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Adoption of new tobacco varieties in Greece: Impacts of empirical findings on policy design

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Abstract

Greece is a major international tobacco producer. Flue-cured tobacco varieties constituted the major alternative crop to Greek farmers growing certain oriental tobacco varieties. Diffusion of flue-cured tobacco was rapid due to its high yields and the depressed market for certain oriental tobacco varieties. Currently, the common organisation of the tobacco market is undergoing substantial changes, and the farmers' response will be a vital factor of success. A portfolio selection model reveals that the major factors influencing the adoption decision of tobacco growers are the size of the farm measured in annual work units, the farm's proximity to urban centres, the farm's diversification and the farmer's age. The number of contacts with institutions is, surprisingly, inversely related to adoption. Future tobacco policies impinging on factors influencing decisions to adopt new varieties or production practices may be more cost-effective.

1. Introduction

Adoption of agricultural innovations has been extensively examined especially among the rural population in less developed countries. Considerable attention has been given to the range of constraints arising when adoption decisions are contemplated (Feder et al., 1985). The constraints of adoption of new varieties of crops or new agricultural practices are also vital for developed countries in the light of agricultural policy reforms. The present paper will attempt to shed light on factors likely to influence the adoption decision process of farmers in a developed agriculture. A portfolio selection model is used to approach this research question.

In Greece, the importance of agriculture in the economy is still relatively high and is revealed by the fact that the sector accounts for approximately 14% of the gross domestic product while the respective figure for the European Union as a whole does not exceed 3%. Employment in agriculture still accounts for over 22% of total employment in the country as compared to 6% for the European Union. The total number of actively employed in agriculture corresponds to about 10% of the total number of farms in the Union.

Tobacco is one of the major cash-crops grown in Greece. Leaf tobacco accounts for 5% of the value of agricultural production, for almost 7.8% of the crop production and occupies 2% of the country's utilised

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agricultural area. Tobacco is an exportable crop and a source of foreign exchange for the Greek State. Tobacco exports account for 4.5% of the country's total exports and almost 14% of the country's agricultural exports. In 1993, the value of tobacco exported reached almost US$ 335 million while aid-premiums from the European agricultural guidance and guarantee fund (EAGGF) – Guarantee section – amounted to US$ 626 million. Today, tobacco is cultivated by almost 71 000 farm households accounting for more than 10% of all Greek farm households while employment in tobacco growing by the household's heads and the members of their families exceeds the equivalent of 210 000 full-time annual work units (Dimara and Skuras, 1997). As a raw material tobacco is used by the tobacco processing and cigarettes industry and creates further value added and employment for the Greek economy. Employment and income multipliers for the tobacco growing sector and the tobacco processing industry are among the highest recorded in the Greek economy (Mattas, 1992; Mattas et al., 1977).

However, Greek tobacco growing faces certain problems and limitations related to the varietal structure of the produce. All sun-cured varieties do not face the same market prospects. The oriental tobacco varieties of tsebelia and mavra experience a very low demand from both the Greek and the international tobacco manufacturing market. This is attributed to the changing consumption patterns towards cigarettes that do not use these varieties of tobacco. However, these varieties are grown by a large number of producers and their growth is regionally concentrated in the most disadvantaged areas of Greece where employment prospects outside tobacco growing alternatives are limited. In 1982, the then introduced flue-cured tobacco varieties (virginia varieties) comprised the most promising alternative to these oriental tobacco varieties, and by 1992 had been adopted by almost 6% of the total number of tobacco producers in Greece.

An important part of agricultural policy planning relies on the voluntary uptake of various instruments by farmers. Response to policy provisions and reaction to market signals depends, among others, on the farmer's ability to collect and process information and on the farm's socio-demographic and economic characteristics.

2. A portfolio model of flue-cured tobacco adoption in 1992

Various approaches have been used to model the economic behaviour of farm households and the farmer's decision to adopt a new variety in particular. In the varietal choice context, farmer's decision is explained by theories of joint production that incorporate behavioral assumptions and include: the portfolio selection model, safety-first or survival algorithms and farmer experimentation models. Portfolio-selection models have been frequently used in order to examine the choices of income generating strategies among households. In adoption of agricultural technology studies, the portfolio-selection model has been used in order to analyse the impact of education on the adoption decision regarding hybrid seeds in China (Lin, 1991a), while other empirical studies have used variants of the portfolio-selection model to explain input allocation decision that, apparently, diverge from profit-maximising outcomes (Hammer, 1986; Pingali and Carlson, 1985). A few studies have attempted to combine one or more of the competing microeconomic theories of joint production to one joint hypothesis as in the case of risk aversion with learning (Tsur et al., 1990), or to test a general model that contains each theory as a special case, as in the case of land allocation decisions of Malawian smallholders when HYV adoption is contemplated (Smale et al., 1994).

