4. Output Markets and Price Risk

4

Output Markets and Price Risk

What are the characteristics of markets for agricultural output in the study area and how variable are the prices in these markets? These questions are raised in this chapter.

The first section characterizes marketing institutions available for the sample households. After this descriptive section, quantitative analyses of price variability are attempted. In the second section, price variability of major agricultural products during the harvest periods is estimated based on annual price data in the nearby wholesale market. Estimates for the annual price variability, which were obtained from regression results after control for trends and autocorrelations, will be used as proxies to households' expected price risk when they decide on production plans. In the third section, spatial and intertemporal price integration is investigated. From individual households' viewpoint, price integration reduces the price risk since it prevents unnecessary price volatility. The price integration favors the sharing of risk across regions and periods by smoothing price variations idiosyncratic to each local market.

Before going into details, a note on market performance in developing countries would help understand the importance of the issues discussed in this chapter, in addition to providing the necessary information for the following chapters. The performance of agricultural markets has been an important issue in development economics. Their efficient performance provides producers with information on technology and consumers' preferences, thereby gen-

erating dynamic production responses to changing market conditions. This dynamics is an indispensable part of economic development. Since numerous developing countries, including Pakistan, are currently promoting market liberalization policies, the issues of market performance and price relations are attracting the attention of academic and policy circles. Whether the reforms will have the expected effects depends on the performance of each market involved. The regression models in this chapter attempt to quantify the performance from several angles.

I. Marketing Institutions in the Study Area

1. Marketing Infrastructure

Sample villages are close to a town with a population of approximately fifteen thousand (see Map 2-2). The town is on the main road and the national railway connecting two cities, Sheikhupura and Sargodha. It is a typical rural town in the Punjab with developed infrastructure for agricultural marketing—there is a local wholesale market (*mandi*) and a railway station in the town area. Therefore, this town is the central place for agricultural marketing in the study area. The distance from sample villages to the town is in the range of about four to twenty kilometers. Most of the roads to the villages are paved and regular bus services connect them with the town, although one of the five sample villages had to be reached by an unpaved road for several kilometers at the time of the survey.[1]

The study area has an active chain of private traders. Among these traders, the most important is a commission agent called *arhti* working in *mandi*. An *arhti* collects various agricultural commodities from growers and middlemen and sells them to wholesalers, retailers, and processors on a commission basis. Transactions in *mandi* are subject to provincial regulations, including the registration of *arhti*s in the Market Committee (Government of Punjab, Agriculture Department, Directorate of Economics and Marketing 1991).

Each sample village has village shops where daily goods are sold. These shops also purchase a small amount of surplus food crops from farmers. However, for a large transaction, direct sales in the town or indirect sales via village brokers (*beopari*) are more common.

2. Wheat Marketing

The Government of Pakistan implements a support-price scheme for wheat. Although deregulation policies in wheat marketing have been implemented since the mid 1980s, public intervention has remained important.[2] The gov-

ernment procures wheat from producers directly; it releases wheat flour to consumers directly through utility stores owned by a government corporation or indirectly through private markets. The prices of wheat marketed through this route are fixed by the federal government: the provincial food departments and the Pakistan Agricultural Storage and Services Corporation (PASSCO)[3] procure wheat in harvest months at the "support" price; the provincial food departments release wheat flour in lean months at the "issue" price. The difference between the issue price and the procurement price does not cover all the storage cost from harvest months to the end of a food year (Pinckney 1989b; Ender 1992).

The average share of the public procurement of wheat to the total production during the study period was 31 per cent in the Punjab province and 14 per cent in the Sheikhupura district (Government of Punjab, Bureau of Statistics 1992). Naqvi and Cornelisse (1986), based on field surveys, estimated the percentage of marketable surplus of wheat in the province at 43 per cent. Public procurement dominates wheat marketing, although the residual under private marketing is substantial.

Officially, the support price is supposed to be announced in October, when wheat sowing begins (Afzal et al. 1992). However, the announcement is often delayed or revised later. Upward price revisions occurred in 1990/91, 1993/94, and 1995/96 after wheat was sown. Thus, from the farmers' point of view, uncertainty exists regarding the wheat support price at the time when they must decide on crop acreage.

There is a public procurement center of the PASSCO in the town. The provincial food department has no procurement facility because the two institutions avoid direct competition for wheat procurement. This institutional framework results in the following outlets of wheat for sample households: wheat can be directly brought to the public procurement center; wheat can be brought directly to the *mandi* and sold through commission agents on a commission basis; wheat can be sold to or through *beopari*; or sold to village shopkeepers. Although the sales to private agencies allowed farmers to store and sell later, this practice was seldom observed mainly due to the lack of storage facilities and lack of liquidity.

3. Basmati Paddy/Rice Marketing

Basmati marketing has a different institutional framework because paddy is husked and cleaned in rice mills. The federal government announces a support price for paddy in the same manner as for wheat. The PASSCO is responsible for supporting paddy prices. However, the quantity of basmati paddy procured by the PASSCO was less than 2 per cent of the total production and the proportion was negligible for the Sheikhupura district during the study

period.[4] The price of basmati paddy was to be supported indirectly through the procurement of cleaned rice by the Rice Export Corporation of Pakistan (RECP), a parastatal institution similar to the PASSCO. The RECP procured cleaned rice from private rice millers and middlemen at a fixed procurement price. It formerly owned rice mills, which were privatized during the research period. In 1987/88, rice export was opened to the private sector.

