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AGRICULTURAL MARKETING AND AGGREGATE PRODUCTIVITY: A DIMENSION TO BE ADDED TO AGRICULTURAL MARKET RESEARCH

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economy into the national market of a developing economy (supplemented by appropriate taxation policies[1] and welfare schemes[2] to counteract the "Urban Bias"[3]) could lift productivity of all participants in this integrated system so that all would be better off, without necessarily depleting resources more than before. The mechanism that brings about the productivity increase is based upon the well-known principle of comparative advantage and specialization.

This paper reports on research underway at ICRISAT. The aim is to fill a gap in the existing body on agricultural market research, and to provide quantitative measurements of the impact of agricultural marketing on aggregate productivity from which estimates of the return to investments into agricultural markets can be derived. At this stage questions of equity in regional and personal income distribution are given secondary attention in the discussion of the implications of results in order to focus on the issue of potential productivity increase due to market integration of agriculture.

1. MARKET RESEARCH AT PRESENT

Researchers working on problems of agricultural marketing in recent years generally belong to one or another of the following schools:

1 - the traditional approach of describing the links between producers and consumers; and of evaluating market cost and pricing efficiencies; Breimyer[4] calls it the "what happens" - school.[5]

2 - the neo-classical approach of stressing the dual role of markets in allocating resources by coordinating economic activities. Markets are

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1 Lakhdawala (18)
2 e.g. Public Distribution Systems as proposed by present Ministry of Commerce of the Government of India.
3 Lipton (19)
4 Breimyer (4)
5 This school of thought comprises a wide area of research, including studies on marketable surplus, price response studies and consumer preference analyses, as well as descriptions of market channels and their evaluation against models of perfect competition or the structure - conduct-and performance-concept.

evaluated according to their performance of this role.[1]

3 - the equity-oriented approach by those who feel that neither one of the above approaches is sufficiently concerned with equity, income distribution, and risk bearing among market participants.[2]

4 - the systems approach, a derivate of the above three schools; followers of this school have a strong concern for equity or environmental aspects but at the same time they are accepting the role of the market as a coordinator of economic activities. However, despite its attempt of a fully comprehensive approach, this school fails to integrate one very essential aspect of agricultural marketing into the system; i.e., the role of efficient resource allocation and spatial distribution of production systems.[3]

This failure of the systems school is not incidental, but it reflects the general situation in agricultural market research. The impact of agricultural markets on aggregate productivity has not received the attention it requires, especially when considering agriculture in developing countries.[4]

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1 This school has a long tradition of quantitative analysis dating back to H.von Thunen, A.Weber and A.Losch. However, recent analytical marketing research along these lines focusses primarily on international trade and world markets; e.g.Reutlinger (27), Adams and Behrman (1), Takayama (37). In studies involving national markets and trade within a national economy, the allocation of facilities such as for storage or processing or the analysis of interregional trade flows have received wide attention (e.g.Reddy *et al* (26), von Oppen and Scott (41) and literature cited there). At the same time the allocation of cropping patterns and its impact upon aggregate productivity in relation to market constraints has been studied only by a very few (e.g.Sherbiny and Zaki (32), Shankayan and Sidhu(29), von Oppen (40)).

2 This school of thought comprises the literature on cooperatives, as well as on horizontal and vertical integration or contract farming.

3 It was the lack of understanding of this role of the marketing system that prompted the summary statement of an FAO-OECD sponsored conference to express the "need for more applied research on agricultural and food marketing development with the objective of coming to a more coincise concept of the role of the marketing system in economic and rural development" (6), p.64.

4 A recent report on market imposed problems in countries of the Sahel which contains a very comprehensive annotated bibliography mentions nowhere the relationship between markets and aggregate productivity (39).

A systematic classification of the literature on agricultural marketing published over the last decade would reveal a general neglect of such essential aspects as regional allocation of cropping patterns and interregional trade in view of the principle of comparative advantage.[1] The reason for the lack of attention paid to these aspects in the past may be many fold: in developed economies researchers do not regard this aspect because generally agriculture has already reached such a degree of commercialization and of regional specialization that substantial gains from shifts in production patterns cannot be expected. In developing countries, agricultural marketing researchers concern themselves primarily with issues such as equity of income distribution among farmers, "middlemen", and consumers; the difficulties of small farmers; and marketed surplus to supply urban consumers. In some instances, the tools and data required for this kind of research are not easily available to many researchers, even if they wanted to deal with the problem.

However, the problem of assessing the market imposed constraints for development of a primarily subsistence-oriented agriculture in the semi-arid tropics requires urgent attention.[2] In the following, an attempt will be made to make use of data available in India and to apply a methodology for measurement of the effects of market efficiency on aggregate productivity.

