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Risk Consideration in Product Prices: An Expected Deviations Approach

Risk in crop production is a well-known phenomenon in less developing countries. It may appear as widely fluctuating yields from period to period, as unstable prices or as some combination of these two. Naturally, these are closely interrelated and constitute the income risk. These may have, irrespective of their causes, serious welfare and efficiency implications for the economy. The welfare implication of risk holds that wider temporal changes in prices and income affect the investment and rational planning of family living expenses. The efficiency implication of risk maintains that unexpected changes in prices and income lead to inefficient allocation of productive inputs and consumption expenditure (Lipton, 1970; Houck, 1973). In other words, risk in crop production not only impairs the growth of the agricultural sector, but also the sectors having strong linkage with agriculture.

Each of the above issues are subject to empirical investigation. But in this paper, we emphasise the importance of association of yield and price risks and its bearing on crop income. In particular, it is argued that risk should be included in product prices for (*a*) correcting crop production imbalances and (*b*) treating risk as a component of cost of cultivation. Specifically, the paper examines the (*a*) nature and magnitude of risk in crop production and (*b*) changes in output prices needed to cover the risk.

DATA AND METHODOLOGY

The scope of the present study is limited to the measurement of risk in the production of major crops in Uttar Pradesh. For this, time-series data on area, yield and prices pertaining to the period 1970-71 to 1986-87 were used. The data on area and yield per hectare were taken from various issues of Estimates of Area and Production of Principal Crops in India, while farm harvest prices and procurement prices[1] were collected from Farm Harvest Prices of Principal Crops in India and Fertiliser Statistics, respectively.

Measurement of Risk

For time-series data, the deviations from trend constitute the risk. Therefore, area, yield and prices adjusted for trend were taken for the measurement of risk.[2] The area under each crop was multiplied with corresponding yield (both net of trend) to get the production. Similarly, crop yield was multiplied with corresponding prices to get gross returns per hectare at farm harvest prices as well as procurement prices. Here it was assumed that year to year changes in gross returns represent the variability or risk in net income as prices of inputs and inputs used (hence cost of production) are known with certainty. The coefficient of variation was used to measure the magnitude of risk in area, yields, production and gross returns per hectare for all the crops.

$$\text{Coefficient of variation} = \frac{\left(\sum_{i=1}^{n}(X_t - \hat{X}_t)^2/n\right)^{1/2}}{\bar{X}} \times 100$$

where X_t is the actual value in the t th year, $\hat{X}_t$ is the trend value in t th year, $\bar{X}_t$ is the period mean of X and n is the number of years in the period.

The probability of actual yield and gross returns per hectare falling 5 per cent or more below their respective trend values were also estimated as:

$$Pr(\bar{X} + e_t \leq 0.95\bar{X}) = Pr(e_t/\sigma_e \leq -(0.5)\bar{X}/\sigma_e)$$

where e_t is the deviation from trend in t th year, and σ_e is the standard deviation of e_t. The average probability was obtained from the statistical table for the cumulative normal distribution.

Risk Equivalent Prices

Any deviation (positive or negative) from trend constitutes the risk for policy makers. But it is the negative deviation which is of prime importance for the farmers. Therefore, any policy option directed towards protecting farmers against risk should take negative deviations into consideration. In our approach, we calculated risk equivalent price which can be defined as an increase in output prices needed to compensate the shortfall in gross returns per hectare. This was calculated for both yield risk and price risk separately, using the expected negative deviations approach.

Expected annual negative deviation (for yield risk)[3] = Average absolute deviation in yield × Probability of shortfall in yield × Period mean of price

Expected annual negative deviation (for yield and price risk) = Average absolute deviation in gross returns per hectare × Probability of shortfall in gross returns,

where average absolute deviation $= \sum_{i=1}^{n}(X_t - \hat{X}_t)/n$

$$\text{Risk equivalent price} = \frac{\text{Expected annual negative deviation}}{\text{Average yield of recent three years}}$$

Risk equivalent prices were computed using both farm harvest and procurement prices separately. Here it is worth mentioning that risk equivalent prices (for yield and price risk) can also be calculated by dividing the average absolute deviation in gross returns per hectare by the average yield of recent three years. This approach compensates total shortfalls in gross returns. However, these prices would be slightly higher than that in the former. It is because of the fact that in the former approach only significant negative deviations are considered.

