8

Fodder Price Risk and Evolution of Rural Markets

So far in this study, market conditions have been assumed to be exogenously determined, a standard assumption in agricultural household models (Singh, Squire, and Strauss 1986). In other words, the previous chapters were mainly focused on the question of how households' individual decisions are affected by the incompleteness of the rural market structure. This chapter attempts to move one step further to the question of how aggregate household decisions affect the incompleteness of the rural market structure. It is expected that rural markets evolve from autarky to an incomplete set of imperfect markets, and then to a situation closer to a complete set of perfect markets, through the feedback between households (microeconomic agents) and markets.

As a preliminary step to investigate the evolution of rural markets, simulation exercises were run in this chapter based on the household model estimated in Chapter 6. In the terminology of mathematical programming, this chapter provides a sensitivity analysis of particular parameters that would be important in assessing the process of market evolution and the potential for policy interventions.[1]

The analysis particularly focuses on two issues. First, how substantial is the welfare cost of risk, especially that of fodder price risk? Households under uncertainty decide on their production plans to maximize expected utility from consumption, resulting in an optimal production decision which is different from the plan that maximizes expected profit. This difference is a potential source of social inefficiency due to risk, but little is known about its empirical incidence. Second, what kind of supply response and welfare impact does a change in fodder market structure have, and how is this change related to households' aggregate decisions? The emphasis is placed on green fodder markets since they are thin and characterized by volatile price movements (Chapter 4).

The first section is a review of the current structure of green fodder markets in the study area. Simulation methods are described briefly in the second section. Simulation results are presented in the third section (the welfare cost of risk) and in the fourth section (changes in the fodder market structure).

I. Green Fodder Markets and Households' Market Participation

As shown in Chapter 4, market prices of green fodder in the last two decades were the most volatile and increased at the highest trend rates among major agricultural commodities in the area. Although not indicated in the table there, the data of green fodder prices show more missing values in months with small supply than those of cereal and dry fodder prices, which implies that markets are not reliable sources of green fodder supply in a certain period of a year.

These empirical observations suggest that green fodder markets are local in nature. Transactions of green fodder began after tractors became popular in the Punjab. In this sense, green fodder markets are the newest among agricultural output markets in the region. Because of its bulkiness and perishability, green fodder is highly characteristic of local commodities, in sharp contrast to wheat and basmati. From the viewpoint of risk-averse farmers, the structure of green fodder markets entails a high risk of transactions.

Table 8-1 summarizes market participation by sample households.[2] About three-fourths of the sample households neither purchased nor sold green fodder. Green fodder sale was more prevalent in the *rabi* season (26 per cent participation rate) than in *kharif* (19 per cent) when grasses on fields and banks are available. Only 2.1 to 2.8 per cent of the sample households purchased green fodder. As already shown in Table 4-1, the proportion of households with market participation experience was not negligible—33 to 38 per cent of the households sold green fodder in *kharif* or in *rabi* and 3 to 5 per cent purchased green fodder in the study period.

Table 8-2 shows similar information in terms of quantity. The ratio of the quantity of green fodder purchased from outside to the total feeding quantity was only 3.4 per cent in *kharif* and 1.5 per cent in *rabi*. The ratio of the quantity of green fodder sold to the market to the total production quantity was only 10.7 per cent in *kharif* and 12.4 per cent in *rabi*.

Comparison of these tables indicates that households were well aware of

TABLE 8-1

CLASSIFICATION OF SAMPLE HOUSEHOLDS BY FODDER MARKET PARTICIPATION IN EACH CROPPING SEASON

	Sale		Purchase		Non-participant	
	No.	%	No.	%	No.	%
Green fodder in *kharif*	55	(19.0)	8	(2.8)	226	(78.2)
Green fodder in *rabi*	74	(25.6)	6	(2.1)	209	(72.3)
Dry fodder: *bhusa*	56	(19.4)	26	(9.0)	207	(71.6)
Dry fodder: rice straw	101	(34.9)	0	(0.0)	188	(65.1)
Cottonseed cake	0	(0.0)	286	(99.0)	3	(1.0)

Source: The author's calculation. The original information was collected by the Punjab Economic Research Institute. See the text in Chapter 2 for more details.

Notes: 1. The number of observations is 289 since two observations without livestock animals were omitted.
2. Numbers in the parenthesis indicate percentage to 289 observations.

the existence of market transactions of green fodder and sometimes participated in them if necessary. Nevertheless, it was more common for them to participate only marginally. Regardless of market participation status, many households produced most of their needs from their fields. It should be emphasized here that even those purchasing households would have produced sufficient green fodder if they had allocated all available land to green fodder. They instead grew other crops for markets but not to an extent that they had to depend completely on purchased green fodder. In other words, those households with tighter land constraints decided on the area allocated to green fodder (and thereby the extent of market dependence) by fully considering the tradeoff between growing green fodder crops and other crops.

