total net cash flows cover its initial investment. It is expressed as a percentage and a project is accepted if the profitability index is greater than one.

Horticulture decision-making takes place in an environment of imperfect knowledge of the future and the prediction of cash flows with certainty is very difficult. Therefore, risk and uncertainty conditions should be taken into account in most agricultural investment evaluations (Vose, 1996; Hardaker et al., 1997; Purvis et al., 1995). In farm management analysis under risk conditions, a budget for investment appraisal for a multi period is just like ordinary budget, except that uncertainties are taken into account and then stochastic simulation analysis is applied.

Stochastic simulation analysis is a risk analysis method, which estimates the distribution of discounted cash flow measures that may be generated from a project. It uses the characteristics of such a distribution to determine whether the project should be accepted and also provides useful information taking into consideration the return and risk of the project. Stochastic features are introduced to a budget by specifying probability distributions for selected key variables, usually those judged to be the most important in affecting the riskiness of the selected measure or measures of performance. Then a Monte Carlo sampling procedure is used to evaluate the budget for a sufficiently large number of scenarios, with a record made of the distribution of the performance measure across these scenarios. Output can be in the form of the probability distribution of the selected performance measure. The @RISK program (Palisade Corporation, 1997) is used to estimate the probability distributions for the performance criteria.

3. Results and discussion

3.1. Financial analysis

The results of decision criteria employed to evaluate financial performance of a modern greenhouse versus a traditional one are reported in Table 4. Results clearly indicate that the introduction of new technology in the greenhouse enterprises is viable. More specific, financial analysis revealed that the investment in a modern greenhouse versus a traditional one is a profitable investment under the condition that there are subsidies for the initial investment cost (application of EU Reg. 2328/91). NPV, IRR and benefit cost ratio are acceptable investment criteria. The incremental net returns for a ten year project's life of a modern greenhouse are positive and the profitability index is also greater than one which means that the net cash flows cover its initial investment cost.

As reported in Table 4, Crete has given better financial results. NPV, IRR and B/C ratio in Crete are the highest between the producing areas. The profitability index is equal to 1.21, which means that the investment is covered by the net returns. The results of the financial analysis for northern Greece are not negative but the investment criteria are quite low which means that the implementation of this investment project is a marginal one. Therefore, the introduction of new technology in greenhouses in south areas is more profitable and has to be the first priority, so the government has to provide incentives for the continuous development and improvement of greenhouse enterprises in view of economic benefits.

Table 4. *Financial results of investment in a modern greenhouse versus a traditional one (0.4ha)*

	Crete	Northern Greece
Net present value (NPV)	$ 28,503	$ 4,780
Internal rate of return (IRR)	23%	19%
Profitability index (PI)	1.21	1.03
Benefit cost ratio (B/C)	1.62	1.48

Table 5. *Simulation results of investment in a modern greenhouse versus a traditional one (0.4ha)*

	Crete	Northern Greece
NPV		
Minimum	-243,096	-186,493
Maximum	461,818	306,321
Mean	73,884	28,488
Std Deviation	95,370	66,070
Skewness	0.410	0.35
Kurtosis	3.046	3.05
CV of NPV	1.290	2.31

3.2. Stochastic simulation risk analysis

Given the uncertainties, regarding yield and price, stochastic simulation risk analysis revealed that the investment of a modern versus a traditional greenhouse is also an acceptable one. Economic mean NPVs from the Monte Carlo simulations are reported in Table 5 and are positive for the two mentioned greenhouse-producing areas. It is important to note that higher returns are achieved in Crete and lower in northern Greece. Stochastic simulation risk analysis for the financial evaluation has revealed that the off-season tomato production presents different degrees of risk. More specifically, the investment of a modern greenhouse in northern Greece is very risky (2.31), while in Crete this investment project embeds less risk (1.29). Conclusively, the applied agriculture policies have to take into account the differences that occurs among regions for the development of a specific sector in terms of embedded risk and its profitability.

4. Conclusions

Nowadays, several new technologies are introduced for application in greenhouses, their main target being the improvement of the micro greenhouse-environmental conditions either for the produced products or for the farmer. In this study an attempt was made to assess the effectiveness of new technology adoption for off-season tomato production under risk and uncertainty environment. The application of new technology in greenhouse claims huge investment cost and special managerial skills from the farmers' point of view, which means that the investment decision needs the appropriate strategy. Financial analysis revealed that the implementation of a modern greenhouse versus a traditional one is acceptable under the condition that there are subsidies for the initial investment cost. While, stochastic simulation risk analysis showed that in Greece there is a different degree of risk according to the producing greenhouse area. More specifically, south areas run less risk in contrast to areas in the north. Conclusively, the applied agriculture policies for the development of the greenhouse sector had to take account of the embedded risk of each region to give the appropriate farmers' incentives.

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