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Economic Factors Influencing the Decision to Plant Almonds on Sloping Land in Saman, Iran

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ABSTRACT

This study investigated the factors influencing the decision to plant almonds in the Saman region of Chaharmahal-Bakhtiari Province in central Iran through conducting an economic survey in 2005. Using portfolio investment theory and econometric model estimation (Shively, 1998), this paper identifies the most important factors influencing the individual farmer's decision concerning the number of almond trees planted during 1995-2004. Results of this study show that farm size, permission for water use, a one-year forecast of almond price changes, and the upcoming year's expected change in the guaranteed price of wheat as a competitor crop in the use of land and water had a significant impact on the number of trees planted. This study indicates that policymakers should take notice of the adverse impact of the increasing wheat price trends on tree planting and indirectly promote more research on the environmental impact of almond plantations, particularly as it relates to soil erosion and environmental issues.

Keywords: Almond planting, Government water policy, Iran, Prices.

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INTRODUCTION

On the basis of developing sector plans, agriculture is a pivotal base of growth in Iran as a developing country. Support for the creation of new orchards and an increase in the number of trees planted are the main objectives called for in national economic and agriculture sector plans. Policy-makers follow these objectives because of the multiple advantages they provide, both for the economy and the environment. Increased production levels, employment generation, and enhanced exports of non-petroleum related products are some of the economic advantages of tree plantations. Tree planting also provides a positive environmental impact as it reduces soil erosion in comparison to annual crops (Shively, 1999). Tree planting, particularly on sloping lands, could be considered as an investment for farmers by inhibiting natural resource degradation in soil and water (Pattanayak and Mercer, 1998).

In recognition of these economic and environmental benefits, specific policies to promote perennial crops are increasingly seen as necessary to achieve development goals (Shively, 1999). One of the most important decision makers in the agricultural sector is the farmer, whose decisions concerning the allocation of resources and use of inputs have a direct impact on basic natural inputs and environmental assets such as land and water. Government policies to achieve sustainable development should encourage farmers to make choices that would incur minimum losses to the environment. The farmers' response to these policies depends on various factors, the recognition and explanation of which could be instrumental for decision making in the agricultural sector.

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For policy-makers in Iran, knowing which policy could broaden the area under plantation, particularly those with a favourable potential such as slopes and hillside lands, is important. The farmers' decision to respond to these policies will be reflected in the number of trees, changes in the area under plantation, and changes in the pattern of land use.

Almond trees play a significant role in the protection of soil and water on sloping lands, mainly regions with high rates of soil erosion due to the cultivation of annual crops such as wheat. Almonds are an exportable product with multiple advantages. This product has a long history in Iran, known historically as one of the first countries to cultivate almonds. The roots of this plant are strong and can prevent soil erosion (Yadollahai and Rahemi, 2005).

One of the main almond production centers in Iran is in Chaharmahal-Bakhtiari Province. The Saman region of this province has seen the highest increase in the area under almond plantation during the past decade. In the Fourth National Economic, Social, and Cultural Development (2005-2009) Plan Iran, almonds rank the highest among perennial trees in the parameters of area under plantation and production.

Saman is a hillside and sloping region above the Zayanderood River. Before irrigation of almond plantations in this area, some farmers cultivated wheat using dry farming methods. The price and non-price support for wheat in Iran caused gradual enlargement of the land area under wheat cultivation. As a result of wheat cultivation on the sloping lands in this region, soil erosion increased, with the eroded soil entering the Zayanderood River causing serious damage to the local dams. After 1995, the government promoted almond planting rather than annual crops along the Zayanderood River margins to increase soil conservation.

The planting decision has been investigated from various viewpoints in the past. Some concentrated on the "to plant or not to plant" decision using Tobit, Probit, and other types of binary models. However, the main variable of this study only included those farmers who had planted almonds in the years 1995-2004. In the literature, tenure arrangements (Raintree, 1987) and household subsistence considerations (Scherr, 1995) in project-based assistance sought to address these concerns.

