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Instability, Supply Response and Insurance in Oilseeds Production in India

L.M. Pandey, Sant Kumar and Mruthyunjaya*

Abstract

Yield and price instability and covariate risks have been examined for major oilseeds, viz. groundnut, rapeseed/mustard, sunflower and soybean, in selected states of India using time series data. Risk behaviour and effects of price and price risk on production have been analyzed in a rational expectations framework. The study has also estimated social gains from yield and revenue insurance in oilseeds. While instabilities in yield, prices and gross return have shown mixed responses, covariate risks have increased. The results of econometric analysis have indicated that the expected prices and price risk are important determinants of oilseeds production. Price elasticities of oilseed production have been found to vary between 0.26 and 0.88 and price risk elasticities of production between –0.006 and –0.07 in different Indian states. The potential efficiency gains from insurance schemes based on rainfall and other meteorological variables have been estimated to be 17.5 to 43 per cent over self-insurance in oilseeds production.

Key words: Oilseeds, instability, covariate risks, rational expectation, production response, risk effect, insurance market, social benefits

1. Introduction

The changing agriculture and economic environment may cause changes in incentives and risks associated with oilseeds production. The post-TMO strategy of integrating marketing and price support with technology diffusion paid rich dividends (Acharya, 1993). A relatively favourable price environment for oilseeds prevailed and minimum support price (MSP) for

* National Centre for Agricultural Economics and Policy Research, Pusa, New Delhi – 110012

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foodgrains were kept in check till early 1990s. As a result, India improved its production performance notably and was able to contain imports of edible oils. During 1986-94, production of oilseeds increased at the rate of 8.2 per cent per annum with 4.9 per cent growth in area and 3.1 per cent growth in productivity. The subsequent period, however, saw a significant turn around. Since mid-1990s, oilseed prices declined relative to other crops due to availability of cheaper edible oils in the international market and rationalization of tariff structure. During 1995-2004, the production of oilseeds declined annually by 1.2 per cent with decline in area by 1.8 per cent and a positive productivity growth of 0.6 per cent.

Currently, a large fraction (more than 40 per cent) of domestic demand for edible oils is being met through imports. The import of edible oils and oilseeds is likely to increase in the coming years with continued growth in domestic demand and further liberalization of trade. The world prices of edible oils are, however, more volatile than domestic prices and may expose oilseed producers to higher financial risks (Srinivasan, 2004). Since the production of oilseeds depends on the expected future prices, the production instability may further cause domestic price volatility. Highly volatile international prices and unstable yields of oilseeds may cause further disruption in production and consumption patterns in the country. The increasing importance of behavioural and policy-induced yield/return variability demands a different strategy for the domestic oilseed sector in the coming years.

Price incentives along with suitable mechanisms for management of price and yield risks could be critical components of new policy strategy for improved production performance and growth in the oilseed sector. Better understanding of pattern in yield/revenue variability, farmer's expectation and response behaviour to the changing incentive environment and effects of price and price risks in oilseeds production are, therefore, essential for internalizing them into policy designing. There is also a need to assess the expected gains from development of appropriate market for production/revenue insurance in the changed environment.

The present study has analysed instability in yield and prices and covariate risks, has examined risk behaviour and effects of price and price risk on production in a rational expectation framework and has estimated gains from market for yield/revenue insurance for major oilseeds.

2. Methodology

2.1. Data

This study has been based on data on area, production and farm-harvest prices of major oilseeds collected from various sources for the period 1980-

81 to 2001-02. Crops covered in this study were: groundnut in Andhra Pradesh and Gujarat, rapeseed and mustard in Punjab and Rajasthan, sunflower in Karnataka and Maharashtra and soybean in Madhya Pradesh. Farm-harvest prices and gross returns were transformed to constant prices (at 1993-94 prices) for analysis of prices and price risk.

