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Supply and Demand for Cereals in Pakistan, 2010–2030

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ABSTRACT

Since the year 2000, Pakistan's population has been growing at a rate that is higher than domestic food grain production. In view of the importance of wheat and rice in the human diet in Pakistan, it is extremely important to estimate the future demand and supply of both cereals. This paper presents the projections of future demand and supply for these two main cereals for 2010, 2015, 2020, 2025, and 2030.

For projecting household demand, the Almost Ideal Demand System (LA-AIDS) is estimated for eight food items using the data of nationally representative household survey. The results are used to project the household demand under three different scenarios. These scenarios are: a business-as-usual situation (per capita income is assumed to grow at a rate of 3 percent per year), an optimistic situation (assumed growth rate of per capita income 4 percent per year), and a pessimistic situation (per capita income is assumed to grow by 2 percent per year). Cereal supply is projected using a short-run production function approach (with such variables as area and share irrigated fixed exogenously at observed levels). This projection is then used to estimate the levels of wheat and rice produced for 2009–2030, with the projections of the exogenous determinants of production based on linear time trend models. The results show that the demand for wheat and rice will more than double by 2030. The projections of supply show an increase in the output of wheat and rice by 2030. From 2008 to 2030, the demand for wheat will increase from 19 million tons to 30 million tons. Projection estimates of wheat supply based on the production function technique show that by 2030, wheat output will reach 28 million tons, and rice output will be 11 million tons. The demand for wheat is expected to be greater than its supply whereas production of rice will be higher than consumption. In other words, the country is likely to face a deficit in wheat and surplus in rice. These results indicate that if production technology remains the same and the growth in production will be slower, the deficit of wheat will be much larger. Therefore appropriate policy measures are needed to address the likely deficit in wheat.

Keywords: cereal demand, cereal supply, Pakistan

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1. INTRODUCTION

Pakistan's population has a high dependence on cereals to meet the daily requirement of food energy. Cereals account for 47 percent of total calorie supply per capita, and the contribution of cereals to protein supply per capita is 46 percent (FAO 2011). Since the year 2000, Pakistan's population has been growing at 2.42 percent per year, a rate that is higher than the growth of domestic food grain production (1.5 percent per year), as shown in Appendix Figure A.1. This finding suggests that the current rate of growth of food grain production may not be adequate to feed Pakistan's increasing population. Worldwide food price inflation and frequent natural disasters in the country have also had a negative impact on Pakistan's food security situation[1] (WFP 2011). Both the United Nations Food and Agriculture Organization's (FAO's) Hunger Map and the IFPRI Hunger Index suggest a serious prevalence of undernourishment and hunger in Pakistan.

In view of the importance of the issues related to food security and food policy, several studies in Pakistan have examined the supply response of food grains[2] and food demand patterns over the past four decades.[3] Although the results of these studies have important policy implications, none provide projections of supply or demand of food in general and cereals in particular.[4] There is even a lack of credible estimates of future demand and supply of food grains in Pakistan on which such policy analyses could rest. This paper provides an economic analysis to help bridge this research gap.

Background and Context

Expenditure on cereal consumption accounts for about 20 percent of total household food expenditure (approximately 15 percent on wheat and 4 percent on rice) in Pakistan. Poor households spend a larger proportion of their income on wheat (23 percent of total income is spent on wheat consumption). However, the share of expenditure on rice (4 percent) is almost the same for households in different income groups (GOP 2009).

Wheat and rice are the major crops grown during the *rabi* (autumn) and *kharif* (spring) growing seasons, respectively. Wheat is grown over an area of 8.5 million hectares and accounts for more than 70 percent of total food grain production in Pakistan. Rice occupies 2.4 million hectares, and its share of total food grain production is 18 percent (GOP 2011). Nearly 26 percent of total households produce wheat, whereas nearly 98 percent of households consume wheat. Even among the wheat producers, 21.6 percent are net buyers (GOP 2006). The basic statistics on wheat and rice are presented in Table 1.1.

Although the prices of wheat and rice in Pakistan have increased substantially since 2008, the increase in prices will only benefit households that produce more wheat or rice than they consume and that are net sellers of these cereals. According to a study by the UN interagency Assessment Mission (2008), the number of people in Pakistan with inadequate food consumption (that is, less than 2,100 kilocalories per capita per day) rose from 72 million (45 percent of the total population) in 2005–06 to 84 million (51 percent) in 2008 as a result of increasing food prices. Thus, food price inflation has resulted in increasing food insecurity in the country. Although international markets provide a source of supply to

[1] The World Food Summit (1996) defines food security as "when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life." This definition implies four major dimensions of food security: availability, accessibility, affordability, and sustainability.

[2] Mohammad (2005) provided a detailed review of these studies. More recently, Haq, Nazli, and Meilke (2008) estimated the food demand patterns in Pakistan.

[3] The authors could not find any substantial literature on food demand supply balance analyses of the post-2008 international food price inflation period in Pakistan.

[4] Kumar, Mruthyunjaya, and Birthal (2007) forecasted the demand for important food items in 2005, 2015, and 2025 for South Asian countries. Their study projected a declining demand of cereals, including wheat and rice in Pakistan, over this period. More recently, Haq, Nazli, and Meilke (2008, 2011) estimated compensated and uncompensated demand elasticities of eight food items for rural Pakistan, urban Pakistan, and all of Pakistan. These two studies observed highly inelastic own price elasticity of wheat and limited substitution between wheat and rice.

meet demand exceeding domestic production, world market prices have risen sharply since 2008 (Ahmed and Yohannes 2010).

According to recent estimates by UN interagency Assessment Mission (2008), the current requirement for wheat in Pakistan is higher than its production. The results of this study indicate that if population grows at an assumed 1.82 percent per year, the country will remain a net importer of wheat.

Table 1.1—Basic statistics on wheat and rice in Pakistan

	Year	Wheat	Rice
Share in agricultural value added (%)	2008–09	14.41	6.58
Share in production of major crops (%)	2008–09	42.82	19.55
Share of household food expenditure (%)	2007–08	14.93	4.25
Urban	2007–08	12.07	4.21
Rural	2007–08	16.55	4.28
Total production (in thousand tons)	Average 2000–07	20,400	4,951
Total exports (in thousand tons)	Average 2000–07	832	2,410
Total imports (in thousand tons)	Average 2000–07	523	5.50
Total supply (in thousand tons)	Average 2000–07	19,439	2,516
Supply per capita (gm/capita/day)	Average 2000–07	109	14.03
Share in daily calorie supply per capita (%)	Average 2000–07	37.22	6.36
Share in protein supply per capita (%)	Average 2000–07	37.94	4.72
Share in fat supply per capita (%)	Average 2000–07	6.44	0.42

Sources: GOP 2010, 2011; FAO (2011).

In a simple partial equilibrium framework, the welfare effect of an increase in the price of a commodity is positive if the welfare change through supply expansion is high enough to compensate the welfare loss due to reduced demand. Thus, from a policy viewpoint, it is important to evaluate the effect of changes in policy variables on both the demand and the supply of food items that constitute a larger proportion of household food consumption.