RESULTS AND DISCUSSION

Nature and Magnitude of Risk

Production: The coefficients of variation (CV) of area, yield and production of major crops for the period 1970-71 to 1986-87 are given in Table I. It shows that the CV of

production was markedly high in coarse cereals, pulses and oilseeds. On the contrary, it was fairly low in wheat, sugarcane and rice - the crops mostly grown on irrigated lands. Furthermore, the CV of production was, in general, higher for *kharif* crops than for *rabi* crops. The obvious reason for this is that insect pests which reduce the crop yields breed more rapidly in *kharif* season.

TABLE I. MAGNITUDE OF RISK IN THE PRODUCTION OF PRINCIPAL CROPS IN UTTAR PRADESH, 1970-71 TO 1986-87

Crop	Coefficient of variation (per cent) of					Probability of shortfall in			Average gross returns (Rs. per ha.) at	
	Area	Yield	Production	Gross returns per ha. at		Yield	Gross returns per ha at			
				FHP	PP		FHP	PP	FHP	PP
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Kharif										
Rice	2.96	7.29	13.03	12.02	5.77	0.25	0.34	0.19	1,572	1,002
Sorghum	5.07	26.11	26.78	25.84	28.25	0.43	0.43	0.43	643	596
Pearl millet	5.18	21.18	21.86	19.62	22.47	0.40	0.40	0.42	749	644
Maize	4.12	28.14	27.86	28.59	26.34	0.43	0.43	0.43	896	806
Ragi	8.52	16.42	8.52	24.97	14.41	0.35	0.42	0.36	938	865
Pigeon pea	5.82	19.20	19.70	42.10	-	0.40	0.45	-	2,325	-
Groundnut	19.14	22.55	29.21	29.77	-	0.41	0.43	-	1,558	-
Cotton	22.83	24.37	36.09	36.72	-	0.42	0.44	-	415	-
Jute	12.31	9.33	19.81	33.11	12.35	0.30	0.44	0.34	2,822	2,510
Sugarcane	7.94	10.58	11.03	22.49	14.68	0.32	0.41	0.37	6,737	5,334
Rabi										
Wheat	3.71	8.59	9.43	10.76	10.03	0.28	0.32	0.31	1,902	1,780
Barley	5.35	9.10	10.17	17.83	-	0.43	0.39	-	1,186	-
Gram	12.00	16.82	21.56	20.86	-	0.38	0.41	-	1,537	-
Rapeseed and mustard	12.35	14.39	16.28	16.59	-	0.36	0.38	-	1,671	-
Linseed	15.49	18.90	23.14	22.53	-	0.40	0.41	-	743	-
Potato	7.96	12.82	18.79	28.04	-	0.35	0.43	-	1,581	-

Note:- FHP = Farm harvest prices; PP = Procurement prices.

Table I further shows that for eight crops, *viz.*, rice, sorghum, pearl millet, maize, pigeon pea, groundnut, wheat and barley, the CV of yield was as high as CV of production and the CV of area was quite low. This means that unstable yield was the dominant cause of production variability in these crops. In the remaining crops, apart from yield, variability in area sown was also an important cause of production variability. Only in the case of jute, variability in area was the major cause of unstable production. From this, we may infer that in all the crops except jute, yield risk constitutes the major component of risk in crop production. However, the chances of occurrence of shortfall in yield varied from crop to crop, as indicated by the probability of shortfall in yield. It ranged from 0.25 for rice to 0.43 for barley. Thus frequency and magnitude of shortfall in crop yields were substantially high during the period under study.

