Adoption of new seed varieties under production risk: an application to rice in Iran

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Abstract

This paper focuses on linkage between new rice seed varieties and production risk and also factors affecting adoption of these varieties in Iran. Farm-level data were collected from a sample of 154 rice farms located in two major districts of Fars province in Southern Iran for 2001-02. The risk-premium associated with the use of seed is estimated following by analyzing a moment-based production risk approach. The results show that the risk premium increases with new seed varieties in the lack of appropriate production conditions implying that new seed varieties is a risk-increasing input and involves a higher cost of risk. However, under suitable production conditions, the cultivation of new rice varieties on average ensures greater yield and at the same time involves less risk as measured by the risk premium. Also, results indicate that the farmer-specific relative risk premium proxies for the risk attitudes of each farmer have negative and significant effect on the decision to adopt new seed varieties. Therefore, farmers that are more risk-averse with respect to their use of seed are less likely to adopt new seed varieties and allow them to decrease their production risk arising from seed requirements.

Keywords: Production risk, moments-based estimation, new seed varieties, rice, Iran.

JEL: D8, Q12, Q16

Introduction

The results of many studies showed that there is a reason that as the cultivation of high-yielding varieties seeds involves both higher average yield as well as higher yield fluctuation compared to the cultivation of traditional seeds, it is rational on the part of a risk averse farmer to allocate his available land between two technologies rather than completely switching to the cultivation of the former. This argument presumes that high-yielding varieties cultivation involves greater risk compared to traditional cultivation. Whilst it maybe due to many factors including in the early stages of introducing new seed varieties, the farmers' perception of risk are associated with lack of information of and incomplete learning about new technology (Saha, 2001) and also, high-yielding varieties are more sensitive to farm managerial-specific factors (including dates of planting, irrigation and chemical poisons, amount of applied fertilizers and seed, the numbering of applied fertilizers and water level fluctuation) compared to traditional seed types. So, risk associated to the technology is not always related to the high-yielding varieties technologies but also in practice is highly dependent to the mentioned factors, the matter of which is ignored by most of the previous studies (e.g. Dillon and Anderson, 1971; Just and Pope, 1979; Feder et al., 1985; Sasmal, 1993; Panell et al., 2000). Considering these factors to study risk comparison of alternative rice seed technologies is the main contribution of this paper.

In this context, the purpose of this study is to evaluate individual risk preferences, risk comparison of alternative rice seed technologies and evaluate rice farmer's decision to adopt new seed varieties.

Materials and methods

The risk-premium associated with the use of new rice seed varieties is estimated by adapting a moment-based approach introduced by Antle (1983, 1987) and Kim and Chavas (2003). The farmer's program can be equivalently written as the maximization of a function of moments of the profit distribution, F(.):

$$\text{Max}_X : EU(\pi) = F[\mu_1(X), \mu_2(X), \ldots, \mu_m(X)], \qquad (1)$$

where μ_j (j = 1, 2, . . . , m) is the jth moment of profit and $\pi = A \times (P \times Y - C)$. A denotes acreage of rice, P is price of output, Y is yield per ha and $C = c(Y(X_i, t, e), X_i, t, e))$ is cost per ha of rice production depending on input choices X_i, technology *t*, and production uncertainty *e*.

The cost of private risk bearing can be measured by the sure amount *R* satisfying:

$$EU(\pi) = U[E(\pi) - R] \qquad (2)$$

where $[E(\pi) - R]$ is the certainty equivalent of profit as is also stated by Pratt (1964) and Hardaker et al., (2004). *R* is the risk premium measuring the largest amount of money that decision maker is willing to pay to replace the random variable π by its expected value $E(\pi)$. Risk aversion implies that $R > 0$, and corresponds to a concave utility function: $\partial^2 U/\partial\pi^2 < 0$ (Pratt, 1964). In general, the certainty equivalent, $E[\pi(x, t, .)] - R(x, t)$, depends on input use *x* and technology *t*.