This study presents projections of demand and supply of two major food grains (wheat and rice) in Pakistan through 2030. The data from the Household Integrated Economic Survey 2007–08 (GOP, 2009) (the latest nationally representative dataset available publically) are used to estimate per capita price and expenditure demand elasticities using the Linear Approximate Almost Ideal Demand System (LA-AIDS) model. Total food expenditure is related to per capita income in a second estimated equation. These estimates are used together to project the future item-wise household and total demand for wheat and rice under three alternative exogenous assumptions about income growth. Cereal supply is projected using a short-run production function approach (with such variables as area and share irrigated fixed exogenously at observed levels). This projection is then used to estimate the levels of wheat and rice produced for 2009–2030, with the projections of the exogenous determinants of production based on linear time trend models.

This paper is divided into seven sections. Section 2 presents the modeling and forecasting of demand for cereals in Pakistan, including the methodology, data, estimates of model, and demand projections up to year 2030 for two cereals (wheat and rice). Section 3 presents the forecasting of indirect demand. The projections of total demand are reported in Section 4. Section 5 discusses the estimation and forecasting models for the supply of wheat and rice. Section 6 presents an assessment of several scenarios of cereal supply deficit (or surplus) based on the alternative estimates of future demand and supply. The conclusions are presented in Section 7.

2. MODELING AND FORECASTING HOUSEHOLD DEMAND FOR CEREALS IN PAKISTAN

This section presents the projections of total demand for cereals in Pakistan for 2015, 2020, 2025, and 2030. These projections are based on estimation of the following:

- Expenditure elasticities of major food items and the relationship of food expenditure to income on a per capita basis
- Total household food consumption using these expenditure elasticities and exogenous income and growth assumptions
- Indirect demand (seed, feed, and wastage)

Methodology and Data

In Pakistan, households spend an average of almost one-half of their total expenditures on food, with those in the lowest-income quintile spending more on food (55 percent) than those who are in the highest quintile (35 percent). As Table 2.1 shows, of the total food budget, households spend a larger proportion (25 percent) on dairy products, followed by cereals (20 percent), edible oil (12 percent), meat (10 percent), vegetables (8 percent), and fruits (4 percent). Compared with rich households, poor households spend a higher proportion of their food expenditures on wheat, edible oil, and vegetables and less on milk, meat, and fruits. In addition, cereals account for a large proportion (27 percent) of the food budget for the poorer households, whereas for richer households, this proportion is 14 percent. On average, 76 percent of total cereal expenditures are for wheat, and 22 percent are for rice, with only about 2 percent coming from maize and other grains for all households. For the poorest households, these proportions are 83 percent for wheat and 16 percent for rice, indicating the relative importance of these two cereals in household consumption.

Table 2.1—Monthly household food expenditures by income groups, 2007–08 (all Pakistan)

	Total	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
Average monthly expenditure (Rs)	12,660	7,485	9,209	10,445	12,235	19,866
Average monthly food expenditure (Rs)	5,598	4,141	4,887	5,246	5,731	7,056
Share of food expenditure (%)	44.22	55.32	53.07	50.23	46.84	35.52
Share in food expenditure of important food items (%)						
Cereals	19.54	27.29	24.41	21.79	19.12	13.77
Wheat and wheat flour	14.93	22.77	19.48	17.23	14.35	9.35
Rice and rice flour	4.25	4.3	4.6	4.16	4.36	4.06
Fruits	3.79	1.82	2.44	3.09	3.71	5.5
Vegetables	7.9	9.25	8.6	8.38	8	6.81
Milk and milk products	25.09	19.14	22.06	23.96	26.47	28.19
Edible oils and fats	11.65	13.66	12.7	12.3	12.02	9.88
Meat and fish	10.33	6.83	8.07	9.17	10.05	13.37
Other	22.07	22.23	22.04	21.72	21.07	22.83

Source: GOP 2009.
Note: Rs = Pakistani rupees.

In the following subsections, we develop a model to forecast the demand of two major food grains: wheat and rice. Following Haq, Nazli, and Meilke (2008), we include eight food items: wheat and wheat flour, rice (all kinds), fruits, vegetables, milk and milk products, edible oil, meat (beef, mutton, fish, and poultry), and other food (pulses, tea, readymade food, condiments and spices, sugar, and so on). The focus is on domestic demand. As shown in Table 1.1, Pakistan is a net importer of wheat and a net exporter of rice. Rice forms a small component, about 4 percent of food expenditures, of domestic consumption.

Theoretical Model of per Capita Food Expenditures[5]

To estimate the expenditure elasticities of the eight food items, we use the Linear Approximate Almost Ideal Demand System (LA-AIDS). This system specifies an expenditure function with price independent generalized logarithmic preferences to derive the Almost Ideal Demand System (Deaton and Muellbauer 1980a, 1980b). The LA-AIDS demand equation in budget share form is as follows:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} + \ln(p_j) + \beta_i \ln\left(\frac{x}{P}\right) + e_i, \qquad (1)$$

where *n* is the number of goods; w_i is the budget share of good *i*; p_j is the price of good *j*; *x* is food expenditure; *P* is a price index approximated by the Stone price index ($\ln(P) = \sum_j w_j ln(p_j)$); and α_i, γ_{ij}, and β_i are parameters. Separability is imposed at the food level, implying that consumers modify their optimal food consumption bundle when relative prices of individual foods change, given an optimal allocation of expenditure on food. Due to separability, the marginal rate of substitution between any food items is independent of the changes in the nonfood items.

To account for the household characteristics, equation (1) is augmented with household specific socioeconomic, demographic, and regional characteristics, using the following relationship proposed by Pollak and Wales (1981):

$$\alpha_i = \alpha_i^* + \sum_j \delta_{ij} z_j, \qquad (2)$$

where z_j is a matrix of socioeconomic variables, and δ_{ij} is the vector of parameters. The socioeconomic variables include household size measured as the number of household members; a binary variable for literacy of the household head; binary variables representing employment of the household head (self-employed, farmer, employee); and regional dummies representing the provinces of Punjab, Sind, and Khyber Pakhtunkhwa (KPK). Binary variables are equal to 1 when the phenomenon exists and 0 otherwise (for example, literacy equals 1 when the household is literate, otherwise it is 0). Substituting equation (2) in equation (1) yields

$$w_i = \alpha_i^* + \sum_{j=1}^{n} \gamma_{ij} + \ln(p_j) + \beta_i \ln\left(\frac{x}{P}\right) + \sum_{j=1}^{n} \delta_{ij} z_j + e_i. \qquad (3)$$

Equation (3) is estimated for the eight food items for the whole of Pakistan on a monthly basis. The theoretical restrictions on the demand function are imposed during estimation. These restrictions include the following:

Adding up:

$$\sum_i^n \alpha_i^* = 1, \quad \sum_i^n \gamma_{ij} = 0, \quad \sum_i^n \beta_i = 0 \qquad \forall \text{ all } i \qquad (4)$$

[5] This section draws heavily from Section 4 of Haq, Nazli, and Meilke (2008).