In this work we adopt a modified portfolio selection model first proposed by Lin (1991a) combined with Just and Zilberman (1983) theoretical work on adoption of new agricultural technology. It is assumed that the objective of a risk avert tobacco grower is to maximise its expected utility. Assume that a farm household grows only oriental tobacco of the undesired tsebelia and mavra varieties on its land, and there are only two available technologies, namely oriental sun-cured tobacco (T) and flue-cured tobacco (F). The adoption of flue-cured tobacco is risky and the variance of the output level depends on the *i*th household head's characteristics and other household specific variables that affect the household's ability in dealing with new varieties and production technologies. The cultivation of oriental tobacco is riskless, and this is evident from the almost constant variation in yield of these varieties, and thus it may be assumed that there is not variance in the output level. Following Lin

(1991a), the ith household's net farm returns when all of its land is cultivated with oriental tobacco is a function of variables representing the economic environment and specific household factors in the form

$$\pi_{i,\mathrm{T}} = M_{\mathrm{T}}(X) + \varepsilon_{i,\mathrm{T}} \tag{1}$$

where X is a vector of independent variables representing the prices of tobacco, price support, costs of inputs and so on, and $\varepsilon_{i,\mathrm{T}}$ a vector of independent variables representing the ith household's specific capacity for producing oriental tobacco. This expression implies that the profits function has a first component $M_{\mathrm{T}}(X)$, common to each household and a second component $\varepsilon_{i,T}$, that varies from household to household and reflects differences in the amount of arable land owned, labour availability, flow of agricultural information to the household, credit availability and the age or experience of the farmer. On the other hand if flue-cured tobacco is adopted on all of the farm household's land the mean net farm returns are,

$$\pi_{i,\mathrm{F}} = M_{\mathrm{F}}(X) + \varepsilon_{i,\mathrm{F}} \tag{2}$$

If the fixed amount of land available for tobacco cultivation is $\bar{\mathrm{L}}$ and a proportion $\mathrm{L}_i/\bar{\mathrm{L}}$ is allocated to the production of flue-cured tobacco, the mean net farm return is expressed as

$$\pi_i = \{M_{\mathrm{T}}(X) + \varepsilon_{i,\mathrm{T}} + (\mathrm{L}_i/\bar{\mathrm{L}})[D(X) + (\varepsilon_{i,\mathrm{F}} - \varepsilon_{i,\mathrm{T}})]\} \tag{3}$$

where

$$D(X) = M_{\mathrm{F}}(X) - M_{\mathrm{T}}(X) \tag{4}$$

It has been assumed that if the ith household allocates all its land to produce oriental tobacco, there will be no variance in its output level, due to absence of risk, and thus to net farm returns. However, if all land is allocated to the production of flue-cured tobacco, the variance in the household's net farm returns, according to variance in output levels, may be assumed to be of the form

$$\nu_i = \nu_{i,\mathrm{F}}(Z_i, X) \tag{5}$$

where X is as defined previously and Z_{i} a vector of household and household head's specific characteristics. Taking into account that $\mathrm{L}_i/\bar{\mathrm{L}}$ proportion of the household's total land is allocated to flue-cured tobacco, Eq. (5) becomes,

$$\nu_i = (\mathrm{L}_i/\bar{\mathrm{L}})^2 \nu_{i,\mathrm{F}}(Z_i, X) \tag{6}$$

Eq. (6) implies that the variance of the household's net farm return is positively related, and increases at an increasing rate to the proportion of land allocated to flue-cured tobacco. Lin (1991a) assumes that the ith household possesses a separable utility function of the form

$$U_i = \pi_i - C(\nu_i) = \pi_i - C(\mathrm{L}_i/\bar{\mathrm{L}}, Z_i, X)$$

where

$$C_1 > 0,\ C_{11} > 0,\ C_{12} < 0,\ \text{and } C(0, Z_i, X) = 0 \tag{7}$$

The specification of C( ) in Eq. (7) implies that the utility loss increases at an increasing rate with the ratio of land allocated to flue-cured tobacco, and that there is no utility loss if flue-cured tobacco is not adopted. The decision problem is thus an optimisation problem defined as,

$$\begin{aligned} &\underset{0\le \mathrm{L}_i/\bar{\mathrm{L}}\le 1}{\mathrm{Max}}\ U_i(\mathrm{L}_i/\bar{\mathrm{L}}|\varepsilon_{ui,\mathrm{T}}, \varepsilon_{i,\mathrm{F}}, Z_i, X) \\ &= \{M_{\mathrm{T}}(X) + \varepsilon_{i,\mathrm{T}} + (\mathrm{L}_i/\bar{\mathrm{L}})[D(X) \\ &\quad + (\varepsilon_{i,\mathrm{F}} - \varepsilon_{i,\mathrm{T}})]\} - C(\mathrm{L}_i/\bar{\mathrm{L}}|Z_i, X) \end{aligned} \tag{8}$$

