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RESEARCH NOTES

INTER-REGIONAL ALLOCATION OF MAJOR FOODGRAINS IN ANDHRA PRADESH : AN APPLICATION OF SPATIAL EQUILIBRIUM MODEL

Andhra Pradesh is a surplus State in foodgrains particularly in rice. The significant increase in production and size of marketable surplus after the introduction of seed-fertiliser-water technology in the mid-sixties in Andhra Pradesh is likely to depress the prices received by the farmers substantially and might result in the substitution of high income non-food crops, unless measures to siphon off the surpluses are taken up. The role of an effective marketing system is to link the different regions of surplus and deficit production within the State together as well as with other States of the country for better exploitation of the comparative advantage of all regions. To achieve this, a normative planning for inter-regional allocation of major foodgrains through a spatial equilibrium model is necessary.

Creation of food zoning is a policy suggestion with far-reaching effect on regional production, marketing and pricing pattern of foodgrains. There are gains to society like price stability and consumer welfare through inter-regional trade. Hence, it is important to understand the effects and implications of restricted food zoning vis-a-vis free trading between regions and to assess whether producers and consumers in the aggregate are better off or worse off.

Thus, the present study is intended to develop a spatial price equilibrium and area allocation model for the three regions and three major foodgrains crops in Andhra Pradesh. The specific objectives of the study are : (i) to determine the optimal pattern of crop allocation, commodity flows and price outcomes consistent with optimal spatial allocation of selected foodgrains, and (ii) to assess the impact of food zoning and the commodity movement restrictions on the overall social welfare in Andhra Pradesh.

MATERIALS AND METHODS

Coastal Andhra, Rayalaseema and Telangana which form the administrative divisions and traditional agro-climatic regions of Andhra Pradesh are selected for the study since the policy implications, if any, from the study would help in regional planning. Rice, jowar and total pulses form 81 per cent of the area and 86 per cent of the production of foodgrains. Government imposed various controls only for these crops to bridge the gap between supply and demand. So, these three crops are considered for the study.

The spatial equilibrium analysis requires supply and demand function of selected crops and their transportation costs between trading regions. The relevant data are drawn from secondary sources and linear[1] regional supply and demand functions were specified (Takayama and Judge, 1971). Weighted average transport cost per quintal between each pair of regions was worked out in the ratio of 1:4 for railways and roadways, based on the volume of freight handled by them at present. A spatial equilibrium model using quadratic programming technique is found to be most appropriate and is used.

The Objective Function

The objective function is the maximisation of net social welfare (NSW) in Andhra Pradesh measured as producer's surplus plus consumer's surplus minus the transportation costs.

The objective function[2] is given by

$$\text{Max } NSW = \sum_{i=1}^{3}\sum_{j=1}^{3} a_{ij} - \frac{1}{2}Q_{ij}^{d}\beta_{ij}Q_{ij}^{d} - V_{ij}Q_{ij}^{s} - \frac{1}{2}Q's_{ij}H_{ij}Q_{ij}^{s} - \sum_{k=1}^{3}\sum_{i=1}^{3}\sum_{j=1}^{3} t_{ikj}X_{ikj}$$

Subject to

$$\sum_{j=1}^{3} l_{ij}Q_{ij}^{s} < L_i \text{ for all i, i=1, 2, 3} \qquad \text{....(1)}$$

$$\sum_{j=1}^{3} n_{ij}Q_{ij}^{d} = N_i \text{ for all i and j} \qquad \text{....(2)}$$

$$e_{ijp}Q_{ijp}^{s} < IR_{ijp} \text{ for all i, i=1, 2, 3} \qquad \text{....(3)}$$

where Q^{d}_{ij} = quantity demanded of commodity j in region i,

Q^{s}_{ij} = quantity supplied of commodity j in region i,

P^{d}_{ij} = demand price of commodity j in region i,

P^{s}_{ij} = supply price of commodity j in region i,

I_{ij} = reciprocal of yield per unit area of crop j in region i,

L_i = land available in region i that can be put under crop j,

e_{ijp} = reciprocal of yield per unit of irrigated area of paddy in region i,

Q^{s}_{ijp} = quantity produced of commodity paddy in region i,

IR_{ijp} = irrigated land that can be put under crop paddy in region i,

n_{ij} = calorie content per unit of product in region i,

N_{ij} = required level of intake of j by population in region i,

$\alpha_{ij} = a_{ij}/b_{ij}$ and $\beta_{ij} = 1/b_{ij}$,

$V_{ij} = -c_{ij}/d_{ij}$ and $H_{ij} = 1/d_{ij}$,

a_{ij} = intercept of the demand function for commodity j in region i,

b_{ij} = slope coefficient of the demand function for commodity j in region i,

c_{ij} = intercept of the supply function for commodity j in region i,

d_{ij} = slope coefficient of the supply function for commodity j in region i,

t_{ikj} = the unit transport cost between each pair of regions i and k of commodity j,

X_{ikj} = the quantity of commodity j flowing from region i to k,

i,k = 1, 2, 3 represent regions, for $i \neq k$,

j = 1, 2, 3 represent commodities.

