

Appendix 1—Spatial Model of India's Wheat and Rice Sectors¹

The wide variation in regional agricultural production and consumption patterns in India suggests that a spatial equilibrium model is an appropriate tool for analyzing the welfare impacts of domestic reforms. A multiregional, partial-equilibrium model of the wheat and rice sectors is used to analyze the impact of selected alternative farm support programs for rice and wheat markets in India. The spatial trade equilibrium model covers 18 major States (regions) that account for 99 percent of total production of these grains. Demand and supply functions for rice and wheat are specified for each State based on elasticity estimates available from the existing literature. These functions are calibrated for the base year 2000-01 using data on all exogenous and endogenous variables. In the model, regional demands and supplies of rice and wheat interact with each other through their substitution possibilities, both in consumption and in production. Equilibrium prices and other variables are obtained as a solution to the commodity balance equations subject to the constraints imposed due to government interventions.²

The two-commodity model described and used here has both strengths and weaknesses for this analysis. A key strength is that, by focusing only on the two crops (rice and wheat) that are most important for the policy issues being examined, the model remains relatively small, simple, and easy to interpret and understand. Rice and wheat are India's dominant food commodities in both production and consumption, and they account for nearly all government expenditure on procurement, distribution, and storage. Interactions with other crops are unlikely to have a major impact on model results in the short- or medium term. Focusing on rice and wheat also plays to the strengths of available data and research on supply and demand elasticities, and minimizes reliance on the relatively poor data and larger number of assumptions necessary to expand the model to other commodities.

Model Limitations

While this two-commodity model is useful in evaluating short- and medium-term implications of the scenarios analyzed, it has more limited value in understanding the longer term implications of the policy options studied. In the longer term, changes in consumer preferences and the prices of other food and nonfood items can be expected to play a larger role in shaping rice and wheat demand. In addition, longer term supply developments are likely to be shaped more significantly by the prices of competing crops, as well as technical trends and developments in water, fertilizer and other input markets that are not accounted for. For more in depth analysis of longer term implications, a more detailed, multi-commodity framework may be needed.

A further limitation of the model, relevant primarily for the analysis of minimum support price (MSP) reductions, is that it does not account for the impacts on production associated with increased producer price risk. Lower MSPs would expose producers to more price risk that could potentially

¹ Model specification, data, calibration of parameters, and results are reported in more detail in Jha and Srinivasan (2006) at <http://www.igidr.ac.in/pub/pdf/PP-052.pdf> and Jha and Srinivasan (2004) at <http://www.ifpri.org/divs/mtid/dp/mtidp67.htm>.

² Computation of equilibrium prices is formulated as a mixed complementarity problem (MCP). The market equilibrium that satisfies the commodity balance equations and the set of inequalities depicting government interventions is obtained as a solution to the MCP using PATH solver in generalized algebraic modeling systems (GAMS) software.

affect planting and input use decisions, indicating that the model will tend to underestimate declines in production associated with lower MSPs. However, since the scenarios analyzed only reduce rather than eliminate the MSPs, it is not clear how significant the impacts are on model results.

Demand and Supply Functions

The total population is divided into six income groups—three for rural areas (rural poor, rural middle class, rural rich) and three for urban areas (urban poor, urban middle class, and urban rich)—with demand functions specified for each group. Aggregate demand in each State is obtained as the sum of group demands weighted by the population of each group. Linear demand functions are used to incorporate the effects of own price, cross price and income. For each region i , the open market demand function for each category of consumers is specified as:

$$D_i = \alpha_i + \beta_i pr_i + \gamma_i qr_i + \lambda_i y_i \quad (1)$$

where

- pr_i = Own retail price
- qr_i = Retail price of the other crop
- y_i = Per capita income

The supply function is also assumed linear. It depends on the weighted average of market and procurement prices received by the farmers.³

$$S_i = a_i + b_i wap_i + c_i qf_i \quad (2)$$

where

- S_i = Production
- $wap_i = \{\lambda pf_i + (1 - \lambda) lvp_i\}$ = weighted average of procurement and market prices
- pf_i = Farm harvest price
- lvp = Levy price (MSP in case of wheat and levy procurement price in case of rice)
- qf_i = Weighted average farm harvest price of substitute crop

Interstate Trade

Aggregate regional imports are defined as the difference between free market demand, i.e., total consumption net of consumption through government distribution programs, and free market supply, i.e., production net of procurement. In addition to transport costs, private traders incur other transaction costs that manifest in the form of policy induced market restrictions, infrastructure bottlenecks, other trade obstacles etc. These transaction costs are modeled as implicit tariffs on interstate trade. In the absence of such transaction costs, spatial arbitrage possibilities are determined by transport costs alone.