It is well known that agricultural prices play an important role in shaping land use decisions over time (Askari and Cummings, 1976). Godoy (1992) in his review described how output price, tenure, information, credit, technology, government policies, and labour availability affect smallholder commercial tree cultivation. He emphasized the role of output price on tree cultivation in different countries. Shively (1998, 1999) described how farm size, farmer age, current prices, one-year forecast price changes, and relative price risks were important determinants of mango planting decisions in Palawan, one of the Philippines provinces, over the period 1984-1994. He also mentioned the environmental effect of tree planting on decreasing soil erosion on the hillside farms of Palawan.

MATERIALS AND METHODS

Data

This investigation aimed to elucidate how forecasting price changes one year prior to planting and how government policy on water retrieval permits can influence the farmer's decision on the number of almond trees to plant. Therefore, this study combined price data (as a forecast of the one-year projected price change at planting time) and farm level data that gives information on planting years, water use permits, individual characteristics of farmers, and other relevant information.

This study followed the Shively (1999) model on imposing expected change in price for every specific farm decision and using the concept of portfolio investment, while applying some basic differences in the methods of forecasting and incorporating different variables.

Data used in this analysis came from a 2005 sample survey of 60 farmers in Saman region, a hillside area to the northeast of Shahrekord in Chaharmahal-Bakhtiari Province. A simple random method of sampling was used on the basis of a relative monotonic situation of farmers in this region and a slight difference in variance between villages. In choosing the number of samples, further to budget and time of research, variance and the dimension of society should also be considered. The Cocran formula was used to identify the number of samples.

$$n = \frac{N * t^2 * s^2}{N * d^2 + t^2 * s^2}$$

In this formula, N is the dimension of the research society and is equal to 2,679. The confidence coefficient, t, is 1.98, and the desired needed accuracy, d, is 1.25. Because calculating the society variance is not possible, 20 pre-test questionnaires were completed and variances of these samples were included in the formula. Replacing the numbers in the formula got the desired number of samples, with n equal to 57.36. On the other hand, the ratio of n to N is less than .05, and the sampling dimension is correct. Finally, 60 questionnaires were completed randomly in some of the gathering places of farmers. These included 46 farmers who planted almonds once during the study period, eight farmers who planted twice, and six farmers who planted three times. Since in every decision of almond planting farmers of different ages and farm sizes were faced with varying prices, every replanting decision is a unique observation and can be included in the model. In conclusion, 80 observations were incorporated in the estimation.

Some parts of the descriptive data are provided in Table 1 and include age, education, income, farm size, farm slope (measured in clinometers), and the average number of trees planted. The entire sample of farmers owned their land, so land tenure was not material.

One of the key factors influencing the almond planting decision is whether or not the farmer has permission to use water from the Zayanderood River. This variable was included as a dummy variable in the final regression. Data for the annual almond farm-gate price used in this analysis were derived from the "sales production price and cost of agricultural services in rural regions of Iran", reported by the Statistical Center of Iran between 1984-2004. Guaranteed wheat price data were derived from the Agriculture Ministry of Iran. Wheat prices had the lowest price risk, and one-year changes in the guaranteed price were determined by the government. However, the government played no role in determining prices, and the one-year price for almonds, change was uncertain. These data are presented in Table 2.

Table 1. Sample statistics for farms, in Saman, Iran.

	Average	Standard Deviation	Minimum	Maximum
Age of Farmer (years)	63.48	87.14	23	80
Education (years)	21.6	56.4	0	16
Almond Planting Experience (years)	31.23	86.14	3	60
Household Size (number of members)	16.5	02.2	2	10
Annual income from almond (million Rials)	573	722	50	100
Farm Size (hectares)	31.4	57.5	3.0	38
Slope of Farm (percent)	83.13	43.11	0	50

Note: Exchange rate in 2004 was approximately 1$ US= 9,000 Rials.

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Table 2. Observed and forecasted almond price, Iran.

Year	Observed price	Forecast price	One-year change in forecast price
1995	3938.2	2145.0	1142.1
1996	3709.7	3287.2	60.2
1997	441.5	3347.4	542.5
1998	494.8	3889.9	482.3
1999	4937.7	4372.3	231.2
2000	5159.8	4603.6	325.4
2001	4771.5	4929.0	93.6
2002	5779.6	5022.7	542.5
2003	7926.1	5565.2	941.9
2004	10542.6	6507.1	1184.9

Note: Price unit is Rial.