This simply means that households will maximise utility through appropriate land allocation decisions, given the ith household head's specific characteristics and exogenous economic environment variables.

Assuming an internal solution for L_i, the solution L_i^* of the optimisation problem in Eq. (8) and in the absence of quotas and any other restrictions on the quantity to be adopted, can be generally represented as,

$$\mathrm{L}_i = \bar{\mathrm{L}}_i \equiv \begin{cases} 0 & \text{if } \mathrm{L}_i^* < 0 \\ \mathrm{L}_i^* & \text{if } 0 \le \mathrm{L}_i^* < \bar{\mathrm{L}} \\ \bar{\mathrm{L}} & \text{if } \mathrm{L}_i^* = \bar{\mathrm{L}},\ i = 0, 1 \end{cases} \tag{9}$$

Given adoption of flue-cured tobacco and Eq. (9), the optimal expected utility, following Just and Zilberman (1983) is

$$V_{\mathrm{F}} = \begin{cases} \bar{U}_{\mathrm{F}} = U_{\mathrm{F}}(\bar{\mathrm{L}}, Z_i, X) & \text{if } \mathrm{L}_{\mathrm{F}}^* = \bar{\mathrm{L}} \\ \tilde{U}_{\mathrm{F}} = U_{\mathrm{F}}(\mathrm{L}_{\mathrm{F}}^*, Z_i, X) & \text{if } 0 < \mathrm{L}_{\mathrm{F}}^* < \bar{\mathrm{L}} \\ \underline{U}_{\mathrm{F}} = U_{\mathrm{F}}(0, Z_i, X) & \text{if } \mathrm{L}_{\mathrm{F}}^* \le 0 \end{cases} \tag{10}$$

where $\bar{U}_F$ denotes expected utility if all land is allocated to flue-cured tobacco production while $\underline{U}_F$

denotes expected utility if all land is allocated to oriental tobacco production after incurring costs of adoption and $\tilde{U}_F$ is maximum expected utility when a mixture of oriental and flue-cured tobacco is grown. Thus, the optimal choice rule is given by

$$I = \begin{cases} 0 & \text{if } V_T > V_F \\ 1 & \text{if } V_T < V_F \end{cases} \quad (11)$$

The probability that a farm household would adopt flue-cured tobacco cultivation equals

$$P_i(F) = \Pr(V_F \geq V_T) = \frac{\exp(\beta' x)}{1 + \exp(\beta' x)} = \Lambda(\beta' x) \quad (12)$$

which is the commonly used logit model where $\Lambda()$ indicates the logistic cumulative distribution function, β is a vector of coefficients to be estimated and x a vector of economic, farm household head's and farm household variables representing both vectors X and Z in the previous equations.

3. Case study area and data

In order to examine the adoption behaviour of tobacco growing households it was decided to carry out a secondary data analysis of a data set of farmers collected in 1992, in the most important tobacco producing prefecture of Greece. The data come from a cross-section survey of 200 randomly selected farm households in the prefecture of Etolia-Akarnania that has been analysed and described by Damianos and Skuras (1996). The study area is situated in the western part of Central Greece and it is noted for its extensive irrigation network. Almost two thirds of the economically active population is engaged in some form of agricultural activity. The farms are small sized and approximately 50% of them are pluriactive. The prefecture has a long-standing tradition in the cultivation of oriental tobacco especially the varieties of tsebelia and mavra. The prefecture of Etolia-Akarnania produces almost 25% of the Greek tobacco production and almost the whole production of the oriental varieties of tsebelia and mavra. Flue-cured tobacco was introduced in the prefecture of Etolia-Akarnania in 1982 and was promoted by local offices of the National Tobacco Organisation of Greece and farmer's co-operatives while credit for the acquisition of the appropriate equipment was offered by the Agricultural Bank of Greece at regular rates.