2.2. Model Specification and Estimation Procedure

Effect of risk on agricultural production and price relationships is a growing area of research (Just, 1974; Binswanger, 1980; Heady and Bhide, 1983; Roe and Antonovitz, 1985; Brorsen *et al.*, 1987; Aradhyula and Holt, 1989; Dillon and Andersen, 1990; Holt and Aradhyula, 1990; 1998). Various methodologies have been developed to incorporate the expected mean and variance of risk variables in agricultural production and output supply decisions. We have used the method of generalized autoregressive conditional heteroskedastic (GARCH) process to derive the expected prices and price risks in oilseeds production. The risk-responsive price-production model was estimated with GARCH process [Equations (1)-(3)] :

$$PDN_t = a_0 + a_1 PRC^e_t + a_2 PRC^v_t + a_3 PDN_{t-1} + a_4 AOL_{t-1} + \xi_{1t} \quad \ldots(1)$$

$$PRC_t = b_0 + b_1 PRC_{t-1} + \xi_{2t} \quad \ldots(2)$$

$$h_t = \alpha_0 + \alpha_1 \xi^2_{2t-1} + \beta_1 h_{t-1} \quad \ldots(3)$$

where, PDN_t is oilseed production in period t, in thousand tonnes; PRC^e_t is the expected farm-harvest price of oilseed in time t, viewed from period t-1, in Rs/q; PRC^v_t is the expected variance of the farm-harvest price of oilseed in time t, also viewed in time t-1; PDN_{t-1} is the oilseed production during period t-1, in thousand tonnes; AOL_{t-1} is the area under edible oilseeds in period t-1, thousand hectares; PRC_t is the farm-harvest price of oilseed in time t, in Rs/q; PRC_{t-1} is the farm harvest price of oilseed in period t-1, in Rs/q, and ξ_{1t} and x_{2t} are error-terms and h_t is the conditional variance of ξ_{2t}.

The expected farm-harvest prices of oilseeds in the production equation (1) were obtained by evaluating the left-hand side of Eq. (2) and its coefficient was expected to be positive. The conditional price variance term in production equation (1) was obtained by substituting the right-hand side of Eq. (3) for PRC^v_t and its coefficient was expected to be negative.

The following portfolio-based insurance model (*see* Pandey *et al.*, 2004) was estimated to obtain social benefits from yield/revenue insurance in oilseeds:

(i) Demand for insurance: $\Omega = \vartheta - \Lambda\lambda$

(ii) Supply of insurance: $\Lambda = \omega/\varphi\Gamma\eta + \chi\psi^{0.5}$

(iii) $\lambda = [(1 - \vartheta) / (1 - \Lambda)]$

where, Ω is the amount of insurance purchased (i.e. proportion of risk insured), ϑ is correlation between the producer's risk (negative of income fluctuation) and indemnity, Λ is normalized price of insurance, λ is parameter estimated, ω is administrative cost as a proportion of actuarial premium, φ is risk aversion parameter for farmer, Γ is coefficient of variation of farmer's income stream, η is relative size of the outside pool of insurer, χ is relative risk aversion parameter of the insurer, and ψ is the spatial correlation of insured event (insurer's risk). The values of various parameters in the system were estimated through iterative method.

In a framework of with and without insurance, the efficiency gain from insurance due to reduction in cost of risk-bearing with risk-pooling was estimated using Eq. (4):

$$(C_0 - C)/C_0 = 1 - \lambda - \Lambda\Omega \qquad \ldots(4)$$

where, C_0 is the base cost (i.e. cost of self-insurance) and C is the cost of portfolio with insurance scheme.

3. Results

3.1. Instability in Yield and Prices of Oilseeds

Average productivity, farm-harvest prices and instability during the period 1986-87 to 1993-94 (Period I) and 1994-95 to 2001-02 (Period II) were analyzed for the major oilseeds in selected states of India. Except for groundnut in Andhra Pradesh, yield of oilseeds in the selected states were higher during the Period II (Table 1). The yield instability in terms of coefficient of variation (CV) showed a mixed response in groundnut. It increased in Andhra Pradesh and declined in Gujarat during Period II. The instability of yield increased in the case of rapeseed and mustard and decreased in sunflower and soybean.

The prices of oilseeds decreased in all the selected states during Period II as compared to those in Period I, except for sunflower in Karnataka. The price instability increased in the cases of rapeseed and mustard in Punjab, sunflower in Maharashtra and soybean in Madhya Pradesh during Period II as compared to that in Period I. In all other cases, the instability in prices reduced. This may be due to the imports of cheaper edible oilseeds and oils during Period II, which kept prices of major oilseeds low but stable in the country.