Theoretical Model

Crop selection on a farm can be viewed as analogous to an investor's portfolio selection problem. A farmer invests assets such as land in an agricultural portfolio consisting of one or more crops (Shively, 1999). Farmers in Saman face two major choices in their agricultural portfolio: almond as a commercial and exportable tree crop, and wheat as a fully subsidized annual crop. In this case, farmers can decide on the number of almond trees to plant on a parcel of land or choose wheat as a potential competitive product in the use of land and water. The mathematical format of this discourse reads as follows and also explains a subjective correlation.

If $U(\pi_t)$ represents a twice-differentiable concave utility function over time and β^t represents a discount factor, then:

$$Max\ E\left\{\sum_{t=0}^{t=\infty} \beta^t U(\pi_t)\right\} \quad (1$$

If the farmer's objective is maximizing utility from income, the income function will be:

$$\pi_t = \theta\, p_t^{almond} g(t) + (1-\theta) p_t^{wheat} y - \theta I \quad (2$$

Where, π_t is the income from two crops (almond and wheat), θ is the share of land in trees, p_t^{almond} is the price of the tree crop, y is the yield of the food crop, and I represents the pre-investment in trees.

If investment occurs in time t, then:

$$\pi_t = \theta\, p_t^{almond} g(t) + (1-\theta) p_t^{wheat} y \quad (3$$

If equation (3) is differentiated, then:

$$\frac{\partial U}{\partial \theta} = \frac{\partial U}{\partial \pi_t} * \frac{\partial \pi_t}{\partial \theta} \quad (4$$

$$\frac{\partial U}{\partial \theta} = \beta^t u'(\pi_{t+1}) \left[p_{t+1}^{almond} g(t) - p_{t+1}^{wheat} y - I \right] \quad (5$$

$$u'(\pi_t) = \beta^t E_t \left\{ u'(\pi_t) \left[p_{t+1}^{almond} g(t) - p_{t+1}^{wheat} y - I \right] \right\} \quad (6$$

For convenience, assume a constant relative risk aversion utility function applied with a risk aversion coefficient γ:

$$u(\pi_t) = \begin{cases} \dfrac{\pi_t^{1-\gamma}}{1-\gamma} & for \quad \gamma \rangle 0 \\ \ln \pi_t & for \quad \gamma = 1 \end{cases} \quad (7$$

Using this utility function in equation (6) and simplifying the equations resulted in equation (8):

$$\frac{1-\gamma}{1-\gamma} \pi_t^{-\gamma} = \beta E_t \left\{ \frac{1-\gamma}{1-\gamma} \pi_{t+1}^{-\gamma} \left[p_{t+1}^{tree} g(t) - p_{t+1}^{food} y - I \right] \right\} \quad (8$$

By omitting the $\frac{1-\gamma}{1-\gamma}$ from both sides of the equation, equation (9) derives as:

$$\pi_t^{-\gamma} = \beta E \left\{ \pi_{t+1}^{-\gamma} \left[p_{t+1}^{tree} g(t) - p_{t+1}^{food} y - I \right] \right\} \quad (9$$

After other mathematical operations and following Hansen and Singleton (1982), equation (9) transforms to:

$$E_t \left\{ 1 - \beta \left\{ \left(\frac{\pi_{t+1}}{\pi_t} \right)^{-\gamma} \left[p_{t+1}^{tree} g(t) - p_{t+1}^{food} y - I \right] \right\} \Big| \Omega_t \right\} = 0 \quad (10$$

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Equation (10) reflects the tree planting decision-making model considering information available for the farmer at the time of planting. This includes price information that shapes the farmer's expectations or price forecasting as well as the age of the farmer, farm size, and government policy at the time of planting. Equation (10) shows that the farmer's decision about the number of trees to plant (or the share of land allocated to the trees) is based upon information that includes individual characteristics of the farm, price expectations, and government policy.

Empirical Model

Equation (10) suggests a correlation between price and the choice variable. The empirical model (regressions) could be easily motivated in different ways. Indeed, equations (1) to (10) only are intended to formalize the discussion (and they really are useful in this way), but they are not needed if one only wanted to start with the regression analysis.