It is important to note that the cultivation of flue-cured tobacco demands high investments, especially during the first year of adoption, for mechanical equipment. On the other hand, adoption of flue-cured tobacco involves entirely different production techniques, efficient managerial practices, entrepreneurial skills and the ability on behalf of the farmer to adjust quickly and efficiently to changing conditions. From an economic point of view the adoption of flue-cured varieties requires a high adoption cost concerning a fixed investment, time for learning, cost for training family and hired labour, and cost for transporting the produce to dryers rather than treating it on the farm. The environment within which success or failure occurs is likely to be vastly different from that which characterises the production of conventional varieties. Flue-cured tobacco has a very high gross margin per hectare of cultivated area and thus secures a satisfactory farm family income even on small sized holdings.

The number of growers rose rapidly between 1983 and 1992 and so did the area allocated to flue-cured tobacco. In 1992, almost 3000 producers grew flue-cured tobacco under almost 810 ha of land. Yields per hectare of flue-cured tobacco were almost double those for tsebelia, the variety of oriental tobacco grown mostly in Etolia-Akarnania. The original data set concerned 200 randomly selected farm households. However, only 111 usable questionnaires concerned tobacco growers. All surveyed farms cultivate tobacco as the main cash crop while other crops such as fresh vegetables, olives, vines and some permanent crops, are grown mainly for own use and limited trade. It was found that none of the surveyed farms grew both types of tobacco. They had either adopted flue-cured tobacco completely on all of their land, sometimes followed by one year experimentation, or continued to cultivate oriental tobacco. Thus, Eq. (9) above accepted, in practice, only corner solutions, that are possible under certain conditions. This is easily explained by the fact that the cultivation of oriental and flue-cured tobacco are two completely different technologies requiring different timing of the jobs on the farm, different labour requirements and different treatment of the produced leaf tobacco. Moreover, in order to achieve economies of scale in the use of machinery, especially dryers, the total production of

Table 1
Definitions and descriptive statistics of independent variables

Variable name	Description	All farmers		Adopters		Non-adopters	
		Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
ADJUST	Fixed adjustment cost in million drachmas	1.584	1.735	1.162	1.179	1.942	2.037
LABOUR	Total annual work units on-farm	2.432	0.983	2.730	0.990	2.180	0.910
PLUR	Total annual work units off-farm	0.450	0.582	0.390	0.490	0.500	0.650
CONT	Number of contacts with organisations in one year	1.649	1.412	0.940	1.080	2.250	1.390
DIVER	Diversification index	0.590	0.227	0.670	0.240	0.520	0.190
PROX	Proximity to main urban centres in km	24.342	16.878	15.670	12.290	31.720	16.810
AGE	Age of the household's head	48.802	10.978	48.060	10.250	49.430	11.610

flue-cured tobacco from one farm should be of a certain size depending on the capacity of the dryer used.

The dependent variable is a dichotomous index of flue-cured tobacco adoption described by Eq. (11). Definitions and descriptive statistics of the independent variables used in this analysis are presented in Table 1. The list of independent variables does not include any price or cost variables because there was no cross-sectional variation in oriental and flue-cured tobacco prices received by farmers and/or prices paid for inputs. This deserves further explanation especially as concerns tobacco price policy. Tobacco growing in Europe is a highly protected and heavily subsidised industry. Tobacco price policy consists of a mechanism aiming to support production by means of premiums paid per quantity produced irrespective of quality, plus a complementary aid based on the product's quality and not exceeding 10% of the premium. In consecutive years, total support to flue-cured tobacco as well as tsebelia and mavra produced in Greece accounted for more than 90% of the producer's total return while the actual market price was less than 5% of the product's final price (Skuras, 1998). Thus, price policy failed either to improve the quality of tobacco produced in all varieties in Greece or to signal the need for changing the cultivation of non-desired varieties. Furthermore, price policy was both inefficient and ineffective as tobacco production rose steeply due to speculative and fraudulent tobacco farming and extensive 'premium hunting' as premiums were several times the market price for many non-demanded varieties.

Prices for inputs did not vary among farmers due to a non-market mechanism for fertiliser and pesticide purchase through farmer's co-operatives and the Agricultural Bank of Greece that secures almost uniform prices to all registered farmers. Furthermore, no differences in interest rates were observed and no information on wages outside agriculture was collected for the members of the farm family employed outside agriculture. For the prefecture of Etolia-Akarnania, Daouli and Demoussis (1992) found that land rents increased dramatically after 1981 and this is attributed to high rental income and the non-constancy of real interest rates. Among the farms of the present sample, land rented in is limited and thus differential land rents are not a significant factor in the decision to adopt flue-cured tobacco cultivation.