II. Simulation Methodology

The household model in Chapter 6 incorporates tradeoff among crops in a theoretically consistent way. The tradeoff not only involves relative profitability, but also profit variability and consumption stability. By growing crops whose profits are less variable and less positively correlated with other sources of income, households can obtain a sort of income insurance (portfolio effects); by growing crops whose profits are positively correlated with prices of major consumption items, households can obtain a sort of consumption price insurance (consumption price effects) (Kurosaki 1995b, chap. 3; Fafchamps 1992a).

The welfare effects of changes in market parameters can be evaluated based on equivalent variation and compensating variation. Denoting an instanta-

TABLE 8-2

FODDER MANAGEMENT BY SAMPLE HOUSEHOLDS

	Annual Fodder Expenditure per AU[a] (1988/89 Rs.)			
	Fed to Animals (1)	Produced from Farm (2)	Sold to Markets (3)	Purchased from Markets (4)
Green fodder in *kharif*	578.9 [27.2%]	626.0	67.0 (10.7%)	19.9 (3.4%)
Green fodder in *rabi*	933.7 [43.9%]	1,050.6	130.7 (12.4%)	13.8 (1.5%)
Dry fodder: *bhusa*	335.0 [15.7%]	374.0	49.6 (13.3%)	10.6 (3.2%)
Dry fodder: rice straw	125.6 [5.9%]	145.9	20.3 (13.9%)	0.0 (0.0%)
Cottonseed cake	152.9 [7.2%]	0.0	0.0 (n.a.)	152.9 (100.0%)
Total	2,126.1 [100.0%]			

Source: See Table 8-1.

Notes:
1. The number of observations is 289 since two observations without animals were omitted.
2. Numbers in the brackets in column (1) indicate the percentage to the total fodder expenditure.
3. Numbers in the parenthesis in column (3) indicate the percentage to column (2).
4. Numbers in the parenthesis in column (4) indicate the percentage to column (1).

[a] Adult-animal equivalent unit.

neous indirect utility function by $v(y, p)$ as before, the welfare status in the default setting (subscript 0) can be expressed as $E\,[v(f(l_0^*, \mu_0, \theta_0), p(\mu_0)]$, where E is the expectation operator, μ is a vector of stochastic market parameters that affect consumption prices and production profits, θ denotes a vector of stochastic production parameters such as the mean yield and yield variance, and household income $f(...)$ is determined by the optimal crop choice (l^*), and stochastic vectors of μ and θ.

By denoting a lump-sum transfer by τ, supply response of the optimal production choice (Δl^*), a change in expected income ($\Delta E(y^*)$), compensating variation (τ_C), and equivalent variation (τ_E) of a change from regime (μ_0, θ_0) to regime (μ_1, θ_1) are defined as

$$\Delta l^* \equiv l_1^*(\mu_1, \theta_1) - l_0^*(\mu_0, \theta_0),$$

$$
\begin{aligned}
&\Delta E\left(y^*\right) \equiv E\left[f\left(l_1^*, \mu_1, \theta_1\right)\right] - E\left[f\left(l_0^*, \mu_0, \theta_0\right)\right], \\
&E\left[v\left(f\left(l_0^*, \mu_0, \theta_0\right), p\left(\mu_0\right)\right)\right] = E\left[v\left(f\left(\hat{l}_1^*, \mu_1, \theta_1\right) - \tau_C, p\left(\mu_1\right)\right)\right], \\
&E\left[v\left(f\left(\hat{l}_0^*, \mu_0, \theta_0\right) + \tau_E, p\left(\mu_0\right)\right)\right] = E\left[v\left(f\left(l_1^*, \mu_1, \theta_1\right), p\left(\mu_1\right)\right)\right],
\end{aligned}
\tag{8.1}
$$

where

$$
\begin{aligned}
l_i^* &= l_i^*\left(\mu_i, \theta_i\right) \equiv \underset{l}{\operatorname{argmax}}\, E\left[v\left(f\left(l, \mu_i, \theta_i\right), p\left(\mu_i\right)\right)\right], \qquad i = 0,\ 1, \\
\hat{l}_0^* &= \hat{l}_0^*\left(\mu_0, \theta_0, \tau_E\right) \equiv \underset{l}{\operatorname{argmax}}\, E\left[v\left(f\left(l, \mu_0, \theta_0\right) + \tau_E, p\left(\mu_0\right)\right)\right], \\
\hat{l}_1^* &= \hat{l}_1^*\left(\mu_1, \theta_1, \tau_C\right) \equiv \underset{l}{\operatorname{argmax}}\, E\left[v\left(f\left(l, \mu_1, \theta_1\right) - \tau_C, p\left(\mu_1\right)\right)\right].
\end{aligned}
$$