³ Depending on the production patterns in different States, rice and wheat are substitutes in production in only some States. However, from the available literature we could not find significant cross price elasticity estimates and had to drop this variable from the supply equations for all States.

Trade from Region i to Region j is determined by the following complementarity (no spatial arbitrage) condition

$$T_{ij} \geq 0 \perp [p_i + tc_{ij} + tm] \geq p_j \quad (3b)$$

where

- T_{ij} = Trade from Region i to Region j
- tc_{ij} = the transportation cost from State i to State j
- p_i = wholesale price
- tm = traders' margins.

With the above complementarity condition, trade will not take place ($T_{ij} = 0$) so long as the sum of purchase cost in State i, cost of transporting grains to State j, and the traders' margin inflated by the implicit tariff exceeds the returns, the open market price in State j, i.e., $(p_i + tc_{ij} + tm) > p_j$. Trade takes place so long as the reverse inequality holds. Perfectly competitive markets imply that trade from State i to j will continue to grow until all the arbitrage benefits are exhausted and total cost equals the open market price in the destination State. Thus, $T_{ij} > 0$ implies that $(p_i + tc_{ij} + tm) = p_j$. Transport costs are assumed to be exogenous (constant average unit costs).

Foreign Trade

External trade is modeled by treating the rest of the world as another region with which individual States can directly trade by incurring the additional costs of transport from the nearest/ cheapest port. Given that the world rice market is thin, we make the large country assumption. Imports, e.g., would tend to become costlier as the magnitude of imports goes up. Similarly, the price received for exports would decline as quantity traded goes down.

Exports take place so long as the price received remains higher than the cost of purchasing the grains plus transport cost from the State center to the port. Imports take place if it is cheaper to import than to buy in the domestic local market. Exports/imports are therefore obtained from the following complementarity conditions

$$x_{i,ROW} \geq 0 \perp [p_i + tc_{i,ROW} + \text{traders' margins}] \geq p_x \quad (4a)$$

$$m_{i,ROW} \geq 0 \perp [p_m + tc_{i,ROW} + \text{traders' margins}] \geq p_i \quad (4b)$$

where x and m denote exports and imports and p_x and p_m denote their respective prices

$$p_x = \text{border price} - \text{port clearance charges} - (ec \times x)$$

$$p_m = \text{border price} + \text{port clearance charges} + (ic \times m)$$

where border price is expressed in domestic currency, ic is the import coefficient and ec the export coefficient. The coefficients ic and ec are obtained from their respective price elasticities of exports (imports) with respect to exports (imports), evaluated at the base year values.

Price Relationships

Equilibrium prices computed in the model are at the wholesale level. However, consumers face the retail price, which enters in the demand equation:

$$pr_i = p_i * (1 + \text{retail margin})^4 \quad (5)$$

Farmers receive the farm harvest price pf_i , which enters the supply equation:

$$pf_i = p_i / (1 + \text{wholesale margin} + \text{marketing cost}) \quad (6)$$

The targeted public distribution system (TPDS) sale price in State i for both rice and wheat is expressed as a fixed percentage lower than the market price:

$$TPDSP_i = n_i p_i$$

The procurement, or farm, price is assumed to be the same for all States and it is exogenous. For rice it is the fixed levy price whereas for wheat it is a fixed minimum support price (MSP).

Public Intervention

Public distribution: Quantities distributed through the targeted public distribution system (TPDS) are fixed exogenously for each State.

Procurement of grains under the MSP: In all scenarios where MSP policy is implemented by physical procurement of grain, the quantities procured of both rice and wheat is determined endogenously based on the complementarity conditions.

$$\begin{aligned} \text{proc}_{Ri} \geq 0 \quad \perp \quad p_{Ri} \geq \text{MSP}_{Ri} \\ \text{proc}_{Wi} \geq 0 \quad \perp \quad p_{Wi} \geq \text{MSP}_{Wi} \end{aligned} \quad (7)$$

where proc_{Ri} and proc_{Wi} denote quantities procured of rice and wheat respectively.