Total area cultivated is postulated to be one of the main factors influencing adoption of new technologies. Just and Zilberman (1983) have proved, analytically and graphically, that the relationship of adoption and farm size follows three regimes. First, no farm size leads to adoption due to excessive fixed costs. Second, there may be a critical farm size level below which some farms do not adopt due to high fixed costs and above which other farms adopt. Third, the spectrum of sizes in relation to adoption is divided into three levels where in the first level no adoption occurs due to high costs, in the middle level there is an opportunity to spread the fixed costs of adoption and in the upper level no adoption occurs due to increasing risk, under certain conditions. Farm size is the major determinant of the adjustment cost associated with the adoption of flue-cured tobacco. The National Tobacco Organisation of Greece has estimated the per hectare operating and fixed adjustment costs for adopting flue-cured tobacco in 1992 (Table 2). Based on the farm's area cultivated with tobacco and the fixed capital

Table 2
Annual production costs for sun-cured and flue-cured tobacco varieties, 1992

Cost per hectare	Tsebelia (sun-cured)	Virginia (flue-cured)	Adjustment cost
	(1)	(2)	(3)=(2)−(1)
Machinery	193 000	259 000	66 000
Fertilisers	114 050	133 920	19 870
Pesticides	160 710	273 330	112 620
Insurance	37 080	49 560	12 480
Other	99 225	251 257	152 032
Total working capital	604 065	967 067	363 002
Interest on fixed capital	111 360	224 000	112 640
Depreciation	161 670	205 581	43 911
Other	33 075	83 752	50 677
Total fixed capital	306 105	513 333	207 228
Total	910 170	1 480 400	570 230

Cost estimates are in 1992 Greek drachmas (Melissa, 1995), and the average exchange rate in 1992 was 215 Greek Drachmas per US dollar.

adjustment costs shown in Table 2, we estimated the total fixed adjustment cost faced by every farm household in the sample (ADJUST) and included it as the main explanatory economic variable.

The size of the farm may be measured by employment requirements. A measure of the size of the farm in annual work units (LABOUR) may also be used as a proxy reflecting costs for training family labour. The size of on-farm labour availability has been used in a study of adoption of hybrid rice in China without resulting in any statistically significant conclusions (Lin, 1991a).

The size of the household's off-farm annual work units (PLUR), indicates the exposition of the farmer to outside information, places restrictions on the use of family labour for the adoption of flue-cured tobacco and indicates available sources of family income outside agriculture. One referee of this Journal pointed out that off-farm employment provides for mixed signals regarding the adoption decision. Access to outside information may have positive effects on flue-cured tobacco adoption, while off-farm income would limit the necessary management resources available for flue-cured adoption. Thus, results on this particular variable should be treated cautiously.

The degree of extension and other institutional contacts measures access to information and expertise that is assumed to reduce both the fixed cost and the risk of adopting flue-cured tobacco. For the purposes of this work the mean number of contacts (CONT) a farmer had with specific organisations and institutions during the last farming period was measured. Each farmer was cited 12 different organisations, but contacts with the National Tobacco Organisation, the Agricultural Bank of Greece and farmer's co-operatives were the usual answers. This is actually a count variable but for the econometric purposes of the present work is treated as a continuous variable. Extension and institutional contacts have been used in adoption studies and showed a high correlation with adoption of new technologies (Shakya and Flinn, 1985; Green and Ng'ong'ola, 1993).

Diversification is generally accepted as a risk reducing strategy (Anosike and Coughenour, 1990) and in this study is used to reflect the farmer's attitudes towards risk. Farm diversification (DIVER) is measured by a modified Hirschamn–Herfindahl index as

$$HH = \sum_{i=1}^{n} p_i^2 \tag{13}$$

where p_i is the proportion of total land devoted to the ith enterprise. This index results in a continuous variable with maximum value of 1 corresponding to complete concentration and minimum approaching zero as the number of different enterprises increases indefinitely. The same variable has been used as an explanatory variable concerning land use strategy decisions with statistically significant decisions (Damianos et al., 1995). A Herfindahl index constructed from enterprise sales shares has been used to model participation in educational programmes and consequent adoption of forward pricing methods without resulting any statistically significant relationships (Goodwin and Schroeder, 1994).