Homogeneity:

$$\sum_i^n \gamma_{ij} = 0, \quad \forall j \tag{5}$$

Symmetry:

$$\gamma_{ij} = \gamma_{ji} \tag{6}$$

Using equation (3), it is possible to derive uncompensated (Marshallian), compensated (Hicksian), and expenditure elasticities. The uncompensated price elasticity for good i with respect to good j is $e_{ij} = \frac{\gamma_{ij}-\beta_i}{w_i} - \delta_{ij}$. The compensated price elasticity for good i with respect to good j is $e_{ij} = \frac{\gamma_{ij}}{w_i} + w_j - \delta_{ij}$, where δ_{ij} is the Kronecker delta, which equals 1 for own price and 0 for cross-price elasticities. The expenditure elasticity (E_i) is $E_i = 1 + \frac{\beta_i}{w_i}$.

The seemingly unrelated regression estimation method of Zellner (1963) is employed to estimate the system of equations in per capita terms. The statistical significance of the estimated elasticities is derived using the delta method. If a surveyed household does not consume a commodity, then the price for that commodity is missing; to keep these (missing) observations in the analysis, missing prices are replaced by average prices (Cox and Wohlgenant 1986). Imposing the property of additivity of the expenditure function makes the variance and covariance matrix singular; thus, one of the equations needs to be omitted to estimate the LA-AIDS. The expenditure equation for "other food" is omitted, and the coefficients for the omitted equation are derived using the theoretical conditions imposed on the estimation process. However, the coefficients estimated using LA-AIDS are invariant to the omitted equation.

Total Household Food Consumption

The previous subsection provides the estimation model for expenditure elasticities by food items. Unfortunately, time-series data on household food consumption are not available in Pakistan. Therefore, in this demand estimation, we use the cross-sectional household survey data. For the purpose of projections, we seek to estimate total household food demand. To accomplish this, a second equation is specified to estimate the per capita food budget expenditure as a function of per capita income. The per capita food budget model can be written as follows:

$$x_i = f(y_i;\ Z_i), \tag{7}$$

where x_i is per capita per month food expenditure by the ith household; y_i is per capita per month income; and Z_i contains individual characteristics of the head of the household, such as education, employment status, place of residence, and so on. Using the estimated coefficients from equations (3) and (7) and exogenous per capita income and population growth assumptions, we can estimate future total demand for wheat and rice.

Data

In 1963, the Pakistan Bureau of Statistics (FBS) started conducting the Household Integrated Economic Survey (HIES); this survey has been repeated periodically since then. The scope of the HIES was expanded in 1998 by integrating it with the Pakistan Integrated Household Survey (PIHS), which collects information on social indicators. The data used in our paper are taken from the 2007–08 HIES (which are the most recent data available).

HIES 2007–08 (GOP 2009) covers 15,512 households selected from the urban and rural areas of all four provinces of Pakistan. A two-stage stratified random sample design was adopted to select the households. In the first stage, 1,113 primary sampling units (enumeration blocks) were selected in the urban and rural areas of the four provinces. In the second stage, the sample of 15,512 households was randomly selected from these primary sampling units. Using a random systematic sampling scheme with a random start, either 16 or 12 households were selected from each primary sampling unit (GOP 2009). The HIES collects data on household characteristics, consumption patterns, household income by source, and social indicators.

Results

Household (per Capita) Food Demand from the LA-AIDS Model

Table 2.2 presents the estimates of expenditure elasticities from the LA-AIDS model (equation (3)). All of the estimated expenditure elasticities are statistically significant and have the expected signs, suggesting that all goods are normal. The elasticities are greater than 1 for fruit, milk, and meat, suggesting that these food items are most responsive to expenditure changes. Wheat has the lowest expenditure elasticity (0.58), whereas rice (0.63) is more expenditure responsive.

Table 2.2—Expenditure elasticities of demand, 2007–08 (all Pakistan)

	Expenditure Elasticities
Wheat	0.581
Rice	0.898
Fruits	1.348
Vegetables	0.808
Milk	1.477
Oil	0.627
Meat	1.190
Others	0.889

Source: Estimated from GOP (2009).
Note: All expenditure elasticities are significant at a 99 percent level of significance.

Estimation of Household (per Capita) Food Budget as a Function of Income

The estimation results of double-log functional form with robust standard errors for equation (7) are reported in Table 2.3. These results show that all variables are significant at a 99 percent significance level, with the exception of a dummy for KPK. The income elasticity is 0.37, indicating that a 1 percent increase in income increases food expenditures by 0.37 percent.

Table 2.3—Estimates of per capita food expenditure as a function of per capita income

Variables	Coefficients	t-statistics
Per capita income	0.366*	50.15
Education (secondary = 1)	0.052*	5.72
Education (high = 1)	0.043*	5.57
Dummy for gender (male = 1)	–0.023**	–2.02
Farm household (farm = 1)	–0.082*	–12.27
Dummy for employment status (employee = 1)	–0.093*	–1.82
Dummy for employment status (self-employed = 1)	0.475*	4.00
Region (urban = 1)	0.014*	2.10
Province (Punjab = 1)	–0.042*	–4.30
Province (Sindh = 1)	–0.055*	–5.51
Province (KPK = 1)	0.010	0.98
Constant	3.274*	45.72
Number of observations	15,182	
R-square	0.42	
Predicted mean food expenditure	890	
Actual food expenditure	893	
Forecasting error	0.03%	

Source: Author's estimations.
Note: Secondary education means 8 years of education and high means more than 10 years.

Forecasting Household Food Budget

Based on the estimated coefficients reported in Table 2.3, the predicted mean value of per capita per month food expenditure is 890 rupees (Rs), whereas actual mean value was Rs 893. The small forecasting error (0.03 percent) in the cross-sectional model implies that this model can be used to forecast household food demand in the future under the assumption that the relation of food expenditure to income over time has the same relationship as food expenditure to income across households at a moment in time. The results reported in Tables 2.3 and 2.2 taken together indicate that demand for wheat and rice is significantly determined by total food expenditure and per capita food expenditure is significantly determined by per capita income. Therefore, it is important to examine the impact of per capita income on demand for these food items by households. At the country level, the growth in both household income and population are important determinants of quantity demanded of a food item.

Due to the unavailability of time-series data on household income, we use the growth of per capita income to project future income levels. During the past 10 years, Pakistan faced a persistently declining growth rate in per capita income, growing at an average rate of 3.2 percent per year[6]. The Planning Commission of Pakistan estimates that the economy needs to grow at an annual growth rate of over 5 percent to reduce unemployment. However, they recognize that the potential per capita growth rate of Pakistan is about 3-4 percent and this is a reasonable target in the short term[7]. .

We assume that one of three different scenarios may prevail in the future. The first is a business-as-usual (BAU) scenario, in which per capita income will grow at a rate of 3 percent per year. The second scenario presents a pessimistic situation, in which we assume that per capita income will grow by 2 percent per year. The third scenario presents an optimistic situation, in which we assume that per capita

[6] http://devdata.worldbank.org/AAG/pak_aag.pdf and GOP (2011).
[7] http://www.pc.gov.pk/hot%20links/growth_document_english_version.pdf.

income will grow by 4 percent per year. Although these growth rates are higher than those observed in recent years, policymakers target similar levels of growth. In addition, the economic performance in recent years has been hampered by external shocks (such as floods and terrorism), and it may be reasonable to expect the economy to return to its long-run growth path.