The risk premium is defined as τ_C in (8.1) when the new regime (μ_1, θ_1) is set to the expected values of (μ_0, θ_0) with zero variance (Pratt 1964; Newbery and Stiglitz 1981). It is interpreted as the maximum amount of money an agent is willing to pay for a situation without risk. Equivalent variation for a riskless environment, τ_E, which is interpreted as the amount of money that should be given to an agent under the initial risky regime to make it indifferent between the two regimes, was also estimated for comparison purposes.[3] These measures of supply response and welfare changes are estimated using numerical methods, whose details are given in the appendix to this chapter. Welfare effects of partial risk elimination are defined in a similar way from (8.1).

Simulations are run for three household groups: "AVG," the reference household group with median characteristics among the sample households; "Land-Poor," the household group with half the size of operational land and other characteristics remaining the same; and "Livestock-Poor," the household group with half the size of livestock herd and other characteristics remaining the same. The "AVG" group is likely to be close to self-sufficiency in green fodder and almost always to have a surplus in wheat and basmati paddy; the "Land-Poor" group is a purchaser of green fodder on average and sometimes is a purchaser of wheat for family consumption; the "Livestock-Poor" group is a net seller of green fodder, wheat and basmati paddy, on average.

III. Welfare Costs of Risk

Table 8-3 gives results simulated for a riskless environment. The reference household group ("AVG") would increase the area devoted to basmati paddy by 29 per cent and that to wheat by 47 per cent. This resource reallocation

TABLE 8-3

SIMULATION RESULTS FOR WELFARE COSTS OF RISK

(%)

	Complete Risk Elimination	Green Fodder Price Elimination
"AVG" household:		
1. Supply response (change in area)		
Basmati paddy	29.2	11.3
Kharif fodder	–37.0	–13.3
Wheat	47.0	32.7
Rabi fodder	–100.0	–66.9
2. Change in expected income (EY)		
% to the initial EY	2.0	1.6
3. Welfare change (equivalent variation)		
% to the initial EY	7.9	4.9
"Land-Poor" household:		
Welfare change (equivalent variation)		
% to the initial EY	10.9	9.2
"Livestock-Poor" household:		
Welfare change (equivalent variation)		
% to the initial EY	7.2	1.9

results in an increase in expected income to the magnitude of 2.0 per cent of the initial expected income. This is the amount of expected income sacrificed for risk considerations. The welfare cost of risk measured by τ_E is estimated at 7.9 per cent of the initial expected income.

In the second column of the table, the welfare costs of fodder price risk are estimated, by eliminating the variability of green fodder prices only. A surprising finding is that, of the total welfare cost of 7.9 per cent in the first column, as large as 4.9 points (or about 62 per cent) are attributable solely to the price risk of green fodder. Only by eliminating the green fodder price risk in *kharif* and *rabi* can households eliminate more than half of the total welfare cost of risk. The finding that the fodder area would decrease dramatically implies that the volatile price of green fodder forces households to grow green fodder to avoid the price risk. By growing green fodder on their farms, farmers can stabilize their welfare level through portfolio effects due to the negative correlation between milk profit and fodder profit, and, through consumption-price effects due to the positive correlation between fodder profit and food prices. But this adjustment causes a loss of expected income and also it is not sufficient to stabilize real income completely. Here lies the major source of the welfare costs of risk.

When green fodder price risk is eliminated, households no longer need to consider these effects of growing green fodder. As indicated in the first four rows in the table, households would decrease the area devoted to fodder and would begin to purchase it from the market. This is in sharp contrast to Sandmo's (1971) classic derivation that the output of a risk-averse firm is lower under price risk. In our case, a risk-averse firm produces more green fodder under green fodder price risk.

The welfare cost of risk, especially of green fodder price risk, is higher for the households with a small land area relative to their livestock herd size. The numbers in the bottom two rows show that the welfare costs of risk rise as the relative size of livestock herd increases. Especially, for the "Land-Poor" group, the welfare costs of green fodder price risk are estimated to be as high as 9.2 per cent of the initial expected income.

These simulation results suggest a vicious circle. Volatility in green fodder market prices induces farmers to pursue self-sufficiency in green fodder. Low market participation in green fodder markets by these households, in aggregate, results in thin markets with inelastic supply and demand. These are indeed the major reasons for price volatility in local fodder markets.