We used multiple regressions to relate the number of almond trees planted to price, government policy, and farm-specific information. Almond trees are the most widely cultivated tree in the study area, accounting for 90 per cent of all trees planted during 1995-2004. These years were employed in this study to relate the farmer's decision about the number of almond trees to plant with a one-year forecasted change in almond price and an expected one-year change in the guaranteed price of wheat. Different methods of exponential smoothing were examined to forecast the year ahead's almond price during the period 1995-2004, including: ARIMA, simple exponential smoothing, exponential smoothing with linear trends, exponential smoothing with exponential trends, and exponential smoothing with damped trends. After using SHAZAM to test the stationary degree of series and the Dicky-Fuler test, we identified that using ARIMA required the price data from 1971. Because price information only is available from 1985, the ARIMA method was not used, so the best method was selected from among the four exponential smoothing methods. Using STATISTICA software and MAPE as an index, the exponential smoothing method with linear trends was the best method of forecasting, so we used it to obtain forecasting prices from 1994-2005.

Empirical analysis was restricted to a two-crop portfolio that included almonds and wheat. The dependent variable was the number of trees planted in a particular year. To find the best empirical model, we estimated all of the linear and logarithmic forms with OLS. Different indexes to select the best functional form and goodness of fit included significance of coefficient by t-ratio, model significance by F-ratio, to accord the sign of variables with theoretical expectations, goodness of fit measurement (R^2), and adjusted goodness of fit ($\overline{R}^2$).

Other indexes in comparison to the goodness of fit between different models —the AIC index, the Ramzy test and, the COX-BOX test — were tested for this model. The logarithmic functional form, in comparison with linear and log-linear models, had the highest significant coefficients and the greater number of (R2) and ($\overline{R}^2$). The AIC of this form is less than the other forms. The COX-BOX test identified that the linear form was rejected and the logarithmic form was accepted. These dependent and explanatory variables appear as the equation:

$$LN(NTree) = a_0 + a_1 LN(Age) + a_2 LN(Fz) + a_3 LN(P_a^e) + a_4 LN(P_w^e) + a_5 PUW + \varepsilon_i$$

In the above equation, NTree is the number of trees planted by individual farmers, Fz indicates farm size, P_w^e is the expected change in wheat price, P_a^e shows the forecasted change in almond price, and PUW denotes a permit for water use. If the farmer at the time of planting had permission for water retrieval, PUW is one; otherwise, it is zero. This parameter indicates the effectiveness of government water policies.

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RESULTS AND DISCUSSION

The regression results reported in Table 3 indicate that, on average, the number of almond trees planted was positively and significantly correlated with the size of the farm at the time of planting. Consequently, farmers with larger farms planted a greater number of almond trees. In terms of economic impact, a one per cent increase in farm size at the sample mean was associated with a 0.5 per cent increase in the number of trees planted. Older farmers tended to plant fewer trees than younger farmers, although the age coefficient is not significant.

This study did not find any significant relation between contemporary almond prices and planting patterns but, as expected, forecasted almond price changes indicated a positive and significant relationship with the number of trees planted. Therefore, in choosing a perennial crop like almond trees, future prices affected farmers' decisions. The regression coefficient of expected change in the guaranteed price of wheat showed that a one per cent increase in guaranteed price is associated with a 0.44 decrease in the number of trees planted. In invariable conditions, government policy in price support of wheat had a diminishing effect on the number of trees planted.

This model shows a significant difference with permission for water use. Farmers with permission for water retrieval from the Zayanderood River at planting time planted more trees than those who did not hold a permit. Models incorporating current prices failed to produce statistically significant results, so these variables were omitted from the final model.

Results presented in Table 3 indicate that farm characteristics in terms of farm size, government policy in granting water use permits to farmers, and expected price changes during 1995-2005 correlated with almond planting decisions. Farm size is strongly associated with the number of trees planted. When and if the government announces that the price of wheat will increase in the coming year, farmers may decide to plant fewer trees and replace almonds with wheat in their portfolio. Similarly, this study shows that, during periods in which a simple forecast would predict an upturn in almond

Table 3. Almond planting regression result.