The estimated equation presented in Table 2.3 examines the relationship between household income per capita per month and household food expenditure per capita per month. The total food expenditure for year *t* is projected using the following formula to construct annual per capita income and thus (with population at time *t* also included in the equation) the total national income:

$$y_t = y_0(1+g)^t * population * 12, \quad (8)$$

where y_t is current year income, y_0 is base year income, g is the growth rate between two years, and t is the time period (year) for which income growth is examined.

Forecast of Cereal Demand

Forecast of Household Food Demand

Based on the relationship between per capita food consumption and per capita expenditure by food item (equation (3)) and the relationship between per capita household food expenditure and per capita income (equation (7)), we can project the quantity demanded of different food items. Table 2.4 presents the projections of per capita per month household food demand of eight food items. Using the projected per capita per month forecast demand for food items and the projected annual national income from equation (8), total annual household demand of these items is projected for 2014–15, 2019–20, 2024–25, and 2029–30. These results are presented in Table 2.5a and are based on the recent annual growth rate of population reported in GOP (2011). In addition, to examine the effect of population, we estimate the demand for wheat and rice using the average population growth rate since 2000 (2.42 percent). Table 2.5b reports these results. In this analysis, prices are held constant at base year relative levels.

Table 2.4—Household demand for food (kg/capita/month), 2015–30

	2007–08	2014–15			2019–20			2024–25			2029–30		
	Base Year	BAU	Pessimistic	Optimistic	BAU	Pessimistic	Optimistic	BAU	Pessimistic	Optimistic	BAU	Pessimistic	Optimistic
Wheat	8.410	9.087	8.880	9.388	9.604	9.482	9.882	10.154	10.054	10.493	10.737	10.664	11.139
Rice	0.918	1.032	0.997	1.083	1.123	1.102	1.172	1.222	1.204	1.284	1.331	1.317	1.406
Milk	6.579	7.809	7.432	8.355	8.839	8.596	9.394	10.013	9.801	10.737	11.349	11.181	12.268
Fruits	1.046	1.163	1.127	1.215	1.255	1.233	1.304	1.355	1.337	1.416	1.463	1.449	1.538
Vegetable	3.782	4.556	4.319	4.900	5.214	5.059	5.569	5.972	5.835	6.440	6.845	6.736	7.446
Edible oil	0.908	0.987	0.963	1.022	1.048	1.033	1.080	1.112	1.101	1.152	1.181	1.173	1.229
Meat	0.779	0.908	0.869	0.965	1.014	0.989	1.071	1.132	1.111	1.206	1.266	1.249	1.358
Others	5.199	5.840	5.644	6.125	6.348	6.228	6.622	6.904	6.804	7.247	7.511	7.435	7.929

Source: Author's estimations.

Notes: BAU = business as usual. Per capita income is assumed to grow at 2 percent, 3 percent, and 4 percent per year for pessimistic, BAU, and optimistic situations, respectively.

Table 2.5a—Household demand of selected food items (in thousand tons/yr); Population growth 2 percent

	2007–08	2014–15			2019–20			2024–25			2029–30		
	Base Year	BAU	Pessimistic	Optimistic	BAU	Pessimistic	Optimistic	BAU	Pessimistic	Optimistic	BAU	Pessimistic	Optimistic
Wheat	16,839	18,559	18,135	19,174	20,007	19,752	20,586	21,574	21,363	22,294	23,271	23,112	24,142
Rice	1,838	2,108	2,037	2,212	2,339	2,295	2,441	2,597	2,559	2,727	2,884	2,855	3,047
Milk	13,173	15,948	15,179	17,063	18,414	17,906	19,568	21,275	20,824	22,813	24,596	24,232	26,589
Fruits	2,094	2,375	2,302	2,481	2,614	2,569	2,717	2,878	2,840	3,009	3,171	3,141	3,332
Vegetable	7,572	9,304	8,820	10,007	10,862	10,538	11,600	12,690	12,399	13,684	14,835	14,598	16,138
Edible oil	1,818	2,016	1,966	2,087	2,182	2,152	2,250	2,363	2,338	2,448	2,560	2,541	2,663
Meat	1,561	1,854	1,774	1,971	2,112	2,060	2,230	2,406	2,361	2,562	2,743	2,707	2,942
Others	10,410	11,927	11,527	12,509	13,224	12,974	13,794	14,669	14,456	15,398	16,279	16,114	17,185

Source: Author's estimations.
Notes: BAU = business as usual. Per capita income is assumed to grow at 2 percent, 3 percent, and 4 percent per year for pessimistic, BAU, and optimistic situations, respectively. Population growth rate = 2 percent per year.

Table 2.5b—Household demand of selected food items (in thousand tons/yr); Population growth 2.42 percent

	2007–08	2014–15			2019–20			2024–25			2029–30		
	Base Year	BAU	Pessimistic	Optimistic	BAU	Pessimistic	Optimistic	BAU	Pessimistic	Optimistic	BAU	Pessimistic	Optimistic
Wheat	16,839	18,635	18,210	19,253	20,172	19,915	20,756	21,842	21,628	22,571	23,656	23,495	24,542
Rice	1,838	2,117	2,045	2,221	2,359	2,314	2,461	2,629	2,591	2,761	2,932	2,902	3,097
Milk	13,173	16,013	15,241	17,134	18,566	18,054	19,730	21,539	21,083	23,096	25,003	24,633	27,030
Fruits	2,094	2,385	2,311	2,491	2,636	2,590	2,739	2,914	2,875	3,047	3,223	3,193	3,388
Vegetable	7,572	9,343	8,857	10,048	10,952	10,625	11,696	12,848	12,553	13,854	15,081	14,840	16,405
Edible oil	1,818	2,024	1,974	2,096	2,200	2,170	2,269	2,393	2,367	2,478	2,602	2,583	2,707
Meat	1,561	1,862	1,781	1,979	2,129	2,077	2,249	2,436	2,390	2,594	2,789	2,752	2,991
Others	10,410	11,976	11,574	12,560	13,334	13,081	13,908	14,851	14,635	15,589	16,549	16,381	17,470

Source: Author's estimations.
Notes: BAU = business as usual. Per capita income is assumed to grow at 2 percent, 3 percent, and 4 percent per year for pessimistic, BAU, and optimistic situations, respectively. Population growth rate = 2.42 percent per year.

3. INDIRECT DEMAND

Indirect demand of cereals refers to the use of cereals for seed, feed, other industrial requirements, and wastage. Total demand of wheat or rice is the sum of food demand and demand for other uses. Several estimates of the other uses are available. First, the government of Pakistan estimates that 10 percent of wheat produced and 6 percent of rice are used as feed, seed, industrial use, and wastage. Second, the food balance sheet of FAO (2011) presents a comprehensive picture of the pattern of a country's food supply during a specified reference period. The total quantity of food produced in a country is added to the total quantity imported and then adjusted for any change in stocks that may have occurred since the beginning of the reference period. The result gives the supply of that food available during the specified period. On the utilization side, a distinction is made between the quantities exported, fed to livestock, used for seed, lost during storage and transportation, and available for human consumption. Third, the residual method can be used to estimate indirect demand. In this method, indirect demand of a cereal can be estimated by subtracting household demand from the total demand. This calculation requires time-series data on household food consumption by food items. The problem with this approach, however, is the nonavailability of this time-series data on total consumption of individual cereals. Thus, we use the first method to estimate indirect demand.