Another implication is the relative ineffectiveness of crop insurance schemes focused on major food-grain crops. At least for farmers in the study region, simulation results confirm that the welfare costs of grain yield risk are not large. Therefore, crop insurance schemes that are currently debated in Pakistan,[4] are not likely to attract farmers' keen interests. This finding is similar to that reported for the ICRISAT households (Bakker 1990; Walker, Singh, and Asokan 1986). It is more likely that interests on crop insurance schemes observed for some farmers in Pakistan are based on their expectation for purely distributive effects of these schemes. They would demand insurance only when the insurance is actuarially biased in favor of farmers, for instance, with an asymmetric income compensation in the event of crop failure without any significant premium to pay.

IV. Effects of Changes in Fodder Market Structure

An obvious natural question is, then, how a change in the structure of local green fodder markets induces a change in household decisions so that the vicious circle is broken. To analyze the effects of changes in green fodder markets rigorously, a sector model that describes market supply and demand is necessary, even if possible general equilibrium effects in the national economy can be ignored. Instead of constructing a fully integrated sector model, however, this chapter focuses on market equilibrium effects for green fodder crops only, because fodder price is the most volatile and has the characteristics of non-tradables that generate the need for a multi-market analysis. Since wheat and basmati markets are assumed to be integrated with national markets, changes in local fodder markets do not affect the price distribution of these two commodities in local markets.

The figures already presented in Table 8-3 do not incorporate the market equilibrium effects for green fodder. The table shows that risk elimination would give households a strong incentive to grow more wheat and basmati. Nevertheless, aggregate effects in local fodder markets might result in higher fodder prices because green fodder is almost a non-tradable commodity from the viewpoint of local markets. A model of local fodder markets incorporates this feedback.

1. Modeling Local Fodder Markets

To incorporate the stylized characteristics of fodder markets in the study area described in Chapter 4, and, to make the model consistent with the assumptions presented in Chapter 6, the following, simple model was constructed. Since the market demand is the sum of the demand from livestock breeders, it is fixed at the sum of the number of livestock animals in the region multiplied by the coefficient of per-animal fodder needs. Market supply is the sum of the supply from agricultural households and a residual source of green fodder supply. As in Chapter 6, household fodder production is assumed to be stochastic around a fixed mean. When an adverse yield shock hits fodder crops in the region, the shipment of green fodder from neighboring regions or the collection of green grass from fields might occur to meet the deficit. The residual source of green fodder supply includes these expensive supplies. Since the residual source cannot adjust elastically to urgent market needs, realized market prices show large fluctuations.

From the farm households' viewpoint, this market structure is equivalent to a market with a completely inelastic supply curve from the household sector and a negatively sloped demand curve. The vertical supply curve shifts horizontally depending on the yield shock to households' fodder production. Since the residual supply source is assumed to be exogenous to the household sector, a market demand curve from the perspective of agricultural households shows a negative slope, in which the absolute value of price elasticity corresponds to the supply elasticity from the residual sector. Denoting this demand elasticity by η, an iso-elastic demand curve from the households' perspective, $D(p)$, is specified as

$$D(p) = Ap^{\eta}. \tag{8.2}$$

Then, using a Taylor expansion (Mood, Graybill, and Bose 1974; Fafchamps 1992a), the *CV* of the price can be approximated by:

$$CV_p = \frac{CV_Q}{-\eta + \frac{1}{2}\left(1 - \frac{1}{\eta}\right)CV_Q^2}, \tag{8.3}$$

where CV_Q is the coefficient of variation of the total quantity of green fodder implicitly traded in the local market.

CV_p was estimated at 0.353 for fodder in *kharif* and at 0.415 for fodder in *rabi*, the highest values among the commodities concerned (Chapter 4, Table 4-3). Based on the yield data used in Chapter 5 and a time-series model similar to price regression models in Chapter 4, CV_Q was estimated at around 0.05. With this information, η, the market price elasticity from the households' viewpoint, was estimated at –0.12 for *kharif* fodder and –0.10 for *rabi* fodder. These estimates confirm that the market price of green fodder is volatile as a result of inelastic fodder demand. Missing fodder markets are a limit case when the elasticity approaches zero.

2. Effects of More Elastic Market Demand

In the previous section, variability in green fodder prices was eliminated without considering how the prices can be practically stabilized. The simulation was justified since its sole purpose was to estimate the welfare costs of price risk. Now, given the fodder market structure as above, what would happen if the green fodder prices were stabilized because the market demand from the households' viewpoint became more price-elastic?

Table 8-4 shows simulation results when the values for η were doubled. From equation (8.3), it was deduced that doubling of η values would result in fodder price stabilization—the *CV* of green fodder price in *kharif* would fall from 0.353 to 0.187 and that in *rabi* would fall from 0.415 to 0.225.