Land Constraint

The maximum area under rice, jowar and pulses during the recent past five years (*i.e.*, from 1978-79 to 1982-83) in different regions was taken as the total availability of land. Similarly, the maximum area under irrigated paddy was taken as the area restriction for rice.

Crop Yields

The highest yields per hectare of paddy, jowar and pulses during the recent past five years (*i.e.*, from 1978-79 to 1982-83), were considered as the productivity levels to be used in the programming.

The entire exercise has been carried out under two economic environments described as under:

(i) *Restricted trade situation*

Andhra Pradesh is considered as a closed economy where only inter-regional commodity flow is allowed, but the flow of commodity in and out of Andhra Pradesh is not allowed. The restrictions of mill levy[3] within each region for rice are expressed as a percentage of its production and related to the commodity flow out of this region. This restriction has been imposed in the model as under :

$$r_{ijp} Q^{s}_{ijp} > X_{ikp} \qquad \text{....(4)}$$

where, r_{ijp} is the coefficient of trade restriction in region i for rice and X_{ikp} is the quantity of rice shipped from region i to k.

(ii) *Free trade situation*

Andhra Pradesh is considered as an open economy where commodity flow out of/into the State is also permitted within limit assigned *a priori*.

The solution for the above quadratic programming problem was obtained through a computer package called MINOS (Bruce and Michael, 1977) available at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad.

RESULTS AND DISCUSSION

Table I shows the optimal demand, supply and commodity flows under free and restricted situations in different regions of Andhra Pradesh. From the table it is evident that Telangana is self-sufficient in rice but deficient in jowar and pulses. Rayalaseema is deficient in rice, but surplus in jowar and pulses. Coastal Andhra is surplus in rice and jowar but deficient in pulses.

Optimal area allocation, production and prices in different regions of Andhra Pradesh under free, restricted and existing situations are shown in Table II. The following inferences can be drawn from a comparison of the free and restricted trade situations.

TABLE I. OPTIMAL DEMAND SUPPLY AND COMMODITY FLOWS IN FREE AND RESTRICTED TRADE SITUATIONS

('000 tonnes)

	Free trade				Restricted trade		
	Telangana	Coastal Andhra	Rayala-seema	Rest of India	Telangana	Coastal Andhra	Rayalaseema
Demand							
Rice	1,489.70	2,370.80	858.75	--	1,563.81	2,503.72	911.30
Jowar	933.93	22.57	101.49	--	975.94	22.76	108.20
Pulses	167.78	199.05	24.05	--	165.33	195.39	23.13
Supply							
Rice	1,769.76	3,012.42	556.15	--	1,663.92	2,796.63	518.28
Jowar	769.82	215.77	366.23	--	642.43	180.03	284.44
Pulses	142.41	189.83	47.63	--	143.49	192.55	48.32
Commodity flows							
Rice		619.00 →				100.11 →	
		22.54 →				292.92 →	
		280.06 →					
Jowar	164.12 ←						
		29.08 →				157.27 ←	
		264.74 →				176.24 ←	
Pulses	1.78 ←					22.34 ←	
		9.22 ←				2.84 ←	
		23.5 ←					

(i) The optimal area allocated for rice and pulses in all the regions, on comparative terms, is lower under free trade. It is higher for jowar. The total area under these three crops remains unchanged under both the situations of trade in Telangana while it differs in the case of Rayalaseema, Coastal Andhra and State as a whole, by about, two per cent, three per cent and one per cent respectively.

(ii) The production of rice and jowar is observed to be lower, on comparative terms, in all the regions and State as a whole. But it is higher by one per cent for pulses.

The aggregate production was lower by about 242 thousand tonnes (nine per cent) in Telangana, by about 119 thousand tonnes (12 per cent) ins Rayalaseema, by about 249 thousand tonnes (seven per cent) in Coastal Andhra and by about 600 thousand tonnes (eight per cent) in the entire State. The magnitude of gain in aggregate production on percentage basis is the highest in Rayalaseema and the least in Coastal Andhra due to liberalisation of trade. Dantwala (1976) observed that zonal food policies brought such disincentives in surplus States.