Forecast of Indirect Demand

The Agricultural Statistics of Pakistan (GOP 2010) reports data on the total availability of different food products. These data do not disaggregate the use by food and other uses. However, they do indicate that 10 percent of wheat production and 6 percent of rice production are utilized as feed, seed, and other uses (see Appendix Table A.3). The data also indicate that this use has been growing at an annual rate of 3 percent during last five years. However, the higher demand of these cereals as seed and feed implies an annual growth rate of 5 percent[8] for both cereals when projecting future demand. Results are reported in Table 3.1.

Table 3.1—Indirect demand of wheat and rice (in thousand tons)

	Wheat	Rice
2007–08	2,330	334
2014–15	3,278	469
2019–20	4,183	599
2024–25	5,339	765
2029–30	6,814	976

Source: Author's estimations.

[8] The use of saved seed is a common practice among farmers in Pakistan. We assume that this practice will continue. In addition, because of increased consumption of poultry, meat, and eggs, the use of seed as feed may grow at a higher rate in future.

4. FORECAST OF TOTAL CEREAL DEMAND

Using the estimates of direct and indirect demand, we can estimate the total demand of wheat and rice. These projections are reported in Tables 4.1a and 4.1b, which assume population growth rates of 2 percent and 2.42 percent per year, respectively. These tables show that by 2030, the demand for wheat and rice will increase by 1.5 times from the base year. As expected, the results indicate higher demand of wheat and rice when the population growth rate is high, which is consistent under all scenarios.

Table 4.1a—Projected total demand (in thousand tons); Population growth 2 percent

	2007–08			2014–15			2019–20			2024–25			2029–30		
	House hold	Indirect	Total	House hold	Indirect	Total	House hold	Indirect	Total	House hold	Indirect	Total	House hold	Indirect	Total
Scenario 1: Business as usual															
Wheat	16,839	2,330	19,168	18,559	3,278	21,837	20,007	4,183	24,190	21,574	5,339	26,913	23,271	6,814	30,085
Rice	1,838	334	2,172	2,108	469	2,578	2,339	599	2,939	2,597	765	3,362	2,884	976	3,861
Scenario 2: Pessimistic situation															
Wheat	16,839	2,330	19,168	18,135	3,278	21,413	19,752	4,183	23,936	21,363	5,339	26,702	23,112	6,814	29,926
Rice	1,838	334	2,172	2,037	469	2,506	2,295	599	2,894	2,559	765	3,324	2,855	976	3,831
Scenario 3: Optimistic situation															
Wheat	16,839	2,330	19,168	19,174	3,278	22,451	20,586	4,183	24,769	22,294	5,339	27,634	24,142	6,814	30,956
Rice	1,838	334	2,172	2,212	469	2,681	2,441	599	3,040	2,727	765	3,492	3,047	976	4,023

Source: Author's estimations.
Notes: Per capita income is assumed to grow at 2 percent, 3 percent, and 4 percent per year for pessimistic, business-as-usual, and optimistic situations, respectively. Population growth rate = 2 percent.

Table 4.1b—Projected total demand (in thousand tons); Population growth 2.42 percent

	2007–08			2014–15			2019–20			2024–25			2029–30		
	House hold	Indirect	Total	House hold	Indirect	Total	House hold	Indirect	Total	House hold	Indirect	Total	House hold	Indirect	Total
Scenario 1: Business as usual															
Wheat	16,839	2,330	19,168	18,635	3,278	21,913	20,172	4,183	24,355	21,842	5,339	27,181	23,656	6,814	30,471
Rice	1,838	334	2,172	2,117	469	2,586	2,359	599	2,958	2,629	765	3,394	2,932	976	3,908
Scenario 2: Pessimistic situation															
Wheat	16,839	2,330	19,168	18,210	3,278	21,488	19,915	4,183	24,099	21,628	5,339	26,967	23,495	6,814	30,309
Rice	1,838	334	2,172	2,045	469	2,515	2,314	599	2,913	2,591	765	3,355	2,902	976	3,878
Scenario 3: Optimistic situation															
Wheat	16,839	2,330	19,168	19,253	3,278	22,530	20,756	4,183	24,939	22,571	5,339	27,910	24,542	6,814	31,356
Rice	1,838	334	2,172	2,221	469	2,690	2,461	599	3,060	2,761	765	3,526	3,097	976	4,073

Source: Author's estimations.
Notes: Per capita income is assumed to grow at 2 percent, 3 percent, and 4 percent per year for pessimistic, business-as-usual, and optimistic situations, respectively. Population growth rate = 2.42 percent.

5. MODELING AND FORECASTING SUPPLY OF CEREALS IN PAKISTAN

As discussed earlier, wheat and rice are the major staple food in Pakistan, with wheat being consumed by a large proportion of the population. Pakistan is a net exporter of rice and remains a net importer of wheat in most years. This section presents two approaches to estimating the future of supply of these cereals in Pakistan.

Production Function Approach: Methodology and Data

The supply of a crop depends on various factors, such as price of output, quantities and prices of inputs, weather, rainfall, irrigation, prices of other competing crops, and so on. The optimal levels of output supply and input demand can be derived by the process of profit maximization. The derived output supply and input demands are the function of input and output prices, prices of competing crops, fixed factors and nonprice determinants (such as weather in a particular year), and production technology. Consider a risk-neutral farmer who uses a vector of variable inputs X subject to a set of fixed and nonprice factors R to produce farm output Q at a given level of technology. Assume that the production function $Q(\cdot)$ is continuous and twice differentiable. Let P denote the output price of farm output and W be the prices (multiple) of inputs X. Farmers are assumed to be price-takers in both the input and output markets. Given the production function $Q(X;R)$, the profits for multiple crops can be written as

$$\max_{X,Q} \pi = PQ(X;R) - WX. \quad (9)$$

The first-order conditions for maximization provide the optimal output supply and input demand for crop i:

$$q_i^* = q_i^*(P,W) \quad (10)$$

$$x_i^* = x_i^*(P,W). \quad (11)$$

For empirical purposes, we specify the output supply function in Cobb-Douglas form:

$$q_i = B_0 p_i^{\beta_1} p_j^{\beta_2} w_i^{\beta_3} r_i^{\beta_4} e_i, \quad (12)$$

where qi is the output of crop i; p_i is the price of crop output; p_j is the price of competing crops; w_i is the (vector of) prices of inputs; and r_i includes all fixed factors and other determinants that can affect output supply, such as area devoted to crop i, irrigation, temperature, rainfall, and so on. The choice of these determinants depends on the characteristics of the production schedule of each crop. e_i is the error term. β_i are estimated coefficients, such that the expectations are $\beta_1 > 0,\ \beta_2 < 0,\ \beta_3 < 0,\ and\ \beta_4 > 0.$

Equation (11) is estimated using the double log for two major crops: wheat and rice. The ordinary least squares (OLS) regression with robust standard errors is applied. The estimated models are checked for presence of autocorrelated error terms. In cases where the Durbin-Watson d-statistic indicates autocorrelation, the regression model is estimated through a Prais-Winsten regression. For each of these crops, only the significant variables are retained, and the regression model is then re-estimated. Time-series published data for 1970–2009 are used[9]. The area planted is used as an exogenous regressor in both models; thus, the models capture only yield responses to output prices and input decision, as opposed to acreage allocation decisions. Unfortunately, data on various important determinants, such as price of seed, price of irrigation, rainfall, and temperature, are not available for the entire period. Because of the different production schedules for wheat and rice, we use different factors in the estimated models of

[9] Data are drawn from GOP (various issues), Agricultural Statistics of Pakistan, and FAO (2011).

these crops: We use quantity of improved seed distributed as a proxy for price of seed, because these data are unavailable. Wheat is grown all over the country in both irrigated and unirrigated areas, whereas rice is cultivated only in irrigated areas. Therefore, we use share of irrigated areas in the wheat model only.