The above complementarity conditions imply that quantities procured will be zero when the open market price is higher than the MSP. Moreover, whenever quantity procured is positive, open market price will equal the MSP. The exception is when rice procurement is by levy, in which case rice procurement is taken as an exogenously fixed percentage of production, $\text{proc}_{Ri} = \mu_i S_{Ri}$ where μ_i is the levy fraction of output in State i .

Market Equilibrium

The market clearing condition equates net availability to demand in each State. Since TPDS quantities are exogenously specified, the condition reduces to equating open market demand with net supply, which caters to the domestic open market demand. The net grain available for consumption within a State through open market purchase is obtained by subtracting from production the outflows from the State, which consist of net regional

⁴ Since we do not have data on retail profit margins, we assume them to be the same percentage as the wholesale margin applied on farm harvest prices to derive wholesale prices.

imports, government procurement and net foreign exports. Thus the equilibrium condition for each State i is

$$S_i + (\sum_j T_{ij} - \sum_j T_{ji}) - \text{proc}_i - (E_i - M_i) = D_i \quad (8)$$

Markets are cleared by the adjustment of price p_i . The level of MSP is such that the quantity procured is more than enough to cover the TPDS requirements. Similarly, the size of the rice levy is such that TPDS needs are met. The difference between the quantity procured and TPDS distribution is taken to be the stocks held by the government.

Welfare Measures

Change in Producer Surplus

$$PS = S_i (\text{wap}_1 - \text{wap}_0) + \frac{1}{2} (\text{spe}) S_i (\text{wap}_1 - \text{wap}_0)^2 / \text{wap}_0$$

where

wap_0 = weighted average of procurement and market prices in the base year scenario,

wap_1 = weighted average of procurement and market prices in the alternative scenarios.

spe = price elasticity of supply.

Change in Consumer Surplus

$$CS = - D_i (\text{pr}_1 - \text{pr}_0) - \frac{1}{2} (\text{dpe}) D_i (\text{pr}_1 - \text{pr}_0)^2 / \text{pr}_0$$

where

pr_0 = own retail base year price,

pr_1 = own retail current year price.

Dp_e = price elasticity of demand.

Gains to Traders

Apart from consumers and producers, other agents in the economy also experience welfare changes. They include traders who earn profit margins by trading within State from farm to wholesale market (*wholesale traders*) and from wholesale to retail market (*retail traders*) and *interstate traders*. The surplus of these traders arises from different sources: (1) if production goes up, more grain is brought from farm gate to wholesale market and hence increases their surplus; (2) if more grain is traded across States, interstate traders gain; and (3) if more grain is consumed, then retailers' surplus goes up. The entire amount of difference between prices at the two points of trade does not constitute the income of traders as they incur some costs to provide services (e.g., finding a buyer and arranging payments, etc). Wholesalers help in the delivery of grain from farm gate to the wholesale markets (within-State transaction) or between wholesale markets in different States.

Using data on profit margins in trading from farm to wholesale market and from wholesale to retail market, we can calculate the gains from trade accruing to traders in each State. The gains from trade are obtained by comparing the surpluses in different scenarios with surpluses in the base scenario.

Wholesale Traders' Surplus (From Farm to Wholesale Markets)

To get this surplus, the margin is multiplied with the wholesale price and local production net of procurement, net exports abroad and net exports to other States. This captures the margins of wholesalers both from inside and outside State i .

$$WTS_i = \text{margin} * p_i * [S_i - \text{proc}_i - \{E_i - M_i\} - \{\sum_j T_{ij} - \sum_j T_{ji}\}]$$

Retail Traders' Surplus (From Wholesale to Retail Markets)

The retail traders' surplus is obtained by applying the margin to the free market demand times the retail price.