In the study area, various basmati paddy outlets were observed: paddy could be brought directly to the *mandi* and sold through commission agents on a commission basis; sold to or through village brokers; sold to the agents of rice millers; and sold to village shops. In any case, farmers sell paddy, not cleaned rice, since they do not own modern rice-milling facilities.

4. Milk and Fodder

In contrast to wheat and basmati rice, there is little public intervention in milk marketing and no intervention in fodder marketing. The self-sufficiency ratio of milk in Pakistan is around 97 per cent and the deficit is compensated by the import of milk powder (Anjum et al. 1989). The government controls only the import and distribution of powdered milk. Private agencies have developed a network for marketing fresh milk (Khan and Shinzel 1982; Perry 1982; Anjum et al. 1989).

In the study area, the main milk sale outlet is through milk collectors called *dodhi*. Farmers with regular surplus sell milk to *dodhi*s who collect milk and bring it to the town market by bicycle. Most *dodhi*s belong to the Gujjar caste, which is known as a dairy caste in a traditional Punjabi village (Chapter 2). The price of milk collected in this manner is usually constant for a cropping season. Within-village sales, both through village shops and through informal relations, are also observed.

Official data on green fodder marketing are limited. Byerlee and Iqbal (1987), using available wholesale prices of green fodder, concluded that the fodder prices were the most volatile among the agricultural commodities, although the seasonality of prices has decreased recently. Their conclusion was confirmed by observations in the study villages. It was common for farmers to sell surplus fodder or to purchase additional fodder to meet their requirement. However, farmers were reluctant to participate in market transactions because the market was very thin. The farmers interviewed described complete dependence on the market as too risky.

A market for dry fodder depicts a pattern similar to that for green fodder, although the price of dry fodder is more stable within a year because dry fodder can be stored more easily. Farmers use both paddy straw and wheat straw (*bhusa*) as dry fodder. *Bhusa* is considered to be superior and is the main commodity traded in the dry fodder market.

TABLE 4-1

MARKET PARTICIPATION EXPERIENCE BY SAMPLE HOUSEHOLDS

	Sales		Purchase	
	No.	%	No.	%
Basmati paddy	290	99.7	0	0.0
Kharif fodder	97	33.3	15	5.2
Wheat	182	62.5	28	9.6
Rabi fodder	110	37.8	9	3.1

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: Numbers show how many households sold or bought each crop in the study period.

A portion of surplus fodder is sold to landless livestock breeders or given to them as in-kind payment. Milk production is one of the major income sources for landless households in the rural Punjab (Hirashima 1978; Aslam and Haider 1982). Those landless households have to depend on farm households for the green fodder they need. They are affected most adversely by an increase in cereal and fodder prices, since they are net buyers of these commodities.

5. Market Participation by Sample Households

Sample households are classified by their market participation status (Table 4-1). Almost all the households sold basmati paddy, the most important cash crop. No household purchased basmati. On the other hand, wheat was sold by some households and purchased by others. Wheat is the staple food for farmers in the region, but not all farm households are self-sufficient in wheat. A number of marginal farmers did not produce a sufficient amount of wheat for their consumption from their land. However, this does not imply that their land is too small to produce a sufficient amount of wheat. Most of the deficit households would not have needed to purchase wheat had they grown wheat on all of their land. On the contrary, they chose to grow other crops, such as fodder for livestock and vegetables for market sales, and chose to purchase wheat from the market.

In contrast to cereal crops, sample households did not participate much in green fodder markets. Only about one-third of the sample households sold surplus fodder and less than 10 per cent purchased deficit fodder. This fact seems to suggest that smaller farm households prefer to be self-sufficient in green fodder even it may imply that they need to purchase deficit wheat. This behavior is reasonable if the market for wheat purchase is stable and reliable.

II. Estimation of Variability in Harvest Prices

In this section, price variability of major agricultural products during harvest periods is estimated. The price data are annual prices in the nearby wholesale market. Secondary data of market prices are used since they are assumed to be common to the sample households, except for the difference in transportation cost to the markets. This assumption will be investigated further in the next section. Price variability is investigated for major production and consumption items, such as basmati paddy, *kharif* fodder, wheat, *rabi* fodder, milk, dry fodder, and concentrate feeds (cottonseed cake).[5]

1. The Empirical Model

What should matter to household decisions is price and income risk based on a subjective distribution, about which no statistical information is available. Therefore, under the assumption that households have rational expectations, the subjective distribution is replaced with the estimates of distribution parameters based on a statistical model.

To consider the effects of inflation and technological changes, a logarithmic model with a deterministic trend is used (Kurosaki 1997). Let p_i represent the market price of commodity i. Then, the estimated model is expressed as

$$\begin{aligned} \ln p_{it} &= \alpha_i + \beta_i t + u_{it}, \\ u_{it} &= \mu_{pi} u_{i,t-1} + \varepsilon_{pit}, \end{aligned} \tag{4.1}$$

where t is a time variable measured in years, μ denotes an auto-regression coefficient, and ε is a white noise with zero mean. Correction for a first-order auto-regressive [AR(1)] structure is employed for all the commodities when feasible so that residuals can be regarded as a white-noise process.

Expected prices are approximated as the natural exponential of fitted values defined as

$$\overline{\ln p_{it}} = \hat{\alpha}_i + \hat{\beta}_i t + \hat{\mu}_{pi} \hat{u}_{i,t-1}, \tag{4.2}$$

where a hat denotes a regression estimate.