These results imply that a region which has a comparative disadvantage in the production of a certain crop, experiences a fall in its production which is being offset by an increase in the production of other crops. It may be recalled that, on comparative terms, Coastal Andhra region is better and Rayalaseema is worse in resource endowments in Andhra Pradesh. All regions put together can export 619 thousand tonnes of rice and 294 thousand tonnes of jowar to the rest of India. In turn, they import 11 thousand tonnes of pulses from it. These figures amount to 12 per cent of rice, 22 per cent of jowar and three per cent of pulses produced annually in Andhra Pradesh (on an average, from 1980-81 to 1982-83). Though the optimal prices are not the same in all regions for the commodities, the differences are small and tolerable. It is observed that the weighted average prices of the commodities, rice and jowar in the State as a whole (all regions put

TABLE II. OPTIMAL ALLOCATION OF AREA AND PRODUCTION AND EQUILIBRIUM PRICES OF RICE, JOWAR AND PULSES IN DIFFERENT REGIONS OF ANDHRA PRADESH UNDER FREE TRADE, RESTRICTED TRADE AND EXISTING SITUATIONS

(area in '000 hectares, production in '000 tonnes and prices in million rupees/'000 tonnes)

	Telangana			Rayalaseema			Coastal Andhra			Andhra Pradesh		
	Free trade	Restricted trade	Existing situation	Free trade	Restricted trade	Existing situation	Free trade	Restricted trade	Existing situation	Free trade	Restricted trade	Existing situation
Area												
Rice	1359.88	1406.51	1407.00	417.61	428.09	428.59	1682.44	1709.58	2256.99	3459.93	3544.18	4092.58
	(36.36)	(37.51)	(37.52)	(39.22)	(40.20)	(40.25)	(54.20)	(55.08)	(72.71)	(43.69)	(44.76)	(51.68)
Jowar	1568.27	1439.41	529.11	376.34	321.53	481.00	320.72	294.35	354.56	2265.33	2055.49	2364.67
	(41.28)	(38.39)	(40.78)	(35.34)	(30.19)	(45.17)	(10.33)	(9.48)	(11.42)	(28.61)	(25.96)	(29.86)
Pulses	757.40	839.57	814.00	181.89	202.99	155.28	541.77	604.49	492.38	1481.06	1647.05	1461.66
	(20.20)	(22.39)	(21.71)	(17.08)	(19.06)	(14.58)	(17.45)	(19.47)	(15.86)	(18.70)	(20.70)	(18.46)
Total	3685.55	3685.69	3750.11	975.84	952.61	1064.87	2544.93	2608.42	3103.93	7206.32	7246.72	7818.91
	(98.28)	(98.28)	(100.00)	(91.64)	(89.46)	(100.00)	(81.99)	(84.04)	(100.00)	(91.00)	(91.51)	(100.00)
Production												
Rice	1769.76	1663.92	1664.50	556.15	518.28	518.87	3012.42	2796.63	3138.95	5338.33	4978.83	5322.32
Jowar	769.82	642.43	682.36	366.23	284.44	425.57	215.77	180.03	138.00	1351.82	1106.90	1245.93
Pulses	142.41	143.49	139.12	47.63	48.32	36.97	189.83	192.55	156.84	379.87	384.35	332.93
Total	2681.99	2449.84	2485.98	970.01	851.04	981.41	3418.02	3169.21	3433.79	7070.02	6470.08	6901.18
Percentage@	100.00	91.34	-	100.00	87.74	-	100.00	92.72	-	100.00	91.51	-
Prices												
Rice	4.52	4.26	2.82	4.52	4.01	2.79	4.82	4.31	1.21	4.53*	3.89*	1.86
Jowar	1.16	0.78	1.37	1.40	1.03	1.26	1.40	1.02	5.27	1.26*	0.88*	1.32
Pulses	4.42	4.51	4.73	4.66	4.77	4.96	4.66	4.75	4.57	4.57*	4.67*	4.24

Percentage@ = Percentage variation under restricted trade over free trade.
* indicates weighted average prices with quantities produced as the weights.
Note:- Figures in parentheses are percentages of figures to exisiting situations.

together) are higher under free trade compared to restricted trade situations. This implies, *ceteris paribus*, that free movement shifts the terms of trade in favour of these crops.

By comparing the free trade and existing situation, the following inferences can be made.