$$RTS_i = \text{margin} \times pr_i \times D_i$$

Savings in Government Costs

Total government cost = purchase cost + procurement incidental cost + storage cost + distribution cost

where

Purchase cost = government procurement \times MSP in the case of wheat,

Purchase cost = government procurement \times levy price in the case of rice,

Procurement incidental cost = government procurement \times incidental cost,

Storage cost = (procurement – PDS) \times storage cost,

Distribution = TPDS \times distribution cost

Sale realization = TPDS \times central issue price

Net government cost = total government expenditure – sales realization

Quantity Data

Supply is taken to be production net of seed, feed and wastage. Rice and wheat consumption is obtained from National Sample Survey data for 1999-2000. TPDS quantities are also taken from the same source and are assumed fixed in the model. Procurement is carried out under price-support for wheat and as a levy for rice in the base scenario. The base year data satisfy commodity balances across States by appropriately adjusting for interstate trade (table 1.1).

Total demand is disaggregated into six different income groups (rural poor, rural middle, rural rich, urban poor, urban middle, and urban rich) based on monthly per capita consumption expenditure data for 1999-2000 (Government of India, Ministry of Statistics and Programme Implementation,

National Sample Survey Organization). Data on groupwise per capita expenditure is obtained by extrapolating 1993-94 expenditure data to 2000-01 using the consumer price index (Murty, 2001). Estimates of open market demand for the six groups are computed based on 1999-2000 State-level survey data on monthly per capita consumption expenditures, rice and wheat consumption, and purchases of TPDS rice and wheat in rural and urban areas by expenditure class for individuals and households, together with State population data. The consumption data are summarized in tables 1.2 - 1.4.

Price Data

Consumer demand is modeled in terms of retail price, which is obtained by applying the retail margin to inflate wholesale prices, taken from Chand (2003). The model equilibrium solution is derived in terms of wholesale price but, since levy prices and MSPs are fixed in terms of farm-gate prices, these are inflated using wholesale margins to make them comparable to wholesale level prices. Adjustments are made using data on margins in surplus States where government procurement occurs. Data on MSPs for wheat and MSPs and levy prices for rice are taken from Government of India sources (table 1.5).

Model Elasticities

Model elasticities are based on the results of recent comprehensive studies of supply response and food demand. Own price elasticities of supply are taken from Jha and Srinivasan (1999) and Mythili (2001). The supply elasticities are estimated in terms of net production obtained after adjusting for seed, feed and wastage. For wheat, an average all-India elasticity is used due to nonavailability of State estimates. Cross-price elasticities are not used in the supply equations because available data shows no substitution in production of rice and wheat in major producing States, since these crops are largely grown in different seasons,.

For demand, own-price and income elasticities of demand for rice and wheat by State, rural and urban groups, and income class are based on comprehensive estimation work by Murty (1997) using National Sample Survey data. Cross-price elasticities of demand for rice and wheat are based on estimations by Gulati and Kelly (1999).

For the purpose of the scenarios analyzed in this study, the results are most sensitive to the size of the price elasticities of supply and demand that govern responses to changes in producer and consumer prices across States resulting from decentralization, and over time as MSPs are adjusted. Although alternative studies and methodologies have yielded somewhat different results for price elasticities of rice and wheat supply and demand in India, both supply and demand are consistently found to be inelastic to price and differences between studies are generally small. Because the differences are small, use of alternative available estimates is unlikely to fundamentally change results, although future estimates based on more recent production data and more recent rounds of the National Sample Survey would strengthen confidence in the scenario outcomes.