The *CV* and the correlation coefficients of prices are approximated as

$$\begin{aligned} CV_{pi} &\equiv \frac{\sqrt{\mathrm{Var}(p_i)}}{\overline{p_i}} \approx \sqrt{\mathrm{Var}(\ln p_i)} = \sigma_{pi}, \\ \rho_{pi,pj} &\equiv \frac{\mathrm{Cov}(p_i, p_j)}{\sqrt{\mathrm{Var}(p_i)}\sqrt{\mathrm{Var}(p_j)}} \approx \frac{\mathrm{Cov}(\ln p_i, \ln p_j)}{\sqrt{\mathrm{Var}(\ln p_i)}\sqrt{\mathrm{Var}(\ln p_j)}} = \rho(\hat{\varepsilon}_{pi}, \hat{\varepsilon}_{pj}), \end{aligned} \tag{4.3}$$

where σ_{pi} is a square root of the estimated variance of ε_{pi} in equation (4.1). They are estimated from the residuals adjusted for the auto-regression.

2. Data

Equation (4.1) was estimated for the period from 1971/72 through 1990/91. Prices observed in private wholesale markets were used. The government support prices are expected to affect prices after harvest. To incorporate these effects, the current support prices of basmati paddy were included in the estimated equation for basmati price. The basmati support prices are usually fixed when the farmers decide on their land allocation at the beginning of an agricultural year. Since the wheat support price is not yet announced when the farmers choose *kharif* crops, it is not included here.[6]

Market price data were obtained from two sources. The prices of wheat, basmati, milk, and cottonseed cake were derived from reports on monthly wholesale prices in Sheikhupura (GOP, Federal Bureau of Statistics, various issues). Sheikhupura is the district headquarters of the villages surveyed and it is located at about fifteen kilometers from the town. The same source provided price data for dry fodder, although for a shorter period. For the prices of green fodder, there are very few data and in Sheikhupura data were not available. Therefore, the prices of green fodder in a nearby market of Faisalabad were obtained from the Government of Punjab, Directorate of Agriculture (Economics & Marketing) (various issues). To represent harvest months, the average price in May and June was calculated for *rabi* crops, and that in December and January was calculated for *kharif* crops.[7]

3. Estimation Results

Table 4-2 presents the regression results for those prices for which data for AR(1) correction were available. These results will be used in the structural estimation of a household model in Chapter 6. Coefficient estimates for the time trend were larger for green fodder: the annual growth rates of green fodder prices were approximately 12 per cent; the corresponding figures for milk were 8 per cent and those for wheat and basmati were 7 per cent. This finding is consistent with the description in Chapter 2 showing that the terms of trade for livestock products improved against major crops during the 1980s. Informal interviews with sample households revealed that they also perceived that green fodder was becoming a scarcer commodity.

Table 4-3 summarizes the *CV*s and time trends, including those for dry fodder and cottonseed cake. Wheat price was more stable than the prices of basmati and milk. The government policies of direct procurement at support prices and public issue at fixed prices are one of the reasons for the stability in wheat price.

TABLE 4-2

REGRESSION RESULTS OF TIME-SERIES MODEL FOR MARKET PRICES

	Basmati	*Kharif* Fodder	Wheat	*Rabi* Fodder	*Kharif* Milk	*Rabi* Milk
Constant	4.966**	2.261***	3.984***	2.452***	4.661***	4.704***
	(2.43)	(11.4)	(101.3)	(9.78)	(65.7)	(97.8)
Time trend	0.071**	0.119***	0.072***	0.116***	0.085***	0.081***
	(2.19)	(3.86)	(11.0)	(2.99)	(7.16)	(9.52)
Log of support price, basmati	0.027					
	(0.07)					
μ	0.452***	0.403	0.424**	0.490	0.496**	0.239
	(2.66)	(1.25)	(2.49)	(1.58)	(2.47)	(1.13)
Standard error	0.141	0.353	0.086	0.415	0.140	0.151
R^2	0.930	0.847	0.965	0.816	0.935	0.915
No. of observations	19	11	19	11	19	19

Source: The author's calculation. See the text for the data source for regression.
Notes: Dependent variables are log of prices; μ is the coefficient of the first-order auto-regression in the error-term, estimated by the Cochrane-Orcutt method. Numbers in the parenthesis are absolute values of *t*-statistics.
*** Significant at 1% level and ** at 5% level (two-sided test).

The *CV*s of green fodder prices were estimated at around 35 per cent in *kharif* and 42 per cent in *rabi*. These values are much higher than those of cereals and milk that are less than 20 per cent. Therefore, the regression results confirm empirically that green fodder price is more volatile than other prices.

Information for dry fodder in Table 4-3 is not strictly comparable to others since it was obtained from a regression model without auto-regression correction. Nevertheless, considering the data availability, it will serve as a rough proxy. The *CV*s of dry fodder prices were estimated at around 20 to 22 per cent. These values are higher than those of cereals and milk but lower than those of green fodder. The estimated trend rates were also intermediate between those of cereals and those of green fodder.

The *CV* of cottonseed cake price was in the range of 16 to 20 per cent and its time trend was estimated at around 4 to 5 per cent. Since the storability of the commodity has similar characteristics to those of dry fodder, its pattern of seasonality and *CV* were close to those of dry fodder. Its time trend was the lowest among the commodities investigated in this section because the supply of cottonseed increased rapidly in the late 1980s. This period is known as the "silver revolution" (green revolution for cotton) in Pakistan.