Gross Returns: It can be further seen from Table I that average gross returns per hectare at farm harvest prices were higher than those at procurement prices for all the crops. This indicates that farm harvest prices did not fall below the procurement prices. The same holds true for the CV of gross returns. Furthermore, the CV and probability of shortfall in gross returns (at farm harvest prices) were substantially higher than those for yield in all the crops

except sorghum and pearl millet. This is contrary to the general belief that variability in gross returns at farm harvest prices should be low as an increase in price in poor harvest years compensates the decrease in crop yield. Therefore, year to year changes in prices should also be taken into consideration for protecting the farmers against risk.

Expected Negative Deviations in Gross Returns

An examination of expected negative deviations in gross returns (Table II) across the crops reveals two broad patterns. First, the negative deviations were high for high return crops and these were quite low for low return crops. This pattern did not change with the change in the nature of risk (yield or price) and the prices at which they were estimated. Secondly, the negative deviations were higher for yield and price risk together than those of yield risk alone for most of the crops. In fact, for five crops, *viz.*, rice, *ragi*, jute, sugarcane and potato, the negative deviations for yield risk were even less than 50 per cent of the deviations for yield and price risk together. This again emphasises the importance of price risk in crop production.

TABLE II. EXPECTED ANNUAL NEGATIVE DEVIATIONS IN GROSS RETURNS PER HECTARE FROM PRINCIPAL CROPS IN UTTAR PRADESH

(Rs.)

Crop	Yield risk		Yield and price risk (at farm harvest price)	Col. (2) as per cent of col. (4)
	At farm harvest price	At procurement price		
(1)	(2)	(3)	(4)	(5)
Kharif				
Rice	22.18	14.34	47.86	46.34
Sorghum	51.42	43.10	54.05	95.13
Pearl millet	46.51	39.03	42.33	109.87
Maize	84.44	73.14	78.34	107.79
Ragi	28.16	26.22	69.81	40.34
Pigeon pea	149.72	-	289.99	51.63
Groundnut	122.95	-	171.90	71.52
Cotton	33.49	-	46.02	72.77
Jute	63.38	58.31	273.51	23.17
Sugarcane	189.58	152.14	502.33	37.74
Rabi				
Wheat	33.20	30.47	45.19	73.46
Barley	35.78	-	69.86	51.22
Gram	78.98	-	94.75	83.36
Rapeseed and mustard	66.45	-	96.01	69.21
Linseed	34.01	-	50.20	67.75
Potato	206.71	-	550.99	37.52

Note:- Risk in farm harvest prices was considered as procurement prices are known in advance

Risk Equivalent Prices

Table III gives the risk equivalent prices for selected crops. As expected, in all the crops except pearl millet and maize, risk equivalent prices for yield and price risk were considerably higher than the corresponding prices for yield risk. Among the crops, risk equivalent prices for yield and price risk were high for cotton (Rs 29.31), groundnut (Rs 26.32), pigeon pea

(Rs 19.62) and linseed (Rs 19.38). In contrast, these were appreciably low for sugarcane (Rs 1.07), wheat (Rs 2.36), potato (Rs 3.40) and rice (Rs 3.55). A similar pattern was also observed for risk equivalent prices for yield risk.

TABLE III. RISK EQUIVALENT PRICES OF PRINCIPAL CROPS IN UTTAR PRADESH

(Rs./quintal)

Crop	Risk equivalent price		
	Yield risk		Yield and price risk (at farm harvest price)
	At farm harvest price	At procurement price	
(1)	(2)	(3)	(4)
Kharif			
Rice	1.64	1.06	3.55
Sorghum	6.53	5.47	6.86
Pearl millet	5.36	4.50	4.88
Maize	6.81	5.90	6.32
Ragi	2.61	2.43	6.47
Pigeon pea	10.13	-	19.62
Groundnut	18.83	-	26.32
Cotton	21.33	-	29.31
Jute	3.25	2.99	14.03
Sugarcane	0.40	0.32	1.07
Rabi			
Wheat	1.73	1.59	2.36
Barley	2.59	-	5.06
Gram	8.88	-	10.66
Rapeseed and mustard	11.89	-	17.17
Linseed	13.13	-	19.38
Potato	1.27	-	3.40