Appendix table 1.1

Base-year quantities

State	Supply		Open Market Demand		Procurement		Public Distribution System	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
<i>Million tons</i>								
Andhra Pradesh	11.45	0.01	8.82	0.30	7.17	0.00	1.40	0.06
Assam	3.89	0.09	3.61	0.24	0.00	0.00	0.17	0.01
Bihar	5.42	4.50	7.71	5.21	0.01	0.00	0.09	0.12
Goa	0.15	0.00	0.10	0.03	0.00	0.00	0.03	0.01
Gujarat	1.01	0.65	1.12	2.41	0.00	0.00	0.14	0.20
Haryana	2.68	9.65	0.26	2.41	1.48	4.50	0.00	0.01
Himachal Pradesh	0.12	0.59	0.22	0.41	0.00	0.00	0.08	0.06
Jammu & Kashmir	0.41	0.15	0.76	0.49	0.00	0.00	0.22	0.06
Karnataka	3.73	0.24	3.09	0.65	0.23	0.00	0.51	0.14
Kerala	0.75	0.00	2.16	0.25	0.00	0.00	1.16	0.14
Madhya Pradesh	0.96	3.89	3.45	4.66	1.03	0.35	0.14	0.10
Maharashtra	1.95	0.98	3.50	4.30	0.04	0.00	0.33	0.44
Orissa	4.61	0.01	5.62	0.34	0.92	0.00	0.48	0.03
Punjab	9.15	15.55	0.23	2.58	6.94	9.42	0.00	0.00
Rajasthan	0.16	5.55	0.20	6.69	0.03	0.54	0.00	0.09
Tamil Nadu	7.22	0.00	5.25	0.30	1.72	0.00	1.70	0.13
Uttar Pradesh	11.54	24.94	7.89	17.25	1.21	1.55	0.16	0.20
West Bengal	12.43	1.06	10.68	1.35	0.00	0.00	0.23	0.14
Total	77.64	67.86	64.66	49.87	20.77	16.36	6.82	1.94

Sources: Chand (2003), www.indiastat.com, Government of India, Ministry of Statistics and Program Implementation, National Sample Survey Organization.

Appendix table 1.2

Percapita consumption expenditure by expenditure class¹

States	Rural			Urban		
	Poor	Middle	Rich	Poor	Middle	Rich
	Population share					
	<i>Percent</i>					
	22	44	7	8	16	3
	Annual per capita expenditure					
	<i>Rupees</i>					
Andhra Pradesh	2,528	3,732	7,843	4,343	6,339	14,352
Assam	2,827	4,550	8,883	4,361	6,015	13,071
Bihar	2,521	4,058	7,921	4,049	5,846	12,705
Goa	2,754	4,155	7,724	4,206	6,506	13,998
Gujarat	2,917	4,537	8,302	4,715	7,461	16,537
Haryana	3,463	5,385	11,169	3,959	5,702	12,122
Himachal Pradesh	3,078	4,948	10,607	4,135	5,790	13,581
Jammu & Kashmir	3,479	5,593	11,989	4,501	6,268	14,704
Karnataka	2,824	4,261	7,922	4,119	6,746	14,515
Kerala	2,612	4,203	9,278	4,761	7,637	19,059
Madhya Pradesh	2,570	3,906	7,760	4,514	6,956	15,959
Maharashtra	2,911	4,691	9,218	4,007	7,582	17,710
Orissa	2,779	4,103	8,622	4,299	6,703	15,176
Punjab	3,287	5,285	11,329	3,885	6,474	15,187
Rajasthan	3,026	4,697	8,921	4,864	6,829	13,129
Tamil Nadu	2,725	4,385	9,680	5,008	7,745	19,327
Uttar Pradesh	2,647	4,260	8,317	3,994	6,204	13,483
West Bengal	2,455	3,731	7,414	4,753	7,185	16,485

¹Expenditure classes are based on monthly per capita expenditure classifications from the National Sample Survey: poor (rupees 0-340/month), middle (rupees 340-775), and rich (rupees 775+).

Sources: Author's calculations based on data from Murty (2001); Government of India, Ministry of Statistics and Program Implementation, National Sample Survey Organization; Government of India, Directorate of Census Operations.

Appendix table 1.3

Rice and wheat consumption by expenditure class¹

Expenditure classes	Rice			Wheat		
	TPDS consumption	Open market demand	Total demand	TPDS consumption	Open market demand	Total demand
<i>Million tons</i>						
Rural						
Poor	1.27	14.93	16.19	0.32	8.04	8.36
Middle	3.27	30.52	33.78	0.87	23.13	24.01
Rich	0.93	4.33	5.27	0.23	5.14	5.37
All	5.46	49.78	55.24	1.42	36.32	37.74
Urban						
Poor	0.28	6.07	6.35	0.11	5.22	5.33
Middle	0.87	7.57	8.45	0.33	7.03	7.36
Rich	0.2	1.24	1.44	0.08	1.29	1.37
All	1.35	14.88	16.23	0.52	13.54	14.06
Total (rural + urban)						
Poor	1.54	21	22.54	0.43	13.27	13.69
Middle	4.14	38.09	42.23	1.21	30.16	31.37
Rich	1.14	5.57	6.71	0.31	6.43	6.74
All	6.82	64.66	71.47	1.94	49.87	51.8

¹Expenditure classes are based on monthly per capita expenditure classifications from the National Sample Survey: poor (rupees 0-340/month), middle (rupees 340-775), and rich (rupees 775+).