TABLE 4-3

SUMMARY RESULTS OF PRICE REGRESSION MODELS

	Annual Trend Rates (%)	*CV* of Prices (%)	Estimation Methods	No. of Observations
Basmati paddy	7.1	14.1	C-O AR(1)	19
Wheat	7.2	8.6	C-O AR(1)	19
Milk in *kharif*	8.5	14.0	C-O AR(1)	19
Milk in *rabi*	8.1	15.1	C-O AR(1)	19
Green fodder in *kharif*	11.9	35.3	C-O AR(1)	11
Green fodder in *rabi*	11.6	41.5	C-O AR(1)	11
Dry fodder in *kharif*	9.3	22.3	OLS	6
Dry fodder in *rabi*	8.6	19.8	OLS	6
Cottonseed cake in *kharif*	4.9	19.8	C-O AR(1)	19
Cottonseed cake in *rabi*	4.3	16.4	C-O AR(1)	19

Source : The author's calculation. See the text for the data source for regression.

Notes : 1. Due to missing data, estimation methods and number of observations are different among models. Missing observations were more frequent in earlier years.

2. Estimation methods: C-O AR(1) by the Cochrane-Orcutt method assuming first-order auto-regression in error terms; OLS by ordinary least squares.

3. *CV* (coefficient of variation) of prices is defined as the residual variation not explained by the model divided by the predicted value from the estimated model.

III. Testing Spatial and Intertemporal Price Integration

In this section, market price integration and the effects of government intervention on it are tested in the case of grain markets in the Pakistan Punjab.[8] The analysis focuses on wheat, the staple food of the nation, supplemented by an analysis on basmati paddy for comparison purposes. Most of the existing studies on market performance in Pakistan are descriptive, except for the work by Faiz Mohammad who analyzed market prices using a simple econometric model (Mohammad 1983, 1985). In the model in this section, quantity variables, such as market surplus or government release, are incorporated to explain the price relations realized in private marketing channels.

1. Methodology

The literature on market performances in developing countries has markedly expanded in recent years. Starting from the classic studies carried out by Lele (1971) and Jones (1972), the literature now covers a wide range of coun-

tries and a number of sophisticated methods (e.g., Ravallion 1986; Baulch 1995, 1996; Goletti, Ahmed, and Farid 1995; Hayami and Kawagoe 1993). As Baulch (1996) argued, recent methods based on time-series analyses, such as the Ravallion model, co-integration, and Granger causality tests, failed to incorporate the nonlinearity caused by the existence of transaction costs and noncontinuous trade flows. Therefore, instead of applying these time-series models, this study adopted an empirical strategy to go back to the arbitrage condition that forms the basis of these studies.

The arbitrage condition needs to be satisfied for prices in a spatial or intertemporal competitive equilibrium (Takayama and Judge 1971; Williams and Wright 1991). Arbitrage (in)equality is satisfied when either of the following two conditions is met. First, if transactions occur between two states of a commodity, price differential should equal transaction costs; the differential should not be larger than the transaction costs, because it implies an arbitrage opportunity. Second, if transactions do not occur, price differential should be smaller than or equal to transaction costs. If the price differential is larger than the transaction costs when transactions do not occur, the arbitrage conditions are clearly violated and the markets are inefficient (Baulch 1995). The transactions between two states include spatial (transportation/trade), intertemporal (storage), or vertical (processing) transactions. When the arbitrage condition holds as an equality, prices in the corresponding two markets are said to be integrated spatially, intertemporally, or vertically.

The arbitrage condition prevents unnecessarily volatile movement of prices. It transmits price signals smoothly from urban food-deficit to rural food-surplus areas or from food-deficit to food-surplus period. In this sense, the condition is necessary for the efficient performance of markets. A well-integrated market system is a key to the efficient allocation of productive resources. It also contributes to household and regional food security. When the arbitrage condition is satisfied, price risk is reduced because a local shock is transmitted to integrated markets. For example, from an individual farmer's viewpoint, the price of a grain in the local market and its yield at his own farm are likely to be highly correlated with a negative sign when the market is less integrated with other markets. As the local market becomes more spatially integrated, the correlation becomes weaker and yield risk at an individual farm is absorbed in the wider geographical coverage of well-integrated markets.

2. Effects of Government Support Prices on Farm-Gate Prices after Harvest

The spatial integration of prices and the effects of government procure-

ment on it were tested using three-year cross-section data on farm-gate prices of wheat and basmati paddy after harvest. Most of the sample households sold these commodities immediately after harvest in the village where they lived. Enumerators recorded prices received by farmers for the most representative transaction. Some farmers brought the commodity directly to the government procurement center or to the town *mandi*. In these cases, transportation costs were subtracted to obtain the farm-gate price. Let P_f denote the farm-gate price recorded in this way.

Analytical and Empirical Models

Since P_f is the price observed in actual transactions in the villages, it is necessary to test whether the arbitrage equality holds or not between the farm-gate price and the price in the town (P^*). Denoting per-unit transportation costs from the farm to the town by T, the arbitrage relation is expressed algebraically as

$$P^* = P_f + T. \tag{4.4}$$

Assuming absolute market margins, the following simple model of transportation costs is used in the empirical investigation.

$$T = \beta_1 D + \beta_2 1/Q, \tag{4.5}$$

where β_1 and β_2 are parameters to be estimated, D is the distance of the farm from the town, and Q is the quantity marketed. β_1 is the marginal transportation cost per unit-distance that is invariant to Q and β_2 is a fixed cost of each transaction. When the values of both β_1 and β_2 are positive, there is a scale economy in transportation. Since we are interested in the effects of government intervention, the government support price (P_p) was used as a proxy for P^*. Since P_p is independent of transactions in villages, P_f was used as the dependent variable explained by P_p and other independent variables.