Results

In our estimation, both models exhibit high R-squared, which indicates that the model has a good fit of data. The high value of the F-test indicates the overall significance of these models. However, the value of the Durbin-Watson test shows the presence of autocorrelation. In the presence of autocorrelation, the residual variance underestimates the true variance, which in turn overestimates the R-squared. In such a situation, usual F- and t-tests may provide misleading inferences about the significance of the coefficient and hence the overall model. Therefore, before going into the detailed discussion of these coefficients and computation of elasticities, we first corrected the problem of autocorrelation. Table 5.1 presents the results of estimated models with robust standard errors, corrected for autocorrelation.[10] Both models confirm the positive and significant effect of area under crop. The availability of improved seeds appears to be an important factor for both crops. An increase in share of irrigated area also has a positive and significant effect on wheat output. However, aside from the proxy for seed prices, we detect no statistically significant effects of input or output prices on output; thus, we dropped these prices from the regressions.

Table 5.1—Estimated production functions for wheat and rice output

Variables	Wheat		Rice	
	Coefficients	t-statistics	Coefficients	t-statistics
Cultivated area	1,531	7.21	1.487	17.61
Quantity of improved seed	0.094	3.95	0.050	3.87
Share of irrigated area	1.979	3.63	-	-
Constant	-4.1	-2.09	-3.207	-5.00
Number of observations	39		40	
R^2	0.967		0.991	
F(3, 35) and F(2, 37)	496.79		267.44	
Durbin-Watson statistics (transformed)	2.010		1.909	

Source: Author's estimations.
Notes: The dependent variable is log output in thousand tons. All variables (dependent and independent) are in log form.

Model Validation

We use the estimated coefficients to test the models for 2006, 2007, and 2008. The results are presented in Table 5.2. For the latest three years, the forecast errors are less than 10 percent for wheat and rice. These forecast errors lead us to conclude that we can use the predicted value of the dependent variable to make supply projections of wheat and rice.

[10] The value of the Durbin-Watson test shows that the model suffers from autocorrelation. This problem is corrected using the Prais Winsten regression.

Table 5.2—Model validation

	Wheat			Rice		
	2006	2007	2008	2006	2007	2008
Predicted output	20,046	20,680	23,098	5,520	5,343	6,980
Actual output	23,295	20,959	24,033	5,438	5,563	6,952
Forecast error	3,249	279	935	–82	220	–28
Forecast error (%)	13.9	1.3	3.9	–1.5	3.9	–0.4

Source: Author’s estimations.
Note: Output values and forecast error are in thousands of tons.

Forecasting Cereal Supply

In the production function method, the regressors of estimated equation for wheat and rice (presented in Table 5.1) are used to forecast output. Wheat and rice inputs are first projected until 2030 using the growth rates from 1999–2009. The projected values are then plugged into the estimated production function to forecast future output of both crops. The forecasted output for wheat and rice is reported in Table 5.3, which shows that by 2030, the wheat output is expected to grow to 28.2 million tons and the rice output to increase to 10.5 million tons. Such a forecasting method assumes that the technology and production function of each crop will remain the same until 2030. If the production becomes more efficient, the same amount of inputs will lead to higher crop output. This finding may be crucial to reducing the gap between forecasted wheat output using time trend and the production function.

Table 5.3—Forecasts for the output of wheat and rice (in thousand tons): Using production function estimates

Period	Wheat	Rice
2007–08	18,558	4,381
2014–15	20,614	5,455
2019–20	22,898	6,791
2024–25	25,435	8,454
2029–30	28,254	10,525

Source: Author’s estimates using Table 5.1 and Appendix Table A.4.

6. ASSESSING THE CEREAL SUPPLY DEFICIT AND SURPLUS

Comparing the projected demands for wheat and rice for 2015, 2020, 2025, and 2030 with their corresponding forecasted supply (domestic production) provides an estimate of the possible future surplus or deficit (Table 6.1). Details of Table 6.1 are given in Appendix Tables A.5a and A.5b (supply projections are based on the production function technique for two different population growth rates).

The results of the production function supply model show that in the future, the demand for wheat will remain higher than supply under all scenarios. In addition, the country will face the problem of wheat deficit. Rice is expected to remain in surplus. The magnitude of the wheat deficit shows an increase over time under all scenarios. The demand and supply projections are based on several assumptions, including constant growth in population, no change in taste and preferences, constant prices, and constant technology of production. Any change in these parameters can change the projections for demand as well as for supply. There is a need for further research to know the direction of change, which suggests that Pakistan cannot simply rely on using more inputs to increase production. If the deficit of wheat is to be reduced, technology will have to improve, and crop output will need to be more efficient.

Table 5.4 compares the results of two different population growth rates and shows that if population continues to grow at an average rate of 2.42 percent per year, the demand of wheat will remain higher than its supply, and the country will suffer from deficit. To make Pakistan a wheat surplus country, there is a need not only to increase wheat production but also to reduce the population growth rate.

Table 5.4—Projections of the surplus and deficit of wheat and rice (in thousand tons)

	Wheat		Rice	
	Population Growth = 2%	Population Growth = 2.42%	Population Growth = 2%	Population Growth = 2.42%
Business as usual				
2014–15	–1,223	–1,299	2,877	2,869
2019–20	–1,292	–1,457	3,852	3,833
2024–25	–1,478	–1,746	5,092	5,060
2029–30	–1,831	–2,217	6,664	6,617
Pessimistic situation				
2014–15	–799	–874	2,949	2,940
2019–20	–1,038	–1,201	3,897	3,878
2024–25	–1,267	–1,532	5,130	5,099
2029–30	–1,672	–2,055	6,694	6,647
Optimistic situation				
2014–15	–1,837	–1,916	2,774	2,765
2019–20	–1,871	–2,041	3,751	3,731
2024–25	–2,199	–2,475	4,962	4,928
2029–30	–2,702	–3,102	6,502	6,452

Source: Calculated from Appendix Tables A.5a and A.5b.