The optimal crop pattern in Telangana reveals that it is possible to make available a surplus of 65 thousand hectares as only 98 per cent of the total area under these crops is utilised. Rayalaseema can reduce 11 thousand hectares (one per cent) under rice. It is possible to withdraw 105 thousand hectares of area under jowar and reallocate 31 thousand hectares for pulses. About 89 thousand hectares out of the total area (eight per cent) under these crops can be released for growing other non-foodgrain crops. It is possible to reduce 575 thousand hectares in Coastal Andhra (19 per cent) under rice and 34 thousand hectares (one per cent) under jowar. But about 49 thousand hectares (one per cent) of additional area can be brought under pulses. The optimal crop pattern in Andhra Pradesh shows that the area under rice and jowar can be reduced by 633 thousand hectares and 99 thousand hectares respectively. But it is possible to increase 19 thousand hectares under pulses. Thus 713 thousand hectares under cultivation of these crops (nine per cent) at present can be reallocated among non-foodgrain crops.

The production of rice, jowar and pulses under the free trade situation is higher than the existing situation at aggregate level because of the realisation of trade gains. In absolute terms, production of rice goes up by 16 thousand tonnes, jowar by 106 thousand tonnes and pulses by 47 thousand tonnes. The aggregate production of all the commodities goes up by 169 thousand tonnes in free trade compared to the existing situation in the State.

The weighted average price is higher at the State level compared to the existing prices only under free trade situation. From this, it follows that inter-regional trade and free movement of commodities bring overall gains to the society through higher prices to producers. A food policy which supports free movement of trade has a measurable effect of increasing productivity of agriculture (von Oppen *et al.*, 1983).

Ceteris paribus, it is advantageous for a region with better market infrastructure to specialise in a crop when it can increase supply at a low per unit cost of production. Suryanarayana (1980) reported that the costs of production per quintal of paddy in Coastal Andhra and of jowar in Rayalaseema are the lowest. So, the production of rice may be concentrated in Coastal Andhra while that of jowar in Rayalaseema as it is comparatively advantageous for those regions to do so.

Evaluation of Gains to Society through Inter-Regional Trade

This study is intended to determine whether the overall welfare (Marshall, 1959) of the society is improved due to a deliberate policy change. Changes in producer's and consumer's surpluses are calculated by the following formulae (Hardakar, 1983).

$$\text{Consumer's Surplus} = (\alpha - \bar{P})'Q^d - \frac{1}{2}Q^{rd}\beta Q^d$$

$$\text{Producer's Surplus} = (\bar{P} - V)'Q^s - \frac{1}{2}Q^s H Q^s$$

where the notations are the same as explained earlier.

The producer's, consumer's and aggregate economic surplus across products in each region and also across products and regions under both the trade situations are presented in Table III. It may be seen that the producer's surpluses are lower in magnitude

compared to the consumer's surplus in each of the regions under both the situations. But, the producer's surpluses are higher under free trade situation compared to restricted trade. In a situation of self-sufficiency, when extra output has to be absorbed domestically, the

TABLE III. PRODUCER'S SURPLUS, CONSUMER'S SURPLUS AND ECONOMIC SURPLUS UNDER FREE AND RESTRICTED TRADE IN DIFFERENT REGIONS OF ANDHRA PRADESH

(million rupees)

	Telangana	Rayalaseema	Coastal Andhra	Andhra Pradesh	Rest of India	At aggregate level
Free trade						
Producer's surplus	6,364.74	2,540.46	11,507.00	20,412.20	3,174.51	23,586.71
Consumer's surplus	9,821.43	3,992.28	12,844.50	26,658.21	- 51.36	26,606.85
Economic surplus	16,186.17	6,532.74	24,351.50	47,070.41	3,123.15	50,193.56
Percentage share of producer's surplus in regional economic surplus	39.32	38.89	47.25	43.36		35.05
Percentage share of consumer's surplus in regional economic surplus	60.68	61.11	52.75	56.64		64.95
Restricted trade						
Producer's surplus	5,571.67	2,158.27	9,974.14	17,704.08		
Consumer's surplus	10,593.40	44,476.84	14,073.87	29,144.40		
Economic surplus	16,165.10	6,635.11	24,047.90	46,848.10		
Percentage share of producer's surplus in regional economic surplus	34.47	32.53	41.48	37.79		
Percentage share of consumer's surplus in regional economic surplus	65.53	67.47	58.52	62.21		

Note:- Under free trade, the surpluses resulting from trade with the rest of India are evaluated considering weighted average prices of rice, jowar and pulses.

benefit of productivity gains will be transferred to consumers (Quizon and Binswanger, 1985). The increase in overall gain in economic surplus by about seven per cent implies that both producers and consumers gain under free trade. Quizon and Binswanger (1985) as well as Subbarao (1985) opined that while gains do accrue under free trade, a disproportionately larger share goes to large producers and rich consumers. But, based on the present study, no firm conclusion could be drawn on the distribution of gains within producers (large, medium, small and marginal farmers) and within consumers (different income groups).