In a similar fashion, Kim and Chavas (2003) proposed to investigate the effects of technological change on risk exposure. They indicated that the risk premium can be approximated by:

$$R_1 = 1/(A \cdot U^1) \cdot [-\Sigma \, (U^j/j!) \cdot (A^{j} \cdot \mu_{j\pi})] \qquad (3)$$

where $U^j = (\partial^j U/\partial \pi^j)(E(\pi))$ is the jth derivative of U with respect to profit π, evaluated at $E(\pi)$, $j = 1, \ldots, m$, $m \geq 2$. Note that $\mu_{j\pi}$ is the jth central moment of π. Thus, expression (3) provides an approximate measure of the risk premium as a function of the first m moments of profit. When $m = 2$, this gives the approximation obtained by Pratt (1964).

In order to utilize equation (3) for $m = 3$ and to evaluate the cost of risk, we need to know the decision-maker's risk preferences. Assuming that the decision maker's risk preferences exhibit constant relative risk aversion (CRRA), with utility function $U(\pi) = \pi^{1-\lambda}$ when $(1 - \lambda) > 0$, and $U(\pi) = -\pi^{1-\lambda}$ when $(1-\lambda) < 0$, $\lambda > 0$ being the relative risk aversion coefficient (Pratt, 1964), we have equation 4 where $\theta_{jk} = -[(\partial F(X)/\partial \mu_j(X))/(\partial F(X)/\partial \mu_1(X))] \times (1/j!)$, $j = 1, \ldots, 3$:

$$\partial \mu_1(X)/\partial X_k = \theta_{1k} + \theta_{2k} \cdot \partial \mu_2(X)/\partial X_k + \theta_{3k} \cdot \partial \mu_3(X)/\partial X_k + u_k \qquad (4)$$

and u_k is the usual econometric error term. θ_{2k} and θ_{3k} are directly related to the theory of decision under risk as $(2\theta_{2k})$ and $(-6\theta_{3k})$ are good approximations of Arrow-Pratt and down-side coefficients of risk-aversion respectively. The risk-premium is then derived as follows:

$$RP_k = \mu_2 \cdot (AP_k/2) - \mu_3 \cdot (DS_k/6) \text{ for each k} \qquad (5)$$

where μ_2 and μ_3 are respectively a measure of the second- and third-order moments of the distribution.

Farmer's attitudes towards risk derived farm-specific relative risk premia are used in the second stage. In particular, they are used to construct the explanatory variable that proxies risk attitudes. This variable is then included in the discrete choice model that

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explains the probability of technology adoption as a function of risk attitudes, farmer-specific socio-economic characteristics and farm-specific qualitative and financial characteristics.

Finally, we used the relative risk premium to estimate a probit model to investigate whether risk attitudes affect the decision to adopt new seed varieties.

Data and variables

Applying a two-stage cluster sampling, 2001-02 farm-level data were collected from a sample of 154 rice producers in Firouzabad and Marvdasht, two major districts of Fars province in Iran. The data contains various economic and cultural variables among which the followings are included in the estimations. X_1: Acreage of rice (ha), X_2: nitrogen fertilizers (kg/ha), X_3: phosphate fertilizers (kg/ha), X_4: seed (kg/ha), T: Dummy variable of new seed varieties, D: Dummy variable for years 2001 and 2002.

Results and discussions

The estimated expected profits by location are presented in Table 1. The coefficients associated with new seed varieties *T* are statistically significant and have expected signs. As shown, there are statistically significant and positive relationship between the variance of profit and new seed varieties. The relative risk premium R_1 was found to increase with new seed varieties. The risk premium was decomposed into two parts: one due to the second moment (variance) and the other due to the third moment (skewness) of rice profit. This provides some insights on the relative role of variance versus downside risk exposure (as captured by the third moment) in the evaluation of the cost of risk. The researchers examined the statistical significance of the new seed

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varieties *T* on the relative risk premium by regressing relative risk premium on the new seed varieties at each mentioned district.