In the first column, the effects of a *kharif* demand change are shown. Fodder price stabilization in *kharif* gives households an incentive to grow more basmati paddy since its expected profitability is higher. However, due to the opposite effects from induced fodder price rises, households would be able to increase the paddy area only marginally. Similarly, the second column shows that fodder price stabilization in *rabi* would lead to a marginal increase in wheat area. Even when the two changes in demand elasticities occur simultaneously (column 3), households would increase the area under food-grain crops only marginally: 0.7 per cent for paddy and 0.2 per cent for wheat. Nevertheless, the adjustment would increase households' expected income

TABLE 8-4

EFFECTS OF MORE ELASTIC FODDER DEMAND

(%)

	Kharif	*Rabi*	*Kharif* & *Rabi*
"AVG" household:			
1. Supply response (change in area)			
Basmati paddy	0.6	0.4	0.7
Kharif fodder	–0.6	–0.5	–0.8
Wheat	0.2	0.1	0.2
Rabi fodder	–0.4	–0.2	–0.4
2. Change in expected income (EY)			
% to the initial EY	0.3	0.7	1.3
3. Welfare change (equivalent variation)			
% to the initial EY	0.9	1.5	2.7
4. Induced changes in expected green fodder prices			
Kharif fodder	2.6	2.1	3.5
Rabi fodder	1.9	1.1	2.2
"Land-Poor" household:			
Welfare change (equivalent variation)			
% to the initial EY	0.7	2.3	3.8
"Livestock-Poor" household:			
Welfare change (equivalent variation)			
% to the initial EY	0.6	0.8	1.5

Note: Price elasticity of green fodder demand is doubled.

by 1.3 per cent and households' welfare by 2.7 per cent. As Table 8-3 showed, the experimental, complete fodder price stabilization would enhance households' welfare by 4.9 per cent. Of this 4.9 per cent welfare gain, 2.7 points (or about 55 per cent) could be attained by a more practical fodder price stabilization. The difference is due to two reasons: first, fodder prices were stabilized only partially in this simulation; second, induced increases in expected fodder prices would prevent households from shifting to food-grain crops significantly.

The two rows at the bottom of Table 8-4 show the welfare effects on the "Land-Poor" and the "Livestock-Poor" household types. "Land-Poor" households would gain more and "Livestock-Poor" households would gain less than the reference group. Compared with the figures in Table 8-3, however, the decrease in welfare gain from 9.2 per cent to 3.8 per cent for "Land-Poor" households is relatively larger than that for the "Livestock-Poor" from 1.9 per cent to 1.5 per cent. This is natural since the adverse effects of induced increases in expected fodder prices are larger for households with a relatively larger livestock herd.

3. Effects of an Increase in Fodder Yields Per Acre

What would happen if a change occurred in fodder crop technology, for instance, an increase in expected fodder yields per acre? Table 8-5 shows simulation results when expected fodder yields were increased by 20 per cent, with demand elasticities remaining the same.[5] The first group of rows shows changes in crop area, which would seem substantial. However, the second group of rows on changes in output quantity shows that households would increase food-grain areas to the extent that fodder production would not change appreciably. The first column for a change in *kharif* fodder yield shows that households would increase the basmati paddy area by 12.2 per cent and decrease the *kharif* fodder area by 14.5 per cent. Since *kharif* fodder yield is improved by 20 per cent, the adjustment would lead to an increase in *kharif* fodder production of only 2.6 per cent. Nevertheless, this supply change would decrease the expected fodder price in *kharif* significantly by 22.0 per cent since this market has a very inelastic demand.

The second column shows a similar scenario when the expected fodder yield in *rabi* increased by 20 per cent. When the change in fodder technology occurred in both seasons, basmati paddy supply would increase by 12.3 per cent and wheat supply would increase by 8.2 per cent (Table 8-5, column 3), resulting in decreases in expected fodder prices: 21 per cent decrease in *kharif* and 15 per cent decrease in *rabi*. The net effect on expected household income is 6.4 per cent gain and that on household welfare is 7.4 per cent gain.

These results show that an increase in fodder yields would free more land for cereal production whose expected profitability is higher. The last groups of rows for the “Land-Poor” household group and “Livestock-Poor” household group confirm this conclusion. The land that would be available for cereals under increased fodder yields is relatively larger for households with a larger livestock herd. On the other hand, households with a smaller livestock herd would lose more from decreases in expected fodder profitability due to induced reduction in fodder prices.