It may be mentioned that economic surplus under free trade in Andhra Pradesh is Rs.47,070 million. But, under free trade, Andhra Pradesh exports 619 thousand tonnes of rice, 294 thousand tonnes of jowar and imports 111 thousand tonnes of pulses. When these quantities are evaluated at weighted average prices, they yield an additional gain of Rs. 3,123 million so that the overall gain to the society is Rs. 50,194 million. This is because of the realisation of comparative advantage of all regions.

CONCLUSIONS AND POLICY IMPLICATIONS

1. The production of rice and jowar may be concentrated in Coastal Andhra and Rayalaseema regions adopting a favourable price policy since it is comparatively advantageous to do so. Telangana has no potential to increase production of these crops by reallocation of the existing area.

2. Trade restrictions put producers at a loss of about five per cent of total possible economic surplus. Aggregate production of all these crops comes down by eight per cent in the State by imposing these restrictions on inter-regional trade. So, free trade is recommended.

The present study yields results which would be very useful for regional planning and other policy decisions. These trends in production indicate the need for the development of marketing, storage, processing and transport facilities for these foodgrains in the three regions to procure and distribute the surplus available from other regions. Thus, identifying potential areas helps in developing suitable agro-based industries in that region, and set up satellite industries by establishing forward and backward linkages. The percolation effects of this are income generation and creation of opportunities for employment.

The results on area allocation help in releasing land for the cultivation of other crops when it is comparatively disadvantageous to produce a certain commodity. The present study offers reasonable clues for effective monitoring of better land use and appropriate price policies and those related to food zoning.

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NOTES

1. The spatial equilibrium model applied in this study requires that the supply and demand functions are linear.

2. If the appropriate Kuhn-Tucker necessary conditions and the lagrangean are formed, it would yield the following equations that are to be solved for optimal solution.

(i) $Q^d_{ij} = a_{ij} - b_{ij} p^d_{ij}$

(ii) $Q^s_{ij} = c_{ij} + d_{ij} p^s_{ij}$

(iii) $P_{ij} - P_{kj} < t_{ikj}$, for all i, k and j, i, k, j = 1, 2, 3

(iv) $$Q^d_{ij} - Q^s_{ij} + \sum_{k=1}^{3} X_{ikj} - \sum_{k=1}^{3} X_{kij} = 0$$

3. According to the Andhra Pradesh Rice Procurement (Levy) and Restrictions on Sale Order 1967, every miller/dealer is required to deliver the prescribed percentage of rice milled to the Government.

REFERENCES

A. Murtagh Bruce and A. Saunders Michael:MINOS User's Guide, Technical Report, No.77-9, Department of Operations Research, Stanford University, California, 1977.

M.L. Dantwala, "Agricultural Policy in India Since Independence", *Indian Journal of Agricultural Economics*, Vol.XXXI, No.4, October-December 1976, pp. 31-53.

J.B. Hardaker: Some Models for Assessing the Economic Consequences of a Supply Shift, Progress Report No.54, Economic Program, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Hyderabad, 1983.

A. Marshall : Principles of Economics, Macmillan Company, Inc., London, 1959.

M. von Oppen, P. Parthasarathy Rao and K.V. Subba Rao, "Impact of Market Access on Agricultural Productivity in India", Paper presented to the International Workshop on Agricultural Markets in the Semi-Arid Tropics, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Hyderabad, 1983.

J.B. Quizon and H.P. Binswangar: The Impact of Agricultural Growth and Selected Government Policies on the Distribution of Income in India, Report No. A3U21 Agriculture and Rural Development Department, The World Bank, Washington, D.C., 1985.

K. Subbarao, "Incentive Polcies and India's Agricultural Development: Some Aspects of Regional and Social Equity", *Indian Journal of Agricultural Economics*, Vol. XL, No. 4, October-December 1985, pp. 494-511.

K.S. Suryanarayana: Economic Aspects of Yield Increasing Technology in Producing Foodgrains in Andhra Pradesh, Technical Report, Department of Agricultural Economics, Andhra Pradesh Agricultural University, Hyderabad, 1980.

T. Takayama and G.G. Judge: Spatial and Temporal Price and Allocation Models, North-Holland Publishing Company, Amsterdam, 1971.