Sources: Author's calculations based on data from Murty (2001); Government of India, Ministry of Statistics and Program Implementation, National Sample Survey Organization; Government of India, Directorate of Census Operations.

Appendix table 1.4

Rural and urban open market demand by State

States	Rice			Wheat		
	Rural	Urban	Total	Rural	Urban	Total
<i>Million tons</i>						
Andhra Pradesh	6.61	2.22	8.82	0.14	0.16	0.30
Assam	3.18	0.43	3.61	0.19	0.05	0.24
Bihar	7.02	0.68	7.71	4.58	0.62	5.21
Goa	0.06	0.04	0.10	0.01	0.02	0.03
Gujarat	0.69	0.43	1.12	1.22	1.20	2.41
Haryana	0.18	0.09	0.26	1.81	0.60	2.41
Himachal Pradesh	0.20	0.02	0.22	0.37	0.04	0.41
Jammu & Kashmir	0.60	0.16	0.76	0.40	0.10	0.49
Karnataka	1.86	1.23	3.09	0.33	0.32	0.65
Kerala	1.63	0.53	2.16	0.17	0.08	0.25
Madhya Pradesh	2.80	0.65	3.45	3.24	1.42	4.66
Maharashtra	1.88	1.62	3.50	2.01	2.29	4.30
Orissa	4.86	0.76	5.62	0.21	0.13	0.34
Punjab	0.13	0.10	0.23	1.86	0.72	2.58
Rajasthan	0.12	0.08	0.20	5.03	1.66	6.69
Tamil Nadu	2.81	2.44	5.25	0.08	0.22	0.30
Uttar Pradesh	6.72	1.17	7.89	14.01	3.24	17.25
West Bengal	8.45	2.23	10.68	0.66	0.69	1.35
Total	49.78	14.88	64.66	36.32	13.54	49.87

Sources: Author's calculations based on data from Murty (2001); Government of India, Ministry of Statistics and Program Implementation, National Sample Survey Organization; Government of India, Directorate of Census Operations.

Appendix table 1.5

Base-year prices

State	Retail price		Wholesale price		Rice levy farm gate price
	Rice	Wheat	Rice	Wheat	
<i>Rupees per 100 kilograms</i>					
Andhra Pradesh	1,477	1,146	1,291	1,002	900
Assam	1,554	1,216	1,328	1,038	846
Bihar	1,378	1,108	1,247	957	861
Goa	1,465	1,261	1,305	1,016	831
Gujarat	1,418	1,062	1,152	863	827
Haryana	1,218	876	1,028	739	904
Himachal Pradesh	1,310	876	1,105	739	904
Jammu & Kashmir	1,442	1,098	1,216	927	904
Karnataka	1,368	1,058	1,277	988	830
Kerala	1,459	1,138	1,317	1,027	830
Madhya Pradesh	1,261	960	1,158	868	840
Maharashtra	1,372	1,157	1,222	932	831
Orissa	1,292	978	1,192	902	869
Punjab	1,218	876	1,028	739	904
Rajasthan	1,248	840	1,097	1,016	881
Tamil Nadu	1,515	1,114	1,305	752	830
Uttar Pradesh	1,176	852	1,028	988	869
West Bengal	1,100	1,040	1,028	791	827

Sources: Chand (2003); <http://www.indiastat.com/>; and Government of India, Ministry of Consumer Affairs, Food, and Public Distribution, Bulletin of Food Statistics.