4. Effects of an Increase in Expected Cereal Prices

As a final experiment, the effects of rises in the mean prices of wheat and basmati rice, i.e., price response of farms, were investigated with or without changes in the fodder market structure. As described in Chapter 4, the Government of Pakistan is implementing deregulation policies in food-grain marketing, which are likely to lead to an upward movement of domestic prices of wheat and basmati. Although the deregulation policies had already started, their effects on the mean market prices were not discernible during the survey

TABLE 8-5

EFFECTS OF 20% INCREASE IN EXPECTED FODDER YIELD PER ACRE

(%)

	Kharif	*Rabi*	*Kharif* & *Rabi*
"AVG" household			
1. Supply response (change in area):			
Basmati paddy	12.2	0.1	12.3
Kharif fodder	–14.5	–0.1	–14.6
Wheat	0.1	8.1	8.2
Rabi fodder	–0.2	–15.3	–15.5
Supply response (change in output quantity):			
Basmati paddy	12.2	0.1	12.3
Kharif fodder	2.6	–0.1	2.5
Wheat	0.1	8.1	8.2
Rabi fodder	–0.2	1.6	1.4
2. Change in expected income (EY):			
% to the initial EY	3.2	3.1	6.4
3. Welfare change (equivalent variation):			
% to the initial EY	3.7	3.7	7.4
4. Induced changes in expected green fodder prices:			
Kharif fodder	–22.0	1.2	–21.1
Rabi fodder	2.2	–16.6	–14.7
"Land-Poor" household:			
Welfare change (equivalent variation)			
% to the initial EY	5.0	5.3	10.6
"Livestock-Poor" household:			
Welfare change (equivalent variation)			
% to the initial EY	1.7	2.1	3.8

period. Therefore, the effects of 20 per cent increases in cereal prices are reported in this section, considering the existing estimates for implicit commodity taxation for wheat and basmati rice during the 1980s (Qureshi, Ghani, and Mushtaq 1988; Salam 1992; JMA 1993).

Table 8-6 presents simulation results. When wheat and basmati prices increased by 20 per cent without changes in the fodder market structure (column 1), the supply response of these food grains was significantly depressed. The basmati paddy area increased by only 2.6 per cent and wheat area by only 0.7 per cent. If not for the effects of induced fodder price increases, households would want to expand cereal production more appreciably. However, because of the equilibrium effects in green fodder markets, households would be able to increase cereal areas only marginally. The adjustments would increase households' expected income by 11.5 per cent but because of increased

TABLE 8-6

EFFECTS OF 20% INCREASE IN EXPECTED CEREAL PRICES

(%)

	No Change in Fodder Markets (1)	Doubled Demand Elasticity (2)	20% Rise in Expected Fodder Yield (3)
"AVG" household:			
1. Supply response (change in area)			
Basmati paddy	2.6	3.9	14.1
Kharif fodder	–3.0	–4.5	–16.9
Wheat	0.7	1.1	8.7
Rabi fodder	–1.2	–2.1	–16.5
Supply response (change in output quantity)			
Basmati paddy	2.6	3.9	14.1
Kharif fodder	–3.0	–4.5	–0.2
Wheat	0.7	1.1	8.7
Rabi fodder	–1.2	–2.1	0.2
2. Change in expected income (EY)			
% to the initial EY	11.5	17.2	19.2
3. Welfare change (equivalent variation)			
% to the initial EY	4.4	13.5	14.7
4. Induced changes in expected green fodder prices			
Kharif fodder	24.6	18.5	1.9
Rabi fodder	12.3	10.6	–2.2
"Land-Poor" household:			
Welfare change (equivalent variation)			
% to the initial EY	–4.3	6.5	9.5
"Livestock-Poor" household:			
Welfare change (equivalent variation)			
% to the initial EY	12.5	18.7	18.4

Notes: In column (1), expected prices of basmati and wheat are increased by 20 per cent. In column (2), these prices are increased similarly, simultaneously with doubling of price elasticities of green fodder demand in *kharif* and *rabi*. In column (3), these prices are increased similarly, simultaneously with increases in expected yields of *kharif* and *rabi* fodder crops by 20 per cent.

variability in household income and due to other repercussions, welfare gain in terms of equivalent variation would be only 4.4 per cent. Furthermore, net welfare effects for the "Land-Poor" household group are negative (–4.3 per cent). Households with smaller land and larger livestock herds would not gain much by increased cereal prices since their surplus is small or sometimes negative; they might lose more from increases in expected fodder prices.

The second column in Table 8-6 shows the effects when cereal price increases are accompanied by a more elastic fodder demand and thereby stabilized fodder prices. The third column shows the effects when cereal price increases and fodder yield improvements occur simultaneously. Both experiments show that the food-grain supply response would become larger than the case without a change in the fodder market structure. An important finding is that when changes in the fodder market structure occur simultaneously, welfare changes would become positive for all types of household groups. Their magnitudes would become larger also—households' welfare gain would be as high as 13.5 per cent for the case with more elastic fodder demand and 14.7 per cent for the case with higher fodder yields. At the same time, there is a change in green fodder market participation by households. Households with relatively larger livestock herds would turn more to purchased fodder and households with relatively larger land would sell more fodder to markets.