Table 1. GLS estimates of three central moments of rice profit

Firouzabad

	First moment		Second moment		Third moment	
	Coefficient	T-value	Coefficient	T-value	Coefficient	T-value
Constant	29.4	1.29^{ns}	1.56	2.49^{**}	1.58	1.81^{*}
X_1	-1007.1	-2.42^{**}	-24517.7	-2.66^{**}	-12166.2	-1.76^{*}
X_2	471.2	1.89^{*}	-742.19	-1.33^{ns}	-4732.79	-1.67^{*}
X_3	-1309.2	-2.32^{**}	-0.71	-0.85^{ns}	423.7	0.87^{ns}
X_4	2124.8	2.79^{**}	322.82	2.26^{**}	17.23	1.72^{*}
X_1^2	522.0	2.26^{**}	713.59	2.47^{**}	-225.77	-0.95^{ns}
X_2^2	-0.11	-1.99^{*}	2.174	1.25^{ns}	12.63	1.46^{ns}
X_3^2	2.19	1.82^{*}	0.22	1.21^{ns}	-2.058	-1.62^{*}
X_4^2	-502.4	-2.67^{**}	1.23	0.97^{ns}	874.74	1.98^{*}
D	80.7	0.98^{ns}	227.31	0.42^{ns}	791	0.78^{ns}
T	1.53	1.89^{*}	3.73	2.87^{**}	-4.91	-1.73^{*}
R^2	0.64		0.52		0.39	

Marvdasht

	First moment		Second moment		Third moment	
Constant	-2.9	-2.45^{**}	0.95	1.94^{*}	0.75	1.76^{*}
X_1	-2236.2	-2.19^{**}	7060.62	1.89^{*}	-684.22	-1.94^{*}
X_2	13080.3	6.38^{***}	-1266.5	-1.87^{*}	-1408.58	-1.45^{ns}
X_3	-1726.8	-1.99^{*}	453.77	1.35^{ns}	635.98	1.24^{ns}
X_4	1236.4	2.88^{**}	-232.15	-1.93^{*}	1397.71	1.39^{ns}
X_1^2	125.3	1.93^{*}	-181.98	-1.94^{*}	-35.4	-1.78^{*}
X_2^2	-30.9	-4.43^{***}	2.39	1.56^{ns}	3.1	1.36^{ns}
X_3^2	5.2	2.47^{**}	-0.415	-1.18^{ns}	-1.087	-1.24^{ns}
X_4^2	-984.7	-2.46^{**}	1197.12	2.85^{**}	-1142.01	-1.43^{ns}
D	192.0	1.18^{ns}	351.73	0.76^{ns}	479.15	0.91^{ns}
T	-0.92	-1.98^{*}	0.42	1.15^{ns}	-2.73	-2.67^{**}
R^2	0.74		0.39		0.33	

*, ** and *** significant at the 10%, 5% and 1% levels and ns = non significant

The estimated risk-aversion measures are shown in Table 2. The θ_{2k} parameter associated with the second moment (variance) of profit is positive and significant, which indicates that farmers exhibit Arrow-Pratt risk aversion, i.e. they are willing to

sacrifice a proportion of their expected profit in order to avoid the risk associated with seed input in their production. The parameter linked to the third moment (skewness or downside risk) of profit is negative and significant, revealing that farmers also exhibit down-side risk aversion and so they are risk averse to a profit distribution that is skewed towards negative values.

Table 2. Estimation results of the risk-aversion measures in studied areas

	Constant	θ_{2k}	θ_{3k}	R^2
Firouzabad	-0.073 (0.044)*	3.15 (1.72)*	-2.08 (0.88)**	0.71
Marvdasht	-0.64 (0.386)*	2.26 (1.28)*	-2.16 (0.94)**	0.77

Standard errors are in brackets.
* and ** significant at the 10% and 5% levels.

Risk comparison of alternative seed technologies

As, risk associated to alternative seed technologies in rice cultivation is examined in this study by farmer-specific relative risk premium proxies for the risk attitudes of each farmer and through several scenarios. Table 3 represents the relative risk premium for alternative high-yielding and traditional varieties of rice in the studied areas.