Appendix table 1.6

Price elasticities of demand for rice by expenditure class¹

States	Own price elasticities of demand						Cross price elasticities (rice/wheat)
	Rural			Urban			
	Poor	Middle	Rich	Poor	Middle	Rich	
Andhra Pradesh	-2.22	-1.77	-1.15	-1.32	-0.87	-0.26	0.045
Assam	-2.25	-1.79	-1.18	-1.35	-0.90	-0.28	0.044
Bihar	-2.25	-1.79	-1.18	-1.35	-0.90	-0.28	0.044
Goa	-2.84	-2.39	-1.77	-1.94	-1.49	-0.87	0.046
Gujarat	-1.07	-0.62	0.00	-0.17	-0.28	0.90	0.046
Haryana	-2.21	-1.75	-1.14	-1.31	-0.86	-0.24	0.045
Himachal Pradesh	-1.92	-1.47	-0.85	-1.02	-0.57	0.05	0.046
Jammu & Kashmir	-1.92	-1.47	-0.85	-1.02	-0.57	0.05	0.046
Karnataka	-2.84	-2.39	-1.77	-1.94	-1.49	-0.87	0.047
Kerala	-2.27	-1.82	-1.20	-1.37	-0.92	-0.30	0.045
Madhya Pradesh	-2.59	-2.14	-1.52	-1.69	-1.24	-0.62	0.047
Maharashtra	-2.29	-1.84	-1.22	-1.39	-0.94	-0.33	0.045
Orissa	-2.22	-1.77	-1.15	-1.32	-0.90	-0.26	0.045
Punjab	-1.92	-1.47	-0.85	-1.02	-0.57	0.05	0.046
Rajasthan	-1.87	-1.42	-0.80	-0.97	-0.52	0.10	0.044
Tamil Nadu	-2.27	-1.82	-1.20	-1.37	-0.92	-0.30	0.047
Uttar Pradesh	-2.25	-1.79	-1.18	-1.35	-0.90	-0.28	0.044
West Bengal	-2.59	-2.14	-1.52	-1.69	-1.24	-0.62	0.045

¹Expenditure classes are based on monthly per capita expenditure classifications from the National Sample Survey: poor (rupees 0-340/month), middle (rupees 340-775), and rich (rupees 775+).

Sources: Murty, 1997; and Gulati and Kelly, 1999.

Appendix table 1.7

Price elasticities of demand for wheat by expenditure class¹

States	Own price elasticities of demand						Cross price elasticities (wheat/rice)
	Rural			Urban			
	Poor	Middle	Rich	Poor	Middle	Rich	
Andhra Pradesh	-2.43	-2.15	-1.99	-1.17	-0.88	-0.72	0.101
Assam	-1.06	-0.78	-0.62	-0.20	0.48	0.64	0.100
Bihar	-1.06	-0.78	-0.62	-0.20	0.48	0.64	0.100
Goa	-1.93	-1.65	-1.48	-0.66	-0.38	-0.22	0.102
Gujarat	-2.47	-2.19	-2.03	-1.20	-0.92	-0.76	0.103
Haryana	-1.55	-1.27	-1.11	-0.28	0	0.16	0.101
Himachal Pradesh	-1.70	-1.42	-1.25	-1.02	-0.15	0.01	0.102
Jammu & Kashmir	-1.70	-1.42	-1.25	-1.02	-0.15	0.01	0.102
Karnataka	-1.93	-1.65	-1.48	-1.94	-0.38	-0.22	0.102
Kerala	-2.14	-1.86	-1.70	-1.37	-0.59	-0.43	0.104
Madhya Pradesh	-1.69	-1.41	-1.25	-0.43	-0.14	0.02	0.101
Maharashtra	-2.52	-2.24	-2.08	-1.26	-0.98	-0.82	0.103
Orissa	-2.43	-2.15	-1.70	-1.17	-0.88	-0.72	0.101
Punjab	-1.70	-1.42	-1.25	-0.43	-0.15	0.01	0.102
Rajasthan	-1.27	-0.99	-0.83	-0.01	0.28	0.44	0.100
Tamil Nadu	-2.14	-1.86	-1.70	-0.88	-0.59	-0.43	0.104
Uttar Pradesh	-1.06	-0.78	-0.62	-1.35	0.48	0.64	0.100
West Bengal	-1.69	-1.41	-1.25	-0.43	-0.14	0.02	0.101

¹Expenditure classes are based on monthly per capita expenditure classifications from the National Sample Survey: poor (rupees 0-340/month), middle (rupees 340-775), and rich (rupees 775+).

Sources: Murty, 1997; and Gulati and Kelly, 1999.