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1 Production economists occasionally mention specialization of farming systems as a way to increase productivity; however, without quantifying and rigorously testing this hypothesis (see e.g.Ruthenberg (28), p.8). Earlier writers have shown that resource allocation in Indian agriculture is efficient (Sahota (30) and literature cited); but this was rather to prove that farmers are rational decision makers than to bring out potential gains from interregional exchange and reallocation of cropping systems. In a recent paper Easter and Abel (7) point out the effect of roads on productivity in rice growing areas of India. D.Narain (20), p.22 has noted the need for research into the effects of spatial differences in prices on locational shifts in areas under different crops.

2 The theory of the "farm-household", which is based on simultaneous determination of consumption and production choices (Singh and Squire (35)) approaches the same problem, but with the aim of influencing household food consumption and production; choices via exogenous changes; thus it refers to short run policies rather than planning long run changes.

2. RESEARCH TO ASSESS IMPACT OF MARKETING SYSTEMS ON AGGREGATE PRODUCTIVITY

The following presents a methodology for measuring and demonstrating the impact of agricultural markets on productivity. Two basic econometric tools are incorporated in this methodology: (1) activity analysis and (2) regression analysis.

2.1. ACTIVITY ANALYSIS OF PRODUCTION AND PRICING AT DIFFERENT LEVELS OF SUPPLY UNDER FREE AND RESTRICTED INTERREGIONAL TRADE

2.1.1 The Model

Effective competition among the industries of two or more regions leads to regional specialization according to the principle of comparative advantage and generates an increase in aggregate productivity.

Competition is made effective via interregional exchange. Depending upon the quality of the market channels through which the interregional trade is flowing, interregional competition may be more or less efficient. The quality of market channels is primarily dependent upon physical facilities and on institutional arrangements.[1/]

The effect of changes in the quality of market channels on productivity varies with different levels of technological inputs. The more advanced technologies tend to be applied in regions or localities where they are particularly well suited, and thus widen the regional differences in productivity of a particular crop or cropping system. Logically, with a widening of productivity differentials, regional

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1/ There are, of course, other factors, such as literacy of the population, education etc., which may have a considerable impact on the prevailing practices such as weighment, acceptance of standardization, and which in turn influence the efficiency of the market channels of one country in comparison to another, but for an interregional analysis within any given country such factors will be ignored for the time being. Also the entire complex of interactions between agrarian structure (farm size distribution, caste systems, etc.) and market systems (see e.g. B.Harris (11)) will be taken as a given exogenous variable since the policy maker cannot do much to bring about changes.

differences in comparative advantage will become more pronounced; consequently, any defects in the market channels which restrict interfarm and interregional exchange will become more costly in terms of foregone aggregate productivity gains; the more advanced the available technologies are, the higher the potential level of productivity is. Similar to long run adjustments, short run reallocations in production systems, according to annual shifts in price-cost relationships, are more effectively carried out and consequently result in higher aggregate production, the higher the allocative efficiency of markets is.

In order to demonstrate this impact of market channels on productivity, an activity analysis model has been set up to investigate commodity flows, pricing and crop allocation at different productivity levels of three crops in three regions.[1] The model is based on data which represent the following hypothetical case: In the three Indian states of Andhra Pradesh, Madhya Pradesh, and Maharashtra, three crops; namely, rice, sorghum and chickpea are grown and all three crops compete for the same resources, which are represented by land. The initial yield levels for each crop are given in Table 1, together with the land available for growing all of the three crops in each state.

Not only is yield per hectare restricting the supply but linked to the yield is a price dependent linear supply function. In other words, together with the physical yield constraint, also economic considerations such as costs of production, local markets, and transport facilities, etc., restrict the supply and enforce price dependency of supply of each crop in each State. The initial elasticities of supply are derived from available estimates and represent actual conditions.[2]

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1 For mathematical derivation of this quadratic programming model, see Appendix I.

2 For rice, estimates are available from a number of sources, but not for sorghum and chickpea. Studies are underway at ICRISAT to estimate the supply and demand elasticities for sorghum, millets, pigeonpeas, chickpeas, groundnuts, and other crops (see Bapna (3)).

Table 1: Assumed Yields and Land Availability

State	Yields (kg/ha)			Land Available (million ha)
	Rice	Sorghum	Chickpea	
Andhra Pradesh	1563	455	375	5
Madhya Pradesh	820	633	680	9
Maharashtra	1031	313	306	8

The model also includes demand as a linear function of price. Both demand and supply elasticities[1] of price for the initial case A for all crops and states are presented in Table 2.