Table 3. Relative risk premium of alternative seed technologies scenario

	Relative risk premium	
	new seed	traditional seed
$D_1=0$ and $D_2=0$	3.57	2.66
$D_1=1$ and $D_2=0$	2.29	2.48
$D_1=0$ and $D_2=1$	1.77	2.26
$D_1=1$ and $D_2=1$	1.34	2.09

To create a representative scenario which dummy variables D_1 and D_2 were set at zero that they denote to date of first irrigation and date of planting and seedling aren't suitable respectively.

When $D_1=0$ and $D_2=0$, the cultivation of traditional seeds have a lower relative risk premium than cultivating new seed varieties. This means that cultivation of traditional seeds is a less risky input than cultivating new seed varieties. This is in a reverse direction if production conditions are suitable (e.g. when D_1 and/or D_2 equal one and refer to date of first irrigation and/or date of planting and seedling is suitable respectively.

The determinants of new seed varieties

In this section, the relative risk premium is used to the estimation of the choice model in order to investigate whether risk attitudes affect the decision to adopt new seed varieties. The value of the derivatives was calculated at the mean values of all the independent variables that are shown in Table 4 and represent the marginal effects of each regressors and approximate changes in the probability of adoption at the regressors' means. The results show that the farmer-specific relative risk premium proxies for the risk attitudes of each farmer have a negative and significant effect on the decision to adopt new seed varieties. That is, farmers that are more risk-averse with respect to their use of seed are less likely to adopt new seed varieties that allow them to decrease their production (yield) risk arising from seed requirements. Farmers with higher debt ratio are more likely to adopt the new technologies. The participation of the farmers in extension classes has significant effect on the probability to adopt the new technologies.

Table 4. Marginal effects on the probability of adoption

Variables	Parameter	Standard Error
Farm's size	0.031	0.035^{ns}
Farmer's age	-0.057	0.030^{*}
Farmer's education	0.047	0.021^{**}
Farmer's experience	0.054	0.117^{ns}
Land ownership	-0.015	0.679^{ns}
No. of land parcels	-0.010	0.021^{ns}
Participation times at extension classes	0.153	0.085^{*}
Production cooperative membership	0.022	0.024^{ns}
Farm's debt ratio	0.329	0.172^{*}
D_1	0.286	0.196^{ns}
D_2	0.242	0.187^{ns}
Relative Risk Premium	-0.097	0.043^{**}

Note: *,** and *** significant at the 10%, 5% and 1% levels and ns = non significant

This may be attributed to the fact that extension classes are more related to high yield varieties. As indicated in Table 4, the more educated the farmer is the higher the probability that he/she adopts new technologies, while the older the farmer the less inclined he/she is to adopt new seed varieties.

Policy implications and recommendations

The weak success of new agricultural technologies in improving productive efficiency in some developing countries is often attributed to a lack of ability and/or willingness to adjust input levels on the part of producers, due to familiarity with traditional agricultural systems (Schultz, 1969) and/or the presence of institutional and cultural constraints. This suggests that a negative relationship may exist between technical progress in conventional agriculture and realized efficiency gains.

The results of this study showed that the risk premium increases with new seed varieties in the lack of suitable production conditions. This implies that new seed varieties are risk-increasing input that involves a higher cost of risk and exposure to downside risk

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increases by these varieties. This consists with the view that modern seed-fertilizer technology involves greater risk compared to traditional cultivation. Risk has often been considered as a major factor reducing the rate of adoption of any kind of innovation. Under suitable production conditions, however, the cultivation of new rice varieties ensures greater average yield compared to traditional rice varieties and also involves less risk as measured by the risk premium.

Findings also indicated that the farmer-specific relative risk premium proxies for the risk attitudes of each farmer have negative and significant effect on the decision to adopt new seed varieties. Thus, the risk-averse farmers are less likely to adopt new seed varieties and allow them to decrease their production risk arising from seed requirements.

To study risk comparison of alternative rice seed technologies, the farm managerial-factors such as dates of planting and amount of applied fertilizers and seed in the farms should be taken into account. The reason is that risk associated to the technology is not always related to the high-yielding varieties technologies but also in practice is highly dependent to these types of factors.

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