Note:- Risk in farm harvest prices was considered as procurement prices are known in advance

Impact of Risk Equivalent Prices on Output Supply and Factor Demand

The impact of risk equivalent prices on output supply and factor (fertiliser) demand was examined using the econometric approach. For this, price elasticities of output supply and factor demand were taken from Kumar and Mruthyunjaya (1989).[4] The results show that risk consideration in prices would increase the output supply as well as demand for fertiliser (Table IV). Interestingly, the increase in output supply is notably high in maize and gram - the crops with poor growth in production. This is because of increased returns on account of an increase in output price. As a result, the high risk crops would compete with other crops like wheat, rice and sugarcane for resources, which in turn would lead to a balanced crop production.

TABLE IV. IMPACT OF RISK EQUIVALENT PRICES ON OUTPUT SUPPLY AND FACTOR DEMAND

Crop	Percentage change in					
	Output supply			Fertiliser demand		
	I	II	III	I	II	III
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rice	1.10	1.08	2.38	1.89	1.84	4.09
Maize	7.78	7.60	7.22	12.50	12.21	11.60
Sugarcane	0.76	0.78	2.05	2.85	2.94	7.64
Wheat	1.22	1.11	1.67	2.32	2.11	3.17
Gram	3.19	-	3.83	*	*	*

Note:- I: Considering yield risk at farm harvest prices.
II: Considering yield risk at procurement prices
III: Considering yield and price risk at farm harvest prices
* Elasticities were not available

Risk Consideration in Prices vs. Crop Insurance

The risk consideration in product prices approach envisages risk parity among crops and hence balanced crop production. It is also expected that an increase in returns will enable the farmers to build their equity over time. This equity would protect the farmers in the years of crop failure. Crop insurance, on the other hand, effectively protects the farmers in case of crop failures. But premium is a cost to the farmers in normal crop years. For example, in rice and wheat, actual yield in Uttar Pradesh was never less than the threshold yield[5] during 1970-71 to 1986-87. For gram and rapeseed and mustard, actual yield was lower than the threshold yield only in two years and the difference was moderate (maximum difference was 17 per cent in rapeseed and mustard in 1979-80). Moreover, in the years of major shortfall in yield only crop loan is insured. Thus crop insurance covers a part of risk in crop production, whereas the proposed approach covers the total risk.

CONCLUSION

To sum up, it is shown that the year to year changes in crop yields and product prices are substantially large. They do not have mutually offsetting behaviour and hence, income from crops is highly unstable in nature. It is suggested that consideration of risk in product prices would bring risk parity among the crops. This would also stimulate the growth in the production of risky crops which is essential for balanced crop production. The proposed scheme could be implemented on homogeneous area basis. However, a major limitation of this scheme is that it would be more beneficial to market oriented farmers (mainly large farmers) and hence it may accentuate the income disparity. But this is largely because of skewed agrarian structure rather than the inherent nature of the scheme.

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NOTES

1. Support prices were taken for those crops for which procurement prices are not relevant.
2. The data were detrended both linearly and exponentially. But considering the R^2 value and randomness of the residuals, the best fit was selected.
3. The deviation of the expression:

Number of years with negative deviation	=	Total number of years in the period	×	probability of shortfall		
and						
Total expected negative deviations in the period (TEND)	=	Average absolute deviation	×	Number of years with negative deviation		
	=	Average absolute deviation	×	Total number of years in the period	×	Probability of shortfall

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$$\text{Expected annual negative deviation} = \frac{\text{TEND}}{\text{Number of years in the period}}$$

$$= \text{Average absolute deviation} \times \text{Probability of shortfall}$$

4. The price elasticities are for pooled data. Therefore, changes in output supply and factor demand were computed for few crops having similarity with pooled situation.

5. Threshold yield is calculated as 80 per cent of the average yield of the previous five years.

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