Similarly, the average gross return per hectare decreased in the cases

Table 1. Instability in yield and prices of major oilseeds in selected states of India, 1986-87 to 2001-02

State	Periods	Yield (q/ha)		Price (Rs/q)		Gross return (Rs/ha)	
		Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
		Groundnut					
Andhra Pradesh	1986-87 to 1993-94	9.38	8.98	883	9.38	8253	8.46
	1994-95 to 2001-02	9.09	24.79	805	5.98	7273	23.01
	Overall	9.23	17.7	845	9.06	7763	17.17
Gujarat	1986-87 to 1993-94	7.05	71.43	1030	15.08	7589	84.46
	1994-95 to 2001-02	9.35	49.84	964	4.82	9026	50.24
	Overall	8.20	58.68	997	11.58	8307	65.03
Both States	1986-87 to 2001-02	8.72	40.92	921	13.42	8035	48.18
		Rapeseed and mustard					
Punjab	1986-87 to 1993-94	10.10	7.63	1069	10.55	10799	13.29
	1994-95 to 2001-02	10.99	13.00	926	11.62	10121	13.67
	Overall	10.54	11.34	997	12.95	10460	13.38
Rajasthan	1986-87 to 1993-94	8.32	10.36	948	9.93	7908	16.46
	1994-95 to 2001-02	8.71	12.11	872	8.01	7607	15.66
	Overall	8.51	11.13	910	9.7	7757	15.58
Both States	1986-87 to 2001-02	9.53	15.52	954	12.33	9109	20.66
		Sunflower					
Karnataka	1986-87 to 1993-94	4.73	24.83	856	41.24	3894	48.28
	1994-95 to 2001-02	5.18	19.24	904	11.97	4694	25.14
	Overall	4.95	21.64	880	28.64	4294	36.43
Maharashtra	1986-87 to 1993-94	3.73	15.04	973	11.48	3633	19.05
	1994-95 to 2001-02	3.90	9.64	898	11.66	3500	15.72
	Overall	3.81	12.23	935	11.88	3567	16.95
Both States	1986-87 to 2001-02	4.38	22.74	908	21.29	3930	31.07
		Soybean					
Madhya Pradesh	1986-87 to 1993-94	8.54	18.57	774	11.58	6628	23.81
	1994-95 to 2001-02	9.77	12.78	660	15.83	6526	25.38
	Overall	9.16	16.52	717	15.45	6577	23.65

of groundnut in Andhra Pradesh, rapeseed & mustard, and sunflower in Maharashtra, and soybean in Madhya Pradesh during the Period II as compared to that in Period I, except for groundnut in Gujarat and sunflower in Karnataka. The instability of gross return per hectare increased in the cases of groundnut in Andhra Pradesh, rapeseed and mustard in Punjab and soybean in Madhya Pradesh during the Period II as compared to that in Period I. In all other cases, it decreased during the same period.

In brief, the productivity of oilseeds has increased while the prices have decreased during Period II as compared to those in Period I. However, the instability in yield, prices and gross return per hectare has shown a mixed response.

3.2. Yield Correlation and Covariate Risk

The correlations and covariate risks for both yield and gross return increased during Period II as compared to those in Period I in all the cases (Table 2). The rising covariate risk may imply increasing synchronization of varieties and cultural practices in oilseeds cultivation across regions and agro-ecosystems. Modern varieties may be susceptible to the same kind of pest and weather stresses. The causal factors underlying patterns of yield/ revenue instability and covariate risks, therefore, need careful examination for effective interventions, including agricultural research priorities and economic policies.

Table 2. Yield correlation and covariate risk in oilseeds in selected states of India: 1986- 87 to 2001-02

Period	Yield (q/ha)		Gross return (Rs in thousand per ha)	
	Correlation	Covariance	Correlation	Covariance
Groundnut				
1986-87 to 1993-94	-0.44	-1.59	0.17	644
1994-95 to 2001-02	-0.16	-1.41	-0.13	-865
Overall	-0.23	-1.67	-0.07	-462
Rapeseed and mustard				
1986-87 to 1993-94	-0.12	-0.07	0.53	849
1994-95 to 2001-02	0.89	1.14	0.73	1027
Overall	0.59	0.62	0.63	989
Sunflower				
1986-87 to 1993-94	-0.03	-0.02	0.59	661
1994-95 to 2001-02	0.33	0.11	0.64	357
Overall	0.13	0.06	0.55	482

3.3. Effects of Prices and Price Risk on Oilseeds Production

The oilseeds production model with price risk and GARCH-generated expectations have been provided in Table 3 and Appendix I. The estimated coefficients in the conditional variance equations h_t are significant (Appendix I). All parameters in the production equations have theoretically correct signs and the estimated production equations also fit in the data well, as indicated by the high value of R^2 (Table 3). The coefficient of expected prices in oilseeds production equations are positive and significant, while expected price risks have negative and significant effects on oilseeds production in all the selected states. The result indicates that expected prices and price risk are important determinants of oilseeds production.