Previous work on farm diversification and adoption of new varieties and on-farm activities highlighted the importance of proximity to main roads and urban centres for the development of alternative farm enterprises strategies (Ilbery, 1988; Shucksmith et al., 1989; Edmond et al., 1993). Such access is assumed to reflect variable costs for inputs (fertiliser, pesticides) and the transport of flue-cured tobacco to dryers. Green and Ng'ong'ola (1993) used a variable

measuring distance from input distribution point in a study of fertiliser adoption among Malawi farmers but without statistically significant results. Furthermore, proximity (PROX) may reflect access to information sources, extension and services. For the purposes of this work the distance in kilometers of the farm from main urban centres, where credit and extension services are located, was used. The degree of correlation among proximity (PROX) and the contact variable (CONT) is low.

Age is related to the receptiveness of a farmer. It is argued that young farmers are likely to be adopters and off-farm pluriactive farmers have high educational qualifications (Gasson, 1988; Shucksmith and Smith, 1991). Younger farmers are more dynamic in the adoption of new farming techniques and products, while older farmers are more experienced and skilful, but less energetic. Considering risky decisions of flue-cured tobacco adoption, older farmers may not adopt as they tend to choose crops of their assured yield and market and quick return. Younger farmers are more likely to adopt flue-cured varieties that have a riskier market, more uncertain yield but higher returns even in the long run. Younger farmers are likely to be 'gamblers' whereas older farmers are likely to be 'satisfiers' (Fotheringham and Reeds, 1979). Age of the farm household head has been used in recent adoption studies. Shaha et al. (1994) showed that the age and education of a farmer are the two most important factors explaining whether or not a producer has heard of agricultural technology.

Lin (1991b), found that the diffusion of hybrid rice in China was a function of past experience, more important than profitability, which did not seem to be of major concern in the adoption decision. In this study we were not successful in utilising other human capital variables concerning education, agricultural training and experience in farming because the sampled farmers displayed a great degree of homogeneity with respect to such characteristics.

4. Model estimation and specification

Estimation of the parameters in Eq. (12) is easily obtained by the Newton–Raphson iterative procedure. However, the parameter estimates of the model in Eq. (12), like those of any non-linear regression model, indicate the direction of the effect of each explanatory variable on the response probabilities, but are not necessarily the marginal effects we are accustomed to analysing. By differentiating Eq. (12), we find the marginal effects of the regressors on the probability (Greene, 1991), as

$$\frac{\partial P_{\mathrm{F}}}{\partial x} = P_{\mathrm{F}}\left[\beta_j \sum_k P_k \beta_k\right] \tag{14}$$

The change in probability is a function of the probability itself which, when multiplied by 100 is the percentage change in the probability of the farm strategy occurring given a change in the variable. Of course, the computation of partial derivatives in Eq. (14) is useful only when the variables in question are continuous.

Separate tests examining the null hypothesis that individual coefficients are zero can be calculated by analogy with the t-test of the conventional multiple regression model. A joint test of the null hypothesis that all the parameters associated with the explanatory variables are equal to zero is a chi-square test based on the maximised likelihood. A goodness-of-fit measure based on the likelihood-ratio test statistic, usually reported as McFadden's pseudo-R^2 measure, or rho-square (Maddala, 1983), is also computed. McFadden (1979), has suggested that ρ^2 values between 0.2 and 0.4 should be taken to represent a very good fit of the model. We also compute another measure that takes into account the number of parameters in the model, usually reported as rho-squared bar. Specification test analysis involved a test for heteroskedasticity based on generalised residuals, a distributional test based on the Burrit model, and a test for omitted variables using predicted values of the dependent variable (Maddala, 1995).

The empirical logit model of Eq. (12) was estimated using the LIMDEP statistical package (Greene, 1991). Maximum likelihood estimated coefficients and the corresponding t-ratios are shown in Table 3. The likelihood ratio test is highly significant with a score of 65.68, and the corresponding goodness-of-fit ρ^2 and $\bar{\rho}^2$ measures indicate a very satisfactory fit (Table 3). The model correctly predicted 84.7% (94 out of 111) of the responses. Correct predictions were relatively higher for the group of adopters (84.3%, or 43 out of 51) than for non-adopters (81.7% or 49 out of

Table 3
Parameter estimates of the logit model

Variable name	Coefficient estimate	Std. error	Asymptotic *t*-ratio
Constant	0.9785	1.6990	0.567
ADJUST	−0.1678	0.1899	−0.884
LABOUR	0.7783	0.3271	2.379
PLUR	−0.4708	0.4624	−1.018
CONT	−0.7334	0.2237	−3.278
DIVER	4.7389	1.4570	3.253
PROX	−0.0694	0.0233	−2.978
AGE	−0.0540	0.0302	−1.786

Summary statistics
Number of observations=111
$\log L_{\Omega} = -43.733$
$\log L_{\omega} = -76.574$
$-2[\log L_{\omega} - \log L_{\Omega}] = 65.682$
ρ^2=0.429
$\bar{\rho}^2 = 0.337$

60). Specification tests did not reveal any significant mis-specification of the model.