Dependant variables	Coefficient	t-statistics
Constant	*** 7.37 (1.32)	5.55
Farmer Age at planting time (years)	-0.2 (0.24)	-0.86
Farm Size(hectares)	***0.5 (0.78)	6.43
One-year forecast of almond price change (Rial per kilogram)	*0.15 (0.83)	1.9
One-year expected change in Guaranteed price of wheat (Rial per kilogram)	**-0.44 (0.17)	-2.55
Permission use of water (dummy variable)	*** 0.45 (0.15)	2.93
R^2=0.32		
$\overline{R}^2 = 0.27$		
F=7.12		
DW=1.9		
Number of observations=80		

Note: Standard errors in parentheses
*Coefficient is significantly different from zero at the 90% confidence level
** Coefficient is significantly different from zero at the 95% confidence level
*** Coefficient is significantly different from zero at the 99% confidence level

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prices, tree planting would increase. Results show that, in a trade-off between wheat as a staple food crop and almonds as a commercial crop, farmers preferred to plant almonds although the wheat price consistently increased during the time period. The majority of farmers selected almonds on the basis of appropriate export markets and a non-price government policy about water retrieval and provision of land for almond planting, even though wheat is still cultivated in different ways such as small blocks and alley cropping between almond rows.

If the government changes its water policy and wheat prices continue to increase, the economic advantage of almonds will be reduced, and people will tend to cultivate wheat again. More income and appropriate markets joined with favourable government policies about water and provision of land for farmers led to the results observed in this survey.

In achieving the objectives of the Fourth Development Plan in Iran, increasing the area of trees planted by farmers, in the short term results in more acreage planted; in the medium term, it induces more production. Identifying the factors that affect the number of trees planted by farmers is important in national and regional planning, particularly for ensuring the sustainability of projects.

Established almond orchards in Saman have the potential to reduce the rate of soil erosion. Future research on the quantity of this impact would be helpful in policy-making for watershed management projects. Our regression findings indicate that smallholder portfolios could be shifted in favour of almond planting even if policy changes to increase the staple grain price. It appears that government policies on almond planting are incompatible with the price support of wheat due to a diminishing effect of positive change in the guaranteed price of wheat on the decision to plant almonds.

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عوامل اقتصادی مؤثر بر تصمیم کاشت بادام در زمینهای شیبدار سامان، ایران

س. ص. حسینی، م. طهماسبی و غ. ر. پیکانی

چکیده

مقاله حاضر، عوامل مؤثر بر تصمیم کاشت درخت بادام در منطقه سامان استان چهارمحال و بختیاری در مرکز ایران را طی جمع‌آوری اطلاعات اقتصادی انجام شده در سال ۲۰۰۵ مورد بررسی قرار می‌دهد. در این مطالعه، تعداد درختان بادام کاشته شده به‌وسیله هر کشاورز در فاصله زمانی ۱۹۹۵ – ۲۰۰۵ ، متغیر اصلی تحقیق است. با به‌کارگیری تئوری پرتفوی سرمایه‌گذاری و تخمین مدل اقتصادی، مقاله حاضر مهمترین عوامل مؤثر بر تصمیم کشاورزان به کاشت درخت بادام در سامان را معین نمود. نتایج تحقیق حاضر نشان می دهد که اندازه مزرعه، اجازه برداشت آب از رودخانه زاینده رود، پیش‌بینی تغییر قیمت بادام در سال آینده و تغییر مورد انتظار در قیمت تضمینی گندم به عنوان رقیب بادام در استفاده از زمین و آب در سال پس از تصمیم به کاشت، تأثیر معناداری بر تعداد درختان بادام کاشته شده به‌وسیله هر کشاورز داشته است. همچنین نتایج این تحقیق، لزوم توجه سیاست‌گذاران این بخش را به اثر منفی روند افزایش قیمت گندم بر تعداد درختان کاشته شده نشان می‌دهد. مقاله حاضر به شکل غیر مستقیم، مطالعات بیشتر روی تأثیرات مثبت زیست محیطی کاشت درخت بادام را بویژه بر کاهش فرسایش خاک در حاشیه زاینده‌رود توصیه می کند.

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