The price elasticities of production have been found positive and varied between 0.26 and 0.88 for major oilseeds (Table 4). The elasticities of price risks were negative and varied between –0.006 and –0.07 for different oilseeds in different states. These results imply the economic significance of price expectations and price risks.

Table 3. Maximum likelihood estimates of oilseeds production model with GARCH-generated expectations

State	Constant	PRC^e	PRC^v	$PDN_{(t-1)}$	$AOL_{(t-1)}$	R^2
			Groundnut			
Andhra Pradesh	-136.2*	1.241**	-0.125*	0.577	0.947***	0.807
	(52.005)	(0.704)	(0.047)	(0.446)	(0.698)	
Gujarat	-143.5*	1.363***	-0.438*	0.112**	0.359	0.692
	(53.806)	(1.017)	(0.159)	(0.064)	(0.288)	
			Rapeseed and mustard			
Punjab	-140.2*	1.771**	-0.175**	0.596***	0.122**	0.762
	(52.47)	(1.002)	(0.099)	(0.428)	(0.07)	
Rajasthan	-139.9*	1.415**	-0.589*	0.671	0.536**	0.842
	(50.36)	(0.795)	(0.219)	(0.538)	(0.305)	
			Sunflower			
Karnataka	-259.03*	0.154**	-0.113*	0.551***	0.288***	0.854
	(97.416)	(0.088)	(0.043)	(0.402)	(0.196)	
Maharashtra	-166.8*	0.185**	-0.342***	0.164**	0.975	0.784
	(63.884)	(0.105)	(0.226)	(0.094)	(0.651)	
			Soybean			
Madhya Pradesh	-107.4*	0.849*	-0.625***	0.913	0.529***	0.826
	(40.651)	(0.322)	(0.45)	(0.753)	(0.386)	

PRC^e = Expected farm-harvest prices; PRC^v =Expected variance of the farm-harvest prices; PDN_{t-1} = Oilseed production in period t-1; AOL_{t-1} = Total area under edible oilseeds in period t-1.

Figures within the parentheses are standard errors

*, **, *** indicate levels of significance at 1, 5, 10 per cent, respectively.

Table 4. Elasticites of oilseeds production for major crops at sample means: 1986-87 to 2001-02

State	Expected prices	Price Risk
	Groundnut	
Andhra Pradesh	0.588	-0.007
Gujarat	0.870	-0.029
	Rapeseed and mustard	
Punjab	0.644	-0.006
Rajasthan	0.885	-0.04
	Sunflower	
Karnataka	0.476	-0.042
Maharashtra	0.887	-0.074
	Soybean	
Madhya Pradesh	0.264	-0.029

3.4. Efficiency Gains from Insurance

The risk and correlation parameters used for estimation of potential gains in oilseeds production from insurance were taken from Tables 1 and 2. Following Pandey *et al*. (2004), we took risk aversion parameters of farmers as 0.3, administrative and information cost of providing insurance as zero and the correlation between indemnity paid and yield/ revenue loss against insured event as 0.9[φ]. Further, the probability of insolvency of farm business and the rate of interest on capital assets used in the model was considered as 5 per cent and 12 per cent, respectively, for estimation of efficiency gains from market insurance over self-insurance by farmers.

For yield as a target variable for insurance, the proportion of risk insured in oilseeds would vary between 65 and 79 per cent (Table 5). The potential efficiency gains from yield insurance varied between 17.5 to 37 per cent. The proportion of risk insured and the potential efficiency gains from insurance were, however, higher when revenue, i.e. gross return per hectare, was considered as target variable.

The proportions of risk insured varied from 68 to 83 per cent and the potential gains varied between 21 and 43 per cent in the case of revenue

[φ] It could be achieved through designing of technically sound insurance schemes based on rainfall and other indicators having favourable climatic conditions on crop productivity. The rainfall data and other meteorological information recorded by the meteorological department could be made available easily and without any extra cost to the insurance agency. It is expected that with the availability and application of modern information and communication technology in the field of agriculture such as remote sensing, precision science and crop growth simulation models, monitoring and implementation cost could be minimal along with increased precision and timeliness of indemnity payment.