Thus, by inserting equation (4.5) into equation (4.4) and adding the error term u, the empirical equation becomes

$$P_f = \alpha_1 + \alpha_2 P_p - \beta_1 D - \beta_2 1/Q + u. \tag{4.6}$$

Equation (4.6) was estimated by a two-stage least squares (2SLS) method since the variable $1/Q$ is endogenous to household decisions. Using all sample observations with market surplus, the model was estimated for wheat and basmati paddy.

Estimation Results and Discussion

The estimation results for wheat are reported in Table 4-4. First, the regres-

sion fit was high (adjusted $R^2 = 0.99$). Second, coefficient estimates for transportation costs showed the correct sign. However, the coefficient on $1/Q$ was not statistically significant. Therefore, the model was re-estimated without $1/Q$ ("Model B"). Third, the coefficient on P_p was 0.95, reasonably close to unity, which is the theoretical prediction in equation (4.4).[9]

The regression results for wheat show that the farm-gate price after harvest is explained almost wholly by the government support price and the distance to the town. Recall that most sample households did not bring wheat to the procurement center but sold it to private middlemen in the villages. Even in these cases, the farm-gate prices were integrated efficiently with the support price in the town. Active competition among middlemen and substantial procurement by the government in the town are responsible for the efficient performance. In other words, the rural marketing network of private middlemen contributes to the spatial integration of wheat prices. Obviously, further research is needed to generalize this result for the whole province or for Pakistan. Nevertheless, the existing literature on the spatial integration of wholesale markets in Pakistan seems to indicate that the relations hold to some extent. Studies by Faiz Mohammad (1983, 1985), who examined market price correlations, and by Kurosaki (1994), who applied Ravallion's model of short-run and long-run integration, all supported the view that most wholesale markets in Pakistan's Punjab are integrated spatially.

A similar regression model was estimated for basmati paddy (Table 4-5). First, adjusted R^2 was very low, showing that a large portion of price variation could not be explained by the support price, the distance to the town, and the quantity marketed. Second, both coefficient estimates on D and $1/Q$ were negative and statistically significant, suggesting the existence of scale economy in transportation. The contrasting results for the coefficient on $1/Q$ between wheat and basmati could be due to a difference in the nature of the two commodities. Wheat is a staple food for which village demand exists even for a small quantity. On the other hand, since basmati paddy is a cash crop in the area that has to be sent to rice mills for processing, a large lot in a village has a natural advantage in transportation. Third, the coefficient on P_p was 0.32, a value significantly smaller than unity, which is the theoretical prediction of perfect arbitrage.

The contrast is striking: the farm-gate price of wheat is explained well by the support price and the distance, with the coefficient on the support price close to unity; the farm-gate price of basmati paddy is not explained well by these variables and the coefficient on the support price is not close to unity. This contrast could be due to a difference in the institutional setting of the government price support. A public procurement center for wheat is opened

TABLE 4-4

2SLS ESTIMATION RESULTS FOR WHEAT FARM-GATE PRICES

Explanatory Variables	Model A	Model B	Statistics of Explanatory Variables
Intercept	5.066*** (6.390)	4.844*** (6.319)	
P_p (Rs./40 kg)	0.949*** (125.6)	0.950*** (126.9)	96.53 [11.81]
D (km)	–0.361*** (–16.51)	–0.367*** (–17.40)	8.99 [4.19]
$1/Q$ (1/40 kg)	–6.888 (–1.220)		0.0306 [0.0387]
Adjusted R^2	0.989	0.989	

Source : Same as Table 4-1.

Notes : 1. Estimated by 2SLS with instrumental variables that include P_p, D, the operational acreage of the farm, family size, livestock size, and dummy variables for tractor and tubewell ownership. t-statistics are indicated in the parenthesis.

2. Numbers under the column "Statistics of Explanatory Variables" indicate mean and standard deviations (in the brackets) of explanatory variables.
3. Dependent variable is P_f whose mean is 93.20 and standard deviation is 11.50.
4. The number of observations is 182.

*** Significant at 1% level (two-sided test).

in the town every year with substantial procurement, while the direct procurement of basmati paddy by the public sector is negligible. The support price for basmati paddy is not transmitted smoothly to farmers through the indirect price support by cleaned-rice procurement. Whether the unexplained variation in basmati paddy prices can be explained efficiently by a difference in marketing methods and in opportunity costs of production factors for farmers and middlemen is an interesting and promising avenue for future research,[10] for which more detailed information on marketing is required.

3. Effects of Government Release on the Seasonality of Wholesale Wheat Prices

How does the public release of wheat to markets in lean months affect intertemporal price changes? This issue was addressed using data on monthly wholesale prices in ten major markets in the province (Lahore, Faisalabad, Rawalpindi, Multan, Gujranwala, Sialkot, Sargodha, Okara, Sahiwal, and Sheikhupura) during the 1989/90 to 1991/92 food years[11] as well as the district-wise data on the quantity of wheat released in the province. The data for

TABLE 4-5

2SLS ESTIMATION RESULTS FOR BASMATI PADDY FARM-GATE PRICES

Explanatory Variables	Model A	Model B	Statistics of Explanatory Variables
Intercept	89.44*** (23.85)	89.13*** (23.40)	
P_p (Rs./40kg)	0.324*** (12.40)	0.320*** (12.07)	142.8 [6.18]
D (km)	–0.157*** (–4.055)	–0.133*** (–3.465)	9.44 [4.26]
$1/Q$ (1/40kg)	–30.851*** (–3.023)		0.0217 [0.0307]
Adjusted R^2	0.376	0.354	

Source : Same as Table 4-1.