7. CONCLUSIONS

This paper presents the projections of future demand and supply for two important cereals (wheat and rice) in Pakistan for 2010, 2015, 2020, 2025, and 2030. These projections are derived under three different scenarios: a business-as-usual situation, an optimistic situation, and a pessimistic situation. The projections of direct and indirect demand show that the demand for wheat and rice will more than double by 2030. These results are based on the current population growth rate (2 percent) and the long-term growth rate for 2000–2011 (2.42 percent). All simulations of direct and indirect demand show a higher demand as compared with the base year.

The projections of supply show an increase in the output of wheat and rice by 2030. From 2008 to 2030, the demand for wheat will increase from 19 million tons to 30 million tons. Projection estimates of wheat supply based on the production function technique show that by 2030, wheat output will reach 28 million tons, and rice output will be 11 million tons. These results indicate that if production technology remains the same, the growth in production will be slower, the deficit of wheat will be much larger than it is today. All scenarios show that the demand for wheat is expected to be greater than its supply. However, in the case of rice, all years show higher production than consumption.

For wheat, Pakistan may have to import large quantities to bridge the gap between demand and supply. A projected increasing surplus of rice will allow for greater local consumption or more export, which would lead to higher foreign exchange earnings.

The projections of demand and supply are based on several assumptions, such as constant growth in population, no change in taste and preferences, constant prices, and constant technology of production. Any change in these parameters can change the projections for both demand and supply. For example, an increase in the price of rice may result in rice–wheat substitution that may increase the demand for wheat. Similarly, an increase in the demand for livestock products may increase the wheat demand for feed, which will raise the total demand for wheat. An increase in the price of cereals and an improved technology may have different effects on the net buyers and net sellers of the crop. There is a need for further research to examine the direction of change and its welfare implications.

APPENDIX: SUPPLEMENTARY TABLES AND FIGURES

Table A.1—Production of cereals, population, and per capita food grain production

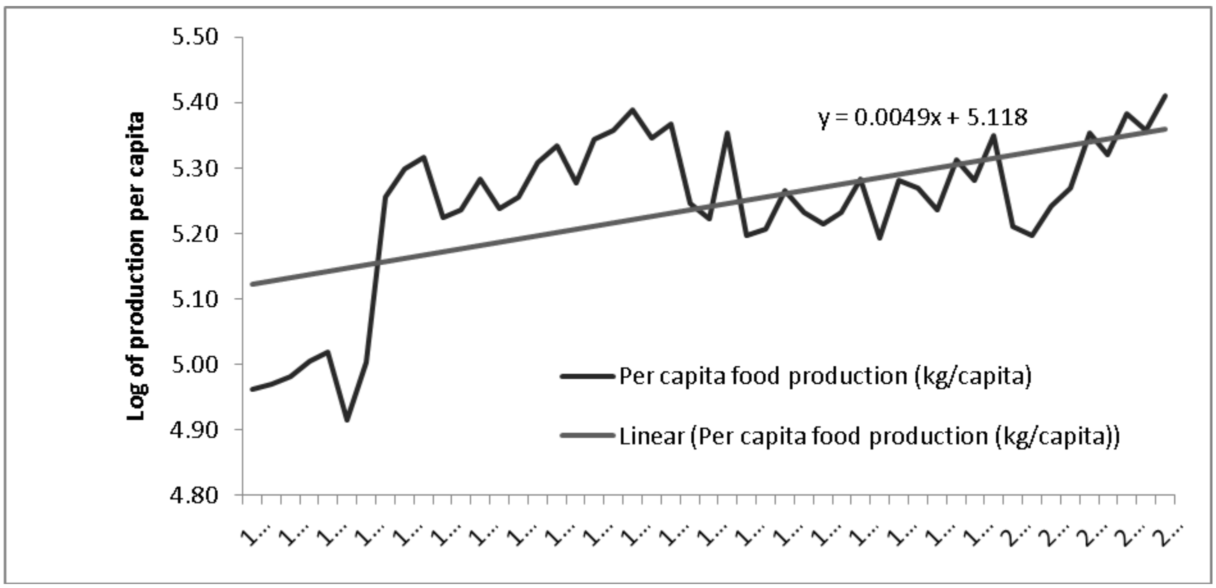
Year	Production (in thousand tons)	Total Population (in thousands)	Per Capita Food Production (kg/capita)
1961	6,730	47,033	143
1962	6,942	48,198	144
1963	7,208	49,414	146
1964	7,565	50,679	149
1965	7,867	51,993	151
1966	7,281	53,359	136
1967	8,167	54,780	149
1968	10,792	56,258	192
1969	11,570	57,791	200
1970	12,097	59,383	204
1971	11,336	61,034	186
1972	11,801	62,751	188
1973	12,731	64,552	197
1974	12,516	66,457	188
1975	13,128	68,483	192
1976	14,263	70,632	202
1977	15,115	72,904	207
1978	14,764	75,303	196
1979	16,305	77,833	209
1980	17,074	80,493	212
1981	18,222	83,280	219
1982	18,076	86,187	210
1983	19,101	89,200	214
1984	17,536	92,300	190
1985	17,699	95,470	185
1986	20,866	98,711	211
1987	18,428	102,012	181
1988	19,240	105,332	183
1989	21,018	108,621	193
1990	20,957	111,845	187
1991	21,138	114,970	184
1992	22,123	118,010	187
1993	23,870	121,030	197
1994	22,338	124,122	180
1995	25,036	127,347	197
1996	25,395	130,737	194
1997	25,260	134,256	188
1998	27,985	137,808	203
1999	27,756	141,261	196

Table A.1—Continued

Year	Production in thousand tons)	Total Population (in thousands)	Per Capita Food Production (kg/capita)
2000	30,461	144,522	211
2001	27,048	147,558	183
2002	27,173	150,407	181
2003	28,964	153,140	189
2004	30,311	155,860	194
2005	33,508	158,645	211
2006	33,028	161,513	204
2007	35,813	164,446	218
2008	35,528	167,442	212
2009	38,148	170,494	224

Source: FAO (2011).

Figure A.1—Growth in per capita food grain production



Source: Author's creation based on Table A.1.

Table A.2—Basic data on wheat and rice in Pakistan

Year	Wheat					Rice			Price of Fertilizer
	Area[a]	Production[b]	Market Price (Rs/ton)	Procurement Price (Rs/ton)	Improved Seed[b]	Area[a]	Production[b]	Market Price (Rs/ton)	(Rs/ton)
1970	5,977	6,476	473	456	8	1,503	2,200	488	535
1971	5,797	6,890	496	456	7	1,456	2,262	527	513
1972	5,971	7,442	566	536	10	1,480	2,330	770	568
1973	6,113	7,629	603	670	15	1,512	2,455	1,054	777
1974	5,812	7,673	683	991	15	1,604	2,314	1,465	851
1975	6,111	8,691	1,004	991	26	1,710	2,618	1,195	796
1976	6,390	9,144	1,045	991	51	1,749	2,737	1,393	708
1977	6,360	8,367	1,089	991	30	1,899	2,950	1,487	684
1978	6,687	9,950	1,254	1,206	30	2,026	3,272	1,608	634
1979	6,924	10,587	1,205	1,250	41	2,035	3,216	1,608	582
1980	6,984	11,475	1,250	1,450	50	1,933	3,123	1,875	814
1981	7,223	11,304	1,450	1,450	52	1,976	3,430	2,125	777
1982	7,398	12,414	1,450	1,600	49	1,978	3,445	2,200	884
1983	7,343	10,882	1,600	1,600	49	1,999	3,340	2,250	1,003
1984	7,259	11,703	1,600	1,750	57	1,999	3,315	2,250	995
1985	7,403	13,923	1,750	2,000	49	1,863	2,919	2,325	999
1986	7,706	12,016	2,000	2,000	42	2,066	3,486	2,550	1,001
1987	7,308	12,675	2,000	2,063	56	1,963	3,241	3,250	1,039
1988	7,730	14,419	2,062	2,125	45	2,042	3,200	3,375	1,101
1989	7,845	14,316	2,125	2,400	46	2,107	3,220	3,587	1,190