Table 5. Proportion of risk insured and efficiency gains from insurance

Crop/ target variable	Proportion of risk insured	Efficiency gains (%)
Groundnut		
Yield	0.79	37.2
Gross return	0.83	43.4
Rapeseed and mustard		
Yield	0.68	21.2
Gross return	0.72	24.2
Sunflower		
Yield	0.78	35.0
Gross return	0.74	29.1
Soybean		
Yield	0.65	17.5
Gross return	0.68	21.3

insurance. The analysis indicates that specific peril insurance based on rainfall and other meteorological variables are viable in the case of oilseeds and that the society would be benefited significantly through such schemes. And, if rainfall (and other meteorological variables)-based crop insurance schemes are carefully designed to meet the financial needs of oilseeds growers, and offered on time with a reasonable administrative cost, its share in terms of coverage of total amount of production risk of oilseeds growers will be around 65 to 83 per cent. The social cost of risk bearing will be reduced by 17.5 to 43 per cent.

4. Conclusions

The economic environment and incentives are changing rapidly and farmers are responsive to these changes in the oilseeds sector. While instability in yield, prices and gross return have shown mixed responses, covariate risks have increased. The results of econometric analysis have indicated that expected prices and price risk are important determinants of oilseeds production. Based on available information on prices and price risk, farmers do form expectations regarding their magnitude and their future course of action. The prices have positive effects while price risks have negative effects on oilseeds production. The price elasticity of oilseeds production has been found to vary between 0.26 and 0.88 and price risk elasticity of production between –0.006 and –0.07 in different states of India. These results imply economic significance of price expectations and price risks and that these economic variables could play an important role in policy decisions to improve oilseeds production in the country.

The economic analysis of potential gains from crop insurance indicates that specific peril insurance based on rainfall and other meteorological variables is viable in the case of oilseeds and that the society would be benefited significantly through the provision of such schemes. And, if rainfall (and other meteorological variables)-based crop insurance schemes are carefully designed to meet the financial needs of oilseeds growers, and offered on time with a reasonable administrative cost, its share in terms of coverage of total amount of production risk of oilseed growers will be around 65 to 79 per cent in the case of yield and 68 to 83 per cent in the case of gross return. The social cost of risk bearing will be reduced by 17.5 to 43 per cent.

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Appendix I

Maximum likelihood estimates of price equation with GARCH process

State	Price Equation		GARCH Process			R^2	log likelihood estimate
	Const.	$PRC_{(t-1)}$	Const.	$et^2_{(t-1)}$	$h_{(t-1)}$		
			Groundnut				
Andhra Pradesh	684.1*	0.609	1.029*	0.244**	0.971*	0.779	-10.05
	(255.64)	(0.543)	(0.396)	(0.137)	(0.372)		
Gujarat	869.9*	0.727**	1.083**	0.109	0.113*	0.752	-10.81
	(355.74)	(0.412)	(0.604)	(0.097)	(0.043)		
			Rapeseed and mustard				
Punjab	755.3**	0.537**	0.827***	0.392***	0.232**	0.588	-19.74
	(427.21)	(0.307)	(0.6)	(0.265)	(0.133)		
Rajasthan	627.4*	0.339***	0.421***	0.161	0.747**	0.629	-10.03
	(237.74)	(0.202)	(0.286)	(0.126)	(0.423)		
			Sunflower				
Karnataka	514.7***	0.178*	0.403**	0.321	0.706**	0.787	-11.61
	(323.9)	(0.069)	(0.231)	(0.244)	(0.398)		
Maharastra	811.04*	0.143***	0.952**	0.171**	0.275***	0.686	-10.82
	(303.31)	(0.091)	(0.54)	(0.098)	(0.168)		
			Soybean				
Madhya Pradesh	621.1*	0.771***	0.995*	0.103***	0.187	0.539	-10.97
	(355.52)	(0.568)	(0.378)	(0.074)	(0.146)		

PRC_{t-1} is the farm-harvest prices in period t-1.
Figures within the parentheses are standard errors.
*, **, *** indicate levels of significance at 1, 5 and 10 per cent, respectively.