Transportation costs between regions correspond to official rail freight rates between centrally located places in each of the three states (see Table 3).

Given this environment the quadratic programming model allocates crop production in each of the states so that producers' plus consumers' welfare minus total costs for transportation be maximized.

This model is depicted in Figure 1 in the form of a back-to-back diagram for the simple case of one commodity and two regions. Figure 1 shows for case A (initial condition of low yields and high costs of production) that by exporting the excess supply $ES^*_a = SI^*_a - DI^*_a$ from Region I to Region II, the equilibrium prices PI^*_a and PII^*_a are found so that the differences between these prices just equals transportation cost. Note that the additional restriction imposed on yields YI_a is operative in Region I.

Suppose now that the governments of the states decided to impose a trade restriction so that the quantity traded from Region I to Region II is allowed to only be 10%, or $.1(ES^*_a) = \overline{ES}_a$. Under this condition the price difference between both regions $(\overline{PI}_a - \overline{PII}_a)$ by far exceeds transportation costs, and the total quantity produced is reduced, i.e. $SI^*_a + SII^*_a > \overline{SI}_a + \overline{SII}_a$ (it can be easily verified from Figure 1 that $SI^*_a - \overline{SI}_a > \overline{SII}_a - SII^*_a$). It can be shown that this is true for all combinations of elasticities of well-behaved demand and supply functions.[2]

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1 From these elasticities, the coefficients to be entered into the model are derived (see Appendix II); the elasticities computed for the different model results are presented in Appendix III.

2 Takayama and Judge (36), p.107 ff.

Application of this model for the above described three-region-three-crop case, yields the results summarized in Table 4.

The initial data set represents existing conditions (1971-72); i.e., low yields and high costs of production "before the introduction of new technology".[1] The imposition of the trade restrictions under these conditions changes production of the three food grains in all three states as follows:

total output of rice remains almost unchanged (slightly increases!)

total output of sorghum decreases by 5%,

total output of chickpea decreases by 13%, and

total output of all food grains together, decreases by 2%.

Suppose that new technologies are found and adopted for all three crops in all regions so that yields increase by 50% in the states which have highest yields and by proportionately less in the states with lower yields[2]. Further, all supply functions shift allowing a productivity growth over initial levels in the same way as yields; at the same time, assume an increase in demand in all regions for all crops uniformally of 25%.

This case of increased productivity by 50% and increased demand by 25% is depicted as case B in Figure 1. It shows that the imposition of the trade restriction reduces production comparatively more under this high-yield, low-cost-of-production case B than the same restriction did in the earlier low-yield, high-cost-of-production case A.

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1 Case B below will demonstrate the effect of the "new technology".

2 The reason for this assumption of proportional yield effects is given in Appendix IV.

Table 2 : Assumed[1] price elasticities of demand and supply

State	Price elasticities					
	Demand			Supply		
	Rice	Sorghum	Chickpea	Rice	Sorghum	Chickpea
Andhra Pradesh	-0.50	-1.19	-0.55	0.55	0.29	--
Madhya Pradesh	-0.82	-0.94	-0.44	0.24	0.30	0.32
Maharashtra	-0.53	-0.78	-0.46	0.58	0.15	0.22

1 These elasticities were produced as a result of the initial model run. They differ somewhat from a set of initially assumed values (Appendix II).

Table 3 : Assumed Transportation rates between states (Rs/ton)

State	Andhra Pradesh	Madhya Pradesh	Maharashtra
Andhra Pradesh	0	30	50
Madhya Pradesh	30	0	40
Maharashtra	50	40	0

'Discussion Paper'

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M. von Oppen†

Anthropological research shows that in the long history of man and during his early cultures, market economies did not develop until relatively late. Polanyi observes "if Babylon and Tyre were not, as it now appears the ancient homes of the price-making market, then the elements of that seminal institution must have come from the Hellenic sphere, sometime in the first millenium B.C. Sixth and fifth century Greece was, therefore in essential respects, economically more naive than even the extreme "primitivist" would have it, while in the fourth century these very Greeks initiated the gainful business practices that in much later days developed in the dynamo of market competition".[1] To some it might seem that this "dynamo of market competition" which is propelling the western economies today, has led to a development based on the global exploitation of limited resources and as it stands at present, has dim prospects for its continuation much longer.[2] Not only physical resources are diminishing rapidly but also human resources in terms of social value systems and religious ties seem to decay under the impact of a commercialized materialistic life.[3]

However, such pessimistic views on certain western economies (whether justified or not remains yet to be seen) should not directly mislead us to the conclusion that developing countries would be better off by keeping village economies in "self sufficient independence".[4] On the contrary, efficient integration of the rural

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