Notes : 1. Estimated by 2SLS with instrumental variables that include P_p, D, the operational acreage of the farm, family size, livestock size, and dummy variables for tractor and tubewell ownership. t-statistics are indicated in the parenthesis.

2. Numbers under the column "Statistics of Explanatory Variables" indicate mean and standard deviations (in the brackets) of explanatory variables.
3. Dependent variable is P_f whose mean is 133.50 and standard deviation is 3.44.
4. The number of observations is 287.

*** Significant at 1% level (two-sided test).

prices were derived from GOP, Federal Bureau of Statistics (various issues) and the data for wheat release were directly obtained from the provincial food department.

Analytical and Empirical Models

Arbitrage (in)equality for intertemporal transactions (i.e., storage) is considered to hold when either of the following relations is satisfied between the current price (P_t) and the immediate future price (P_{t+1}) (Williams and Wright 1991):

$$(P_t + C)(1+r) = E_t[P_{t+1}], \qquad S_t > 0 \tag{4.7a}$$

$$(P_t + C)(1+r) \geq E_t[P_{t+1}], \qquad S_t = 0 \tag{4.7b}$$

where C is the physical storage cost per period, r is the interest rate, $E_t[..]$ is an expectation operator at t, and S_t is the quantity of private storage carried over from period t to t+1.

Considering the nature of the public wheat release policy, two extreme situ-

ations can be considered to stylize private storage activities in this context. First, if wheat released by the government and wheat stored by the private sector are perfect substitutes, and, if the public release is continued as long as market demand exists at the issue price,[12] then, the private sector stores wheat only in the early months when it expects zero public release (equation (4.7a) holds). Once the private sector expects a positive public release, no private storage is carried over since it inevitably incurs a loss (the inequality in equation (4.7b) holds). This is a situation with full government effects.

On the contrary, if wheat released by the government and wheat stored by the private sector form two completely segmented markets, or, if the public release is cut off with probability one at the level lower than the market demand at the issue price, then, market demand for private storage persists even when the government releases wheat. Therefore, market prices continue to rise regularly throughout a food year, following the equality in equation (4.7a). This is a situation without government effects.

The reality is expected to lie between these two cases. In early months when the quantity of public release is small, market prices rise in a way close to the equality in equation (4.7a). The market is dominated by privately stored wheat. As the public release increases in lean months, private storage begins to be crowded out by publicly stored wheat, but not completely. Figure 4-1 graphically supports this hypothesis. From May to October, market prices rise regularly; from October to April, intertemporal price relations vary from year to year.

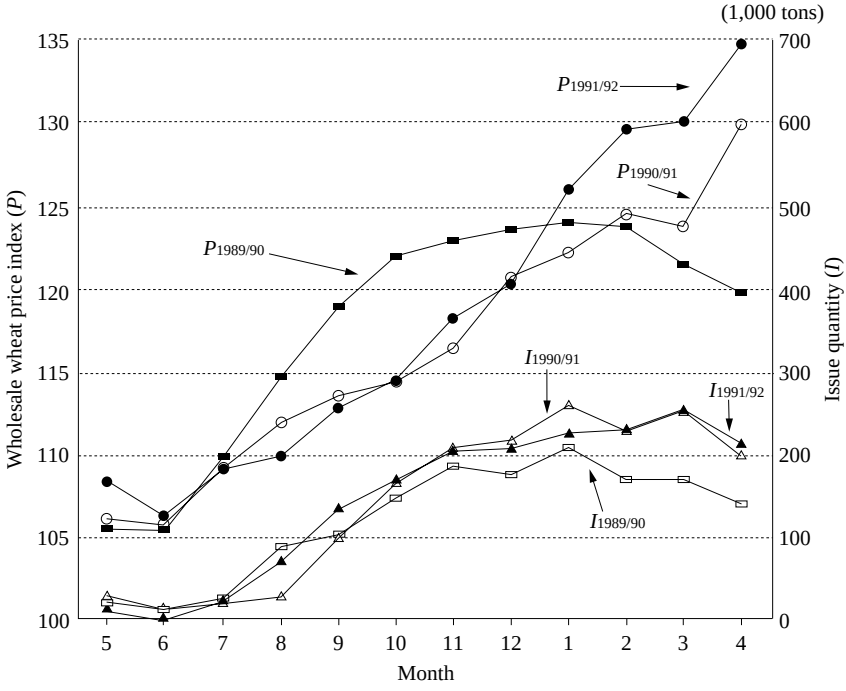
Based on the model in equation (4.7), the following empirical model was adopted, in which the impact of public release was estimated simultaneously with the seasonal patterns:

$$P_t = P_{t-1} \cdot \exp(\alpha + \beta D_{g,t}) + u_t, \tag{4.8}$$

where α and β are parameters to be estimated, D_g is a dummy variable for government wheat release, and u is an error term with zero mean. α is an estimate for the rate of total storage costs,[13] which should have a positive value. β represents the effects of government release on price changes. If the value is zero, the government wheat release has no effect on market prices; if it is negative, price rises are repressed by government release; and if β completely offsets the total storage costs ($\alpha+\beta=0$), the government release at the issue price stabilizes market prices completely, a situation with full government effects.