The results of Eq. (14) for adopters are presented in Table 4. The results for non-adopters are of exactly the same magnitude and opposite sign. The estimated marginal probability responses and estimated asymptotic *t*-ratios reveal some significant relationships between the variables and the adoption decision, with profound implications for the design and implementation of effective tobacco policy.

Fixed adjustment costs (ADJUST) are inversely related to the adoption decision but are not statistically significant. The sign of the coefficient is the expected one, however, the fact that the coefficient is not significant points to the conclusion that fixed adjustment costs are not a major determinant of the decision to adopt. Fixed adjustment costs are higher for large farms and thus maybe a major obstacle to the adoption decision. In this case a policy, appropriately designed to support access to credit, may reduce the adoption risk of certain large farms and assist the adoption process. It has been found that increasing credit assists medium and large farmers to exploit new livestock forage and milk marketing innovations (Nyaribo and Young, 1992).

Table 4
The effect of independent variables on the change in probability

Variable name	Adopters estimate	Asymptotic *t*-ratio
ADJUST	−0.040	−0.882
LABOUR	0.189	2.364
PLUR	−0.114	−1.013
CONT	−0.178	−3.180
DIVER	0.115	3.233
PROX	−0.017	−2.855
AGE	−0.013	−1.786

The size of the farm in work units (LABOUR) reveals a statistically significant relationship between size and the adoption decision. An increase of the farm size by one annual work unit increases the probability of adoption by almost 19%. The cultivation of oriental tobacco is labour intensive while cultivation of flue-cured tobacco varieties are less labour intensive and more capital demanding enterprises. Greek cost production studies have found that family and hired labour costs account for almost 65% of the total production costs of oriental tobacco and only 30% of the total production costs of flue-cured tobacco varieties (Ziogas et al., 1992). The results concerning size of farm in labour requirements accept two alternative explanations. One may confirm the results of Just and Zilberman (1983) that above a critical level of farm size, here measured in labour units, adoption of new technology gives the opportunity to spread fixed costs. Furthermore, Feder (1980), proved that the area allocated to a modern crop increases with farm size if absolute risk aversion is decreasing and thus, adoption decisions take into account the degree of risk and the attitudes of the decision maker towards risk, which in turn are not independent of farm size. Adoption of flue-cured tobacco has a positive effect on the household's supply to the labour market and a negative effect on its demand for hired labour. This has been observed in other studies of new crop adoption (Lin, 1994, 1995) and may be attributed to uncertainty regarding labour supply in peak seasons (Feder et al., 1985). Adoption of flue-cured tobacco may be a risk reducing strategy as concerns labour availability, especially in the prefecture of Etolia-Akarnania where seasonal labour is supplied by immigrants and is highly dependent on foreign policy matters. Non-adoption of flue-cured tobacco varieties may be regarded as a survival strategy if the farm household aims at facilitating excess family labour force that cannot be accommodated outside the farming sector. This argument, however, is not supported by evidence

of the present sample because non-adopters exhibit a higher mean of off-farm annual work units than adopters (Table 1). Furthermore, it was also hypothesised that high labour requirements on the farm may also represent high fixed adoption costs for training. This hypothesis is not supported by the results of the present analysis. This may be attributed to the fact that expected profitability of flue-cured tobacco is higher than perceived fixed training costs, but we are not able to present any strong arguments in support of this alternative hypothesis.

An increase in the off-farm annual work units (PLUR) decreases the probability of adopting flue-cured tobacco varieties, but this relationship is not statistically significant. The result concerning contacts with extension and credit organisations (CONT) is unexpected. The probability of adopting flue-cured tobacco varieties decreases by almost 18% as the mean number of contacts in one year increases by one. This result is in contrast with other empirical findings that have indicated that as producers become more informed of a production practice or a new technology, the uncertainty decreases and adoption probability increases (Feather and Amacher, 1994). On the other hand, of course, contacts with organisations may not have such an impact on the decision to adopt as it may have the farmer-to-farmer dissemination of the new variety (Grisley, 1994), a factor that we did not examine in this research. We examined if there is a confounding factor related to the receptiveness of a farmer that explains such behaviour. For example factors related to education, age, training and experience may result in the acquisition of the appropriate information in fewer contacts. In order to pursue such a hypothesis an exogeneity test was performed concerning the variable measuring contacts. The Wu–Hausman and other tests (Maddala, 1995) did not reveal any exogeneity of the variable. It may be assumed that a self-selection process is going on, the more risk-averse farmers seeking several second opinions.