Table A.2—Continued

Year	Wheat					Rice			Price of Fertilizer
	Area[a]	Production[b]	Market Price (Rs/ton)	Procurement Price (Rs/ton)	Improved Seed[b]	Area[a]	Production[b]	Market Price (Rs/ton)	(Rs/ton)
1990	7,911	14,565	2,905	2,800	43	2,113	3,261	3,750	1,310
1991	7,878	15,684	3,400	3,100	46	2,097	3,243	3,875	1,412
1992	8,300	16,157	3,649	3,250	49	1,973	3,116	4,375	1,439
1993	8,034	15,213	4,036	4,000	50	2,187	3,995	4,625	1,631
1994	8,170	17,002	4,674	4,000	63	2,125	3,447	5,250	1,955
1995	8,376	16,907	4,720	4,325	65	2,162	3,967	5,550	2,193
1996	8,109	16,651	6,004	6,000	77	2,251	4,305	6,382	2,366
1997	8,355	18,694	7,408	6,000	79	2,317	4,333	7,750	2,389
1998	8,230	17,858	7,231	6,000	104	2,424	4,674	7,565	2,592
1999	8,463	21,079	7,694	7,500	106	2,515	5,156	8,049	2,429
2000	8,181	19,024	8,244	7,500	159	2,377	4,803	8,625	2,593
2001	8,058	18,226	7,871	7,500	143	2,114	3,882	8,234	2,749
2002	8,034	19,183	8,825	7,500	129	2,225	4,479	9,870	2,906
2003	8,216	19,500	9,150	8,750	136	2,461	4,848	10,446	3,259
2004	8,358	21,612	10,696	10,000	171	2,520	5,025	12,211	3,510
2005	8,448	21,277	11,126	10,375	168	2,621	5,547	12,702	3,721
2006	8,578	23,295	10,750	10,625	163	2,581	5,438	13,848	3,500
2007	8,550	20,959	10,840	15,625	204	2,515	5,563	15,216	5,647
2008	9,046	24,033	11,390	23,750	251	2,963	6,952	15,758	7,130
2009	9,132	23,311	24,391	23,750		2,883	6,883	25,641	6,419

Sources: GOP (various issues). Price data taken from FAO (2011).
Notes: [a]In thousand hectares; [b] In thousand tons.

Table A.3—Indirect uses of wheat and rice in Pakistan (in thousand tons)

	Indirect Use of Wheat	Indirect Use of Rice
1990–91	1,432	196
1991–92	1,456	195
1992–93	1,568	187
1993–94	1,616	240
1994–95	1,521	207
1995–96	1,700	238
1996–97	1,691	258
1997–98	1,665	260
1998–99	1,869	280
1999–2000	1,786	309
2000–01	2,108	289
2001–02	1,902	233
2002–03	1,823	269
2003–04	1,918	291
2004–05	1,950	302
2005–06	2,161	333
2006–07	2,128	326
2007–08	2,330	334
2008–09	2,096	417

Source: GOP 2010.

Table A.4—Time trends of wheat and rice inputs

	Time (year)	t-statistic	Constant	t-statistic	Observations	R^2
Wheat area	0.0092	1.96	8.99	245.40	11	0.99
Rice area	0.0213	2.38	7.70	113.41	11	0.97
Wheat irri.	0.0005	0.39	-0.15	-17.18	11	0.79
Wheat seed	0.0672	4.02	4.70	42.84	11	0.76
Rice seed	0.2406	11.73	0.51	3.66	11	0.97

Source: Author’s estimations.
Notes: The variables are in log form. “Wheat irri” is the share of irrigated area of wheat. “Wheat seed” and “Rice seed” are the quantity of improved seed of wheat and rice, respectively. The time trend is determined using data for 1999–2009.

Table A.5a—Projections of surplus/deficit of wheat and rice (in thousand tons); Population growth 2 percent: Production function method

	2014–15			2019–20			2024–25			2029–30		
	Demand	Supply	Surplus/ Deficit	Demand	Supply	Surplus/ Deficit	Demand	Supply	Surplus/ Deficit	Demand	Supply	Surplus / Deficit
Scenario 1: Business as usual												
Wheat	21,837	20,614	–1,223	24,190	22,898	–1,292	26,913	25,435	–1,478	30,085	28,254	–1,831
Rice	2,578	5,455	2,877	2,939	6,791	3,852	3,362	8,454	5,092	3,861	10,525	6,664
Scenario 2: Pessimistic situation												
Wheat	21,413	20,614	–799	23,936	22,898	–1,038	26,702	25,435	–1,267	29,926	28,254	–1,672
Rice	2,506	5,455	2,949	2,894	6,791	3,897	3,324	8,454	5,130	3,831	10,525	6,694
Scenario 3: Optimistic situation												
Wheat	22,451	20,614	–1,837	24,769	22,898	–1,871	27,634	25,435	–2,199	30,956	28,254	–2,702
Rice	2,681	5,455	2,774	3,040	6,791	3,751	3,492	8,454	4,962	4,023	10,525	6,502

Source: Author's estimations.
Note: Population growth rate = 2 percent.

Table A.5b—Projections of surplus/deficit of wheat and rice (in thousand tons); Population growth 2.42 percent: Production function method

	2014–15			2019–20			2024–25			2029–30		
	Demand	Supply	Surplus/ Deficit	Demand	Supply	Surplus/ Deficit	Demand	Supply	Surplus/ Deficit	Demand	Supply	Surplus/ Deficit
Scenario 1: Business as usual												
Wheat	21,913	20,614	–1,299	24,355	22,898	–1,457	27,181	25,435	–1,746	30,471	28,254	–2,217
Rice	2,586	5,455	2,869	2,958	6,791	3,833	3,394	8,454	5,060	3,908	10,525	6,617
Scenario 2: Pessimistic situation												
Wheat	21,488	20,614	–874	24,099	22,898	–1,201	26,967	25,435	–1,532	30,309	28,254	–2,055
Rice	2,515	5,455	2,940	2,913	6,791	3,878	3,355	8,454	5,099	3,878	10,525	6,647
Scenario 3: Optimistic situation												
Wheat	22,530	20,614	–1,916	24,939	22,898	–2,041	27,910	25,435	–2,475	31,356	28,254	–3,102
Rice	2,690	5,455	2,765	3,060	6,791	3,731	3,526	8,454	4,928	4,073	10,525	6,452

Source: Author's estimations.
Note: Population growth rate = 2.42 percent.

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