$D_{g,t}$ is defined as a threshold dummy variable that takes the value of unity when per capita release in a district in month t exceeds some critical level and takes the value of zero otherwise. The use of this variable enables to under-

Fig. 4–1. Seasonality of Wheat Wholesale Prices and Public Wheat Releases



Source : Drawn by the author. See the text for original data.

Notes : 1. The wholesale wheat price index is defined as the average of wholesale wheat price indices in the ten wholesale markets. The wholesale wheat price index in each market each year is an index with government support price in the year taken as 100.

2. The issue quantity is defined as the sum of government release of wheat in the ten markets each month.

stand the effects of an active government intervention into private markets, which occur in the late months of a food year (Figure 4-1).

Estimation Results and Discussion

Table 4-6 shows the results estimated by a maximum likelihood (ML) method assuming the normality of u. The threshold level for $D_{g,t}$ was set at 2.5 kg per capita. In the initial regression, α and β were allowed to vary from market to market and from year to year. However, since differences among markets were not statistically significant (a finding consistent with spatially integrated markets), estimation results without location dummies are reported in Table 4-6. In Model A, α and β were allowed to vary from year to year. Since the null hypothesis that α is constant over years is not rejected at 10 per

TABLE 4-6

ML ESTIMATION RESULTS FOR INTERTEMPORAL WHEAT PRICE RELATIONS

Parameter	Model A	Model B
$\alpha_{1989/90}$	0.0208 (3.676)***	
$\alpha_{1990/91}$	0.0175 (3.371)***	
$\alpha_{1991/92}$	0.0139 (3.296)***	
α_{common}		0.0167 (5.882)***
$\beta_{1989/90}$	–0.0140 (–1.872)*	–0.0099 (–1.756)*
$\beta_{1990/91}$	–0.0043 (–0.633)	–0.0035 (–0.667)
$\beta_{1991/92}$	0.0076 (1.334)	0.0048 (1.010)
R^2	0.946	0.946
Log likelihood	–820.440	–820.925

Source : Same as Table 4-2.

Notes : 1. Asymptotic *t*-statistics are indicated in the parenthesis.
2. Dependent variable is P_t whose mean is 114.8 and standard deviation is 16.0.
3. The number of observations is 300 (= 10 markets×3 years×10 months). Each year in each market consists of ten months to avoid the discontinuity of wheat in a food year. The model in (4.8) is estimated for P_t with t = June to March.
4. In each year with 100 observations, the government release dummy (D_g) takes the value of unity in 53 cases (1989/90), 54 cases (1990/91), and 51 cases (1991/92).

*** Significant at 1% level and * at 10% level (two-sided test).

cent by the Wald test, estimation results with the restriction of constant α are reported as well (Model B).

According to the results of Model B, α was estimated at 1.7 per cent per month, or 21 per cent per year. This is the estimate for total storage costs. According to *State Bank of Pakistan Bulletin*, market interest rates during the study period were about 11 per cent (the average lending rate from commercial banks to the private sector) or 12 to 12.5 per cent (the short-term lending rate from the Agricultural Development Bank of Pakistan). A reliable study estimated the physical storage loss at around 7 per cent per year (Pinckney 1989b). Therefore, the estimate for total storage costs at 21 per cent seems reasonable and can be attributed to interests (12 per cent), storage loss (7 per cent), and other physical storage costs (2 per cent).

Parameter estimate for β was significantly negative in 1989/90 but not significant in the next two years. Therefore, the government release repressed price rises in 1989/90 but its effects were not discernible in 1990/91 and 1991/92. On the other hand, the null hypothesis that $\alpha + \beta = 0$ for 1989/90 was rejected at 10 per cent by the Wald test for both models. This suggests that even in the year 1989/90 when the government release did repress market

price rises, the prices did not remain at the issue price but increased at a repressed rate.

These findings indicate two characteristics of the wheat markets. First, from private traders' viewpoint, there is an uncertainty regarding how sufficient the government release in the next month will be. In spite of the official policy of unlimited release at the issue price, the government follows its annual schedule for wheat release with some flexibility to adjust the actual quantity to the ongoing market situation. Therefore, the actual quantity of wheat released by the government is likely to be short of the market demand but be able to meet a substantial portion. Because of this uncertainty, the private sector has an incentive to store wheat even in lean months.

Second, the wheat released by the government and the wheat stored by the private sector are neither perfect substitutes nor segmented commodities. The main reason for imperfect substitutability is that a major portion of the government-released wheat is marketed as wheat flour. Demand for wheat comprises direct demand for consumption and derived demand for storage. The first demand can be met by the government-released wheat flour, but the storage demand cannot be met by the flour. In addition, a difference in quality might exist between government-released and privately stored wheat.

Because of these characteristics, the government effects were different among years. Judging from the long-term trend, the national wheat production in 1988/89 was close to normal while that in 1989/90 and 1990/91 was below normal. In a food year after a bad domestic harvest, the uncertainty regarding government release increases. The substitutability between government-released and privately stored wheat decreases because the premium for storability increases. Therefore, the effects of government release on price changes become insignificant in a bad harvest year, as indicated in the regression results for 1990/91 and 1991/92. Since the actual quantity of wheat released by the government in these two years was not below that in 1989/90 (Figure 4-1), the observed price relations cannot be justified easily ex post. Nevertheless, it might have been individually rational ex ante for private traders to continue to keep store wheat in anticipation of a significant decrease in the quantity released by the government. Whether this behavior of private traders was a collectively rational and efficient response to uncertainty or an excessive response without economic justification deserves further investigation.