V. Summary and Policy Implications

In this chapter, a sensitivity analysis of the household model has been carried out to obtain insights into the question of how the incompleteness of the rural market structure is related to household decisions. It was found that the welfare cost of risk is in the range of 7 to 11 per cent of the initial expected income, being higher for land-poor households. These figures are comparable with the estimates for semiarid India (Walker and Ryan 1990). Of these welfare costs, those attributable to green fodder price risk alone account for the major part. Only by eliminating green fodder price risk, can households eliminate more than half of the total welfare cost of risk. This finding suggests that since a crop insurance scheme to hedge against yield risk may not enhance households' welfare significantly, households' demand for such a scheme would not be substantial.

Simulation results based on a simple model of iso-elastic market demand for green fodder have highlighted the importance of elastic fodder demand or yield innovation in green fodder production. The results suggest that these changes would improve household welfare, especially that of poorer sections, with more active green fodder markets. Especially if fodder yields were to be improved, the pressure on scarce land to meet household fodder needs could be reduced, thereby leaving more land for cereal crops under less distorted market environments. The fodder yield improvement would increase fodder supply to markets from households that already produce fodder for markets, thereby contributing to fodder price stabilization. By combining the two innovations in fodder technology, larger welfare gains for agricultural households and deeper green fodder markets could be expected.

Simulation results have also shown that the supply response of cereal crops to an increase in their expected prices would be much larger when the market demand for fodder is more elastic or fodder yields are improved. Demand for green fodder becomes more elastic when technological innovations occur that create cheaper substitutes for green fodder or that make green fodder more storable and easier to transport. In Pakistan, public expenditure on agricultural research and extension has concentrated on increasing food-grain productivity, neglecting fodder crops, since “fodder crops seem to be nobody’s responsibility” (GOP, Ministry of Food and Agriculture 1988, p. 192). This chapter has shown that additional public investment in fodder technology could contribute to an enhanced production of cereals and to the improvement of household welfare.

Appendix to Chapter 8

Numerical Methods to Estimate Welfare Measures

In this appendix the technical procedures to estimate welfare measures such as compensating variation (τ_C) and equivalent variation (τ_E) are outlined. Supply response is estimated as a by-product. Since the distribution of income is endogenous to household production decisions, approximating the two welfare measures by a closed-form expression (Newbery and Stiglitz 1981; Turnovsky, Shalit, and Schmitz 1980) might result in a large bias. To avoid this bias as much as possible, a numerical method based on algorithms to find zero-roots of a system was directly applied to estimate τ_C and τ_E. The mathematical problem for τ_C was to solve the following equation:

$$\begin{aligned} &F\left[\tau_C \,\middle|\, (\mu_0, \theta_0, \mu_1, \theta_1)\right] \qquad \text{(8.A1)} \\ &\quad \equiv E\left[v\left(f\left(l_0^*, \mu_0, \theta_0\right), p\left(\mu_0\right)\right)\right] - E\left[v\left(f\left(\hat{l}_1^*, \mu_1, \theta_1\right) - \tau_C, p\left(\mu_1\right)\right)\right] = 0, \end{aligned}$$

where l_i^* is defined in (8.1), (μ_0, θ_0) denotes the initial regime of stochastic environment, and (μ_1, θ_1) denotes its new regime. A computer algorithm solves equation (8.A1) in the following way. Any value of τ_C has corresponding optimal decisions (l_0^* and $\hat{l}_1^*$). By inserting these decisions, a value of $F[\tau_C]$ can be calculated, which need not be zero. The value of τ_C should be changed and the whole procedure repeated. When a value of τ_C that results in zero value of function F is determined, the compensating variation is obtained. The algorithm consists of an inner loop that calculates the value of $F[\tau_C]$ and an outer loop that searches for an optimal τ_C. A FORTRAN program was written to solve this problem.

Inner Loop

In the first step in the inner loop the optimal value of l^* must be determined and in the second step the value of $F[\tau_C]$ must be calculated. Since the empirical household model in Chapter 6 is based on a first-order Taylor approximation to the derivatives of an indirect utility function, the values of expected utility in the simulations are approximated using a second-order Taylor approximation to the indirect utility function.[6]

To determine the optimal value of l^*, a system of four nonlinear equations should be solved. This system consists of two equations that represent production constraints and two equations that are derived from the first-order conditions for the optimal crop choice (Chapter 6). Although the system does not have an explicit solution for l^*, it can be reduced to a system of two equations with two unknowns of three-order polynomials. Let this system be denoted by $G(l^*) = 0$. Newton's method, which uses first derivatives, can solve this type of problem by revising the n-th guess (l_n) by the following formula (Gill, Murray, and Wright 1981; Atkinson 1989):

$$l_{n+1} = l_n - \left[\frac{\partial G(l_n)}{\partial l} \right]^{-1} G(l_n). \tag{8.A2}$$

The use of the algorithm enabled to find a solution quickly and stably for the model in this chapter.