Diversification (DIVER) is related to the risk attitudes of the farmer. It was expected that the higher the diversification index, i.e., the higher the degree of concentration, the higher the probability of adopting flue-cured tobacco varieties, because concentration is an indication that the farmer is a risk taker. Indeed, an increase in the diversification index by 0.1 increases the probability of adopting flue-cured varieties by 11.5%. Proximity of the farm household to urban centres (PROX), is negatively related to adoption decisions. The greater the distance from urban centres the less the probability of adopting flue-cured tobacco varieties. Distance from urban centres reflects spatial variation of costs for inputs due to transportation and costs of taking leaf tobacco to dryers if the farmer has not invested to install his own equipment.

Finally, the age of a farmer (AGE) is inversely related to adoption of flue-cured tobacco (statistically significant at the 10% level), which is a well documented result in adoption studies.

5. Empirical findings and policy design

The Commission of the European Union at its latest report to the Council of Ministers (Commission of the European Community, 1996), concerning proposals for the common organisation of the leaf tobacco market recognised the importance of tobacco growing activities for the rural areas of the Union and stated that: "... tobacco cultivation is very labour intensive involving approximately 190 000 jobs in the production and processing sectors. ...The cultivation of tobacco enables the maintenance on-the-spot of the growers and their families, generates an industrial activity which contributes to the survival of regions threatened by desertification and the rural exodus."

The report examined alternative scenarios for the future common organisation of the tobacco market. One scenario envisaged the complete withdrawal of community support to the sector, and was rejected because it would imply the end of a very important activity. Scenarios concerning continuation of the present production support system (status quo) or the conversion of price support to an aid per hectare system were also ruled out because they either would not have any positive effect on the quality of production or would be difficult to control.

The Commission proposed an integrated policy framework that includes many innovative features. First, connects the payment of a part of Community premiums with the quality of tobacco produced as determined by its purchase price. This modulation system would comprise a fixed and a variable part in order to give both a minimum income to the

producer and reward production of higher quality. Thus, the pressure to increase quality will be strong, and those producers who will not upgrade production will find it difficult to stay in the sector. Second, specific measures to facilitate withdrawal from the sector on a voluntary basis, like quota buy-backs, are proposed. Third, supplementary measures which facilitate the transfer of quotas, the creation of national reserve of quotas, the simplification of quota management, increased environmental protection and strengthening of the existing control measures are also proposed.

Drawing from the aforementioned exposition of the tobacco policy reform proposals, it is evident that producers will be in a position to choose between their present situation and quality improvements or adoption of quality varieties (transfer of quota) or withdrawal from the sector. This choice position is similar to the adoption decision examined in this work between undesired oriental tobacco varieties and flue-cured tobacco. From the preceding portfolio analysis is evident that flue-cured tobacco varieties were adopted by farm households facing lower adjustment costs, with more concentrated enterprises than non-adopter's farms, situated close to urban centres. Adopters are of a younger age, and need less contact with extension and credit institutions. Thus, it may be possible for policy makers to identify a target population for delivering the improved tobacco quality and transfer of quota proposed instruments.

The high adjustment costs related to the adoption of new tobacco varieties or to the adoption of cultivation practices for the production of quality tobacco should be reduced by appropriately designed credit policies. Thus, a part of the cost to support the product's price may be directed to either an aid to lower interest rates for fixed capital or grant aid that will reduce the risk of adoption. There is a need for the policy to shift from price support mechanisms to structural measures and achieve higher effectiveness on public spending.

The spatial dimension of the adoption of agricultural innovation has been well documented in studies of the geography of innovation. The present study confirms previous findings relating the spatial disposition of land holdings with adoption of new technology on the farm or adoption of alternative enterprises utilising farm human capital and assets.

The result concerning frequency of contacts in relation to adoption is not surprising if we take into account a self selection process by which the more risk-averse farmers seek more information. However, it may be a good practice if policy makers propagate producer's contacts with extension and credit services by the institution of different sets of incentive measures. It is surprising that the proposed tobacco policy measures do not contain training to farmers for the production of high quality tobacco or tobacco with desired smoking characteristics. Training would reduce uncertainty concerning future yields if certain cultivation practices are adopted, and it would increase the rate and pace of adoption. Training should be in the first place selective and directed to young, full-time farmers.

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