IV. Summary and Conclusions

In this chapter, the nature of agricultural markets in the study area has been

characterized, with emphasis placed on the variability of market prices. The government intervenes directly in wheat markets and indirectly in basmati paddy markets. Public intervention is almost nil in milk and fodder marketing. Regression results in this chapter have contrasted the difference in price risk among commodities due to the difference in these marketing institutions.

First, results from the model of annual price variation have shown that green fodder prices increased more rapidly and were more volatile than the prices of cereals and milk. This implies that, by growing fodder on their farms as an input for livestock production, households can obtain a kind of price insurance. This motivation is expected to become stronger as the herd size of milk livestock increases relative to the land size.

Second, investigation on spatial price relations after harvest has demonstrated that the farm-gate prices of wheat were mostly explained by the support price whereas those of basmati paddy showed variations that could not be explained. This difference is likely to be due to a difference in the price support mechanism: direct (wheat) and indirect (basmati paddy).

Third, empirical analysis on the intertemporal price relations and the effects of public wheat release on them has shown that wheat prices regularly increased at the rate of storage costs in the first half of a food year, but the price rise was repressed by the government release in the second half in a year with a normal wheat harvest.

The second and third findings imply that the price risk, in terms of the variation unexplained by arbitrage conditions, is the smallest for wheat after harvest. The price risk might be somewhat higher for basmati paddy after harvest and wheat in lean months. Policy implications of these findings are fully discussed in Kurosaki (1996a). It might be sufficient to state here that private traders in Pakistan are capable of achieving efficient price relations, which support the current wheat policies of deregulation and liberalization, as long as the policy revision is marginal.

A practical implication of the findings in this chapter is that it is justifiable to use parameters characterizing annual price risks in Table 4-3 to represent price risks facing sample households. As long as a shock to local markets is absorbed spatially and intertemporally, households need to care only about a yield shock idiosyncratic to their farms and price and yield shocks common to the integrated markets in harvest months. Since the price integration was found to be weaker for basmati and lean-month-wheat than for harvest-month-wheat, it is likely that the price variabilities shown in Table 4-3 were underestimated to some extent. At the same time, any econometric analysis that estimates the price variability as the unexplained variation of a regression model is likely to overestimate the variability due to mis-specifications. Since the magnitude of

over- and underestimation cannot be quantified, it is assumed in the following chapters that the net effects after canceling each other are negligible.

Notes

1 In 1996, thanks to the construction of a national highway close to the sample villages, road conditions were improved significantly.
2 Deregulation policies include the lift of the ban on private inter-provincial trade of wheat and wheat de-rationing. See Cornelisse and Naqvi (1987, 1989), Alderman, Chaudhry, and Garcia (1988), Pinckney (1989b), and Ender (1992) for details.
3 The PASSCO is a parastatal agency that procures and stores wheat for inter-provincial distribution. Among the four provinces of Pakistan, Punjab is the only surplus province. The PASSCO is responsible for the supply of wheat to the deficit provinces.
4 The figure was obtained directly from the PASSCO.
5 Results for the first five commodities are cited from Kurosaki (1997).
6 Obviously, the past support prices of wheat may affect expectation on the market price of wheat. The empirical model for wheat price incorporates the effects of past wheat prices in the market, which reflects the information on the support prices until then.
7 Since green fodder is marketed continuously before the peak of grain harvest, other months were also examined for fodder prices. However, this adjustment did not change the regression results qualitatively. Therefore, the results based on the months described in the text are reported.
8 This section is extracted from Kurosaki (1996a).
9 Strictly speaking, the Wald test rejected the null hypothesis that $\alpha_2 = 1$ at 1 per cent level. However, P^* in the theoretical model in equation (4.4) should be a price in the town net of marketing costs that are not incurred in transactions in villages. These marketing costs include, for example, commission fee, facility usage fee, the opportunity cost of waiting in front of the procurement center, etc. When the variable P_p in equation (4.6) was replaced by the support price discounted by 3 per cent, the estimate for α_2 became much closer to unity and $\alpha_2 = 1$ was no longer rejected. In this sense, the coefficient estimate of 0.95 for α_2 was "reasonably" close to unity.
10 Hayami and Kawagoe (1993) explored this direction for the case of upland crops in Indonesia.
11 A food year corresponds to the period from May to April, which implies a one year lag in wheat accounting. For example, the wheat crop harvested in April–May 1990 is counted as a produce of 1989/90 fiscal year but as a food grain for 1990/91 food year.

12 This is the official stance of the government release policy (Pinckney 1989b).

13 This approximation is more precise when the physical storage cost C is proportional to the initial value of the commodity. By inserting $C = cP_t$ on the left-hand side of the equality in equation (4.7a),

$$(P_t + C)(1+r) = P_t(1+c)(1+r) = P_t \cdot \exp(\alpha) = E_t[P_{t+1}],$$
$$\therefore \alpha \approx c + r.$$

The physical storage costs include storage loss, rental fee for storage space, chemicals costs, etc. Among them, the storage loss, which is expected to be the most important under the conditions in Pakistan, is likely to be proportional to the initial quantity. Therefore, the approximation of C by cP_t might be justifiable.