Appendix table 1.8

Income elasticities of demand for rice by expenditure class¹

State	Rural			Urban		
	Poor	Middle	Rich	Poor	Middle	Rich
Andhra Pradesh	1.34	0.77	0.34	1.23	0.66	0.23
Assam	1.23	0.66	0.23	1.12	0.55	0.12
Bihar	1.23	0.66	0.23	1.12	0.55	0.12
Goa	1.54	0.98	0.55	1.43	0.87	0.44
Gujarat	1.26	0.69	0.26	1.15	0.58	0.15
Haryana	1.35	0.79	0.36	1.24	0.68	0.25
Himachal Pradesh	1.40	0.83	0.40	1.29	0.72	0.29
Jammu & Kashmir	1.40	0.83	0.40	1.29	0.72	0.29
Karnataka	1.54	0.98	0.55	1.43	0.87	0.44
Kerala	1.20	0.64	0.21	1.09	0.53	0.10
Madhya Pradesh	1.05	0.49	0.06	0.94	0.38	-0.05
Maharashtra	1.35	0.79	0.36	1.24	0.68	0.25
Orissa	1.34	0.77	0.34	1.23	0.66	0.23
Punjab	1.40	0.83	0.40	1.29	0.72	0.29
Rajasthan	1.86	1.29	0.86	1.75	1.18	0.75
Tamil Nadu	1.20	0.64	0.21	1.09	0.53	0.10
Uttar Pradesh	1.23	0.66	0.23	1.12	0.55	0.12
West Bengal	1.05	0.49	0.06	0.94	0.38	-0.05

¹Expenditure classes are based on monthly per capita expenditure classifications from the National Sample Survey: poor (rupees 0-340/month), middle (rupees 340-775), and rich (rupees 775+).

Source: Murty, 1997.

Appendix table 1.9

Income elasticities of demand for wheat by expenditure class¹

State	Rural			Urban		
	Poor	Middle	Rich	Poor	Middle	Rich
Andhra Pradesh	2.06	1.92	1.53	1.75	1.61	1.21
Assam	0.79	0.65	0.25	0.47	0.33	-0.06
Bihar	0.79	0.65	0.25	0.47	0.33	-0.06
Goa	1.22	1.08	0.68	0.90	0.76	0.36
Gujarat	1.18	1.04	0.65	0.87	0.73	0.33
Haryana	0.79	0.65	0.25	0.47	0.33	-0.07
Himachal Pradesh	0.79	0.65	0.25	0.47	0.34	-0.06
Jammu & Kashmir	0.79	0.65	0.25	0.47	0.34	-0.06
Karnataka	1.22	1.08	0.68	0.90	0.76	0.36
Kerala	1.89	1.75	1.35	1.57	1.43	1.04
Madhya Pradesh	1.24	1.10	0.70	0.92	0.78	0.39
Maharashtra	0.99	0.85	0.45	0.68	0.54	0.14
Orissa	2.06	1.92	1.53	1.75	1.61	1.21
Punjab	0.79	0.65	0.25	0.47	0.34	-0.06
Rajasthan	1.11	0.97	0.57	0.80	0.66	0.26
Tamil Nadu	1.89	1.75	1.35	1.57	1.43	1.04
Uttar Pradesh	0.79	0.65	0.25	0.47	0.33	-0.06
West Bengal	1.24	1.10	0.70	0.92	0.78	0.39

¹Expenditure classes are based on monthly per capita expenditure classifications from the National Sample Survey: poor (rupees 0-340/month), middle (rupees 340-775), and rich (rupees 775+).

Source: Murty, 1997.

Appendix table 1.10

Supply elasticities for wheat and rice

State	Wheat	Rice
Andhra Pradesh	0.090	0.060
Assam	0.090	0.060
Bihar	0.090	0.115
Goa	0.090	0.090
Gujarat	0.090	0.115
Haryana	0.090	0.060
Himachal Pradesh	0.090	0.090
Jammu & Kashmir	0.090	0.090
Karnataka	0.090	0.115
Kerala	0.090	0.115
Madhya Pradesh	0.090	0.115
Maharashtra	0.090	0.115
Orissa	0.090	0.115
Punjab	0.090	0.060
Rajasthan	0.090	0.115
Tamil Nadu	0.090	0.090
Uttar Pradesh	0.090	0.060
West Bengal	0.090	0.060

Source: Jha and Srinivasan, 1999 and Mythili, 2001