In the second step the value of $F[\tau_C]$ is calculated using the optimal l^* determined in the first step. The expectation operator in (8.A1) is replaced by an expression based on a second-order Taylor approximation to $v(y, p)$.[7] To minimize an approximation error, the approximation point is reset in every iteration at the new expected income.

Outer Loop

The outer loop of the algorithm revises the value of τ_C in each iteration to find a zero-root of $F[\tau_C]$. Newton's method is not applicable because the function $F[\tau_C]$ has no explicit form. Therefore, for the outer loop the secant method that uses observed slope information instead of first derivatives (Gill, Murray, and Wright 1981; Atkinson 1989) is applied. The secant method revises the n-th guess ($\tau_{C,n}$) in each iteration by the following formula:

$$\tau_{C,n+1} = \tau_{C,n} - \frac{\tau_{C,n} - \tau_{C,n-1}}{F[\tau_{C,n}] - F[\tau_{C,n-1}]} F[\tau_{C,n}]. \tag{8.A3}$$

The algorithm converged to a solution rapidly and stably.

Compensating vs. Equivalent Variation

Equivalent variation can be estimated similarly. The mathematical problem to be solved for τ_E is

$$F\left[\tau_E \middle| (\mu_0, \theta_0, \mu_1, \theta_1)\right] \tag{8.A4}$$

$$\equiv E\left[V\left(f\left(\hat{l}_0^*, \mu_0, \theta_0\right) + \tau_E, p(\mu_0)\right)\right] - E\left[V\left(f\left(l_1^*, \mu_1, \theta_1\right), p(\mu_1)\right)\right] = 0.$$

The use of the same algorithm of an inner loop and an outer loop enables to solve this problem quickly and stably.

When only one experiment is simulated, the two algorithms for equivalent variation and for compensating variation have to use the same loop structure. When a large number of experiments are simulated repeatedly, however, the algorithm for equivalent variation has one advantage in saving computation time. The first term in (8.A4) is a function of τ_E with parameters (μ_0, θ_0). Since μ_0 and θ_0 represent the default regime, they do not change in any simulations. Therefore, once a whole grid of the first term is constructed as a function of τ_E, recalculation of the outer loop is not needed for an additional simulation.

In contrast, for the definition of compensating variation in (8.A1), τ_C is in the second term with parameters (μ_1, θ_1). Since μ_1 and θ_1 change in each simulation run, the outer loop has to be recalculated every time. Thus, the algorithm for compensating variation cannot save computation time.

Notes

1 A summary of the simulation results included in this chapter is presented in Kurosaki (1996c).

2 The figures in this table are smaller than those in Table 4-1 in which households with market participation experience in the survey period were enumerated. In Table 8-2, only households that participated in market transactions in a particular cropping season were enumerated.

3 As Kurosaki (1995b, chap 6) showed, the compensating variation and the equivalent variation move very closely, which justifies the exclusive use of equivalent variation as a welfare measure in the discussion in this chapter. See Willig (1976) and Just, Hueth, and Schmitz (1982) for the relationships among the two welfare measures and consumer surplus. See the appendix to this chapter for an algorithm advantage in using equivalent variation.

4 In early 1996, the Government of Pakistan considered the introduction of a crop

insurance scheme for wheat, rice, cotton, sugarcane, and tobacco, against the crop losses due to flood, excessive rain, drought, and locust attack. The government's intention was to make it compulsory for all the farmers who seek bank credit. In 1986, a pilot crop insurance scheme was experimented for cotton, without success (*Dawn* newspaper 1996, Feb. 15 and Feb. 19; Fasihuddin 1996).

5 It is assumed in the simulation that the 20 per cent increases in expected yields are associated with 44 per cent increases in variances so that the *CV*s of fodder yields do not change.

6 Another method uses a stochastic simulation (Chavas and Holt 1996; O'Donnell 1993). However, it is not practically possible to apply the method to this study because the number of disturbance terms is too large. There are price and yield risks to the output from six farm activities: food-grain crop, fodder crop, and milk in *kharif* and *rabi* seasons. Chavas and Holt (1996) reported that even the quadravariate normal distribution requires a very large computational space.

7 See equations (6.8) and (6.10) in Chapter 6 for the functional form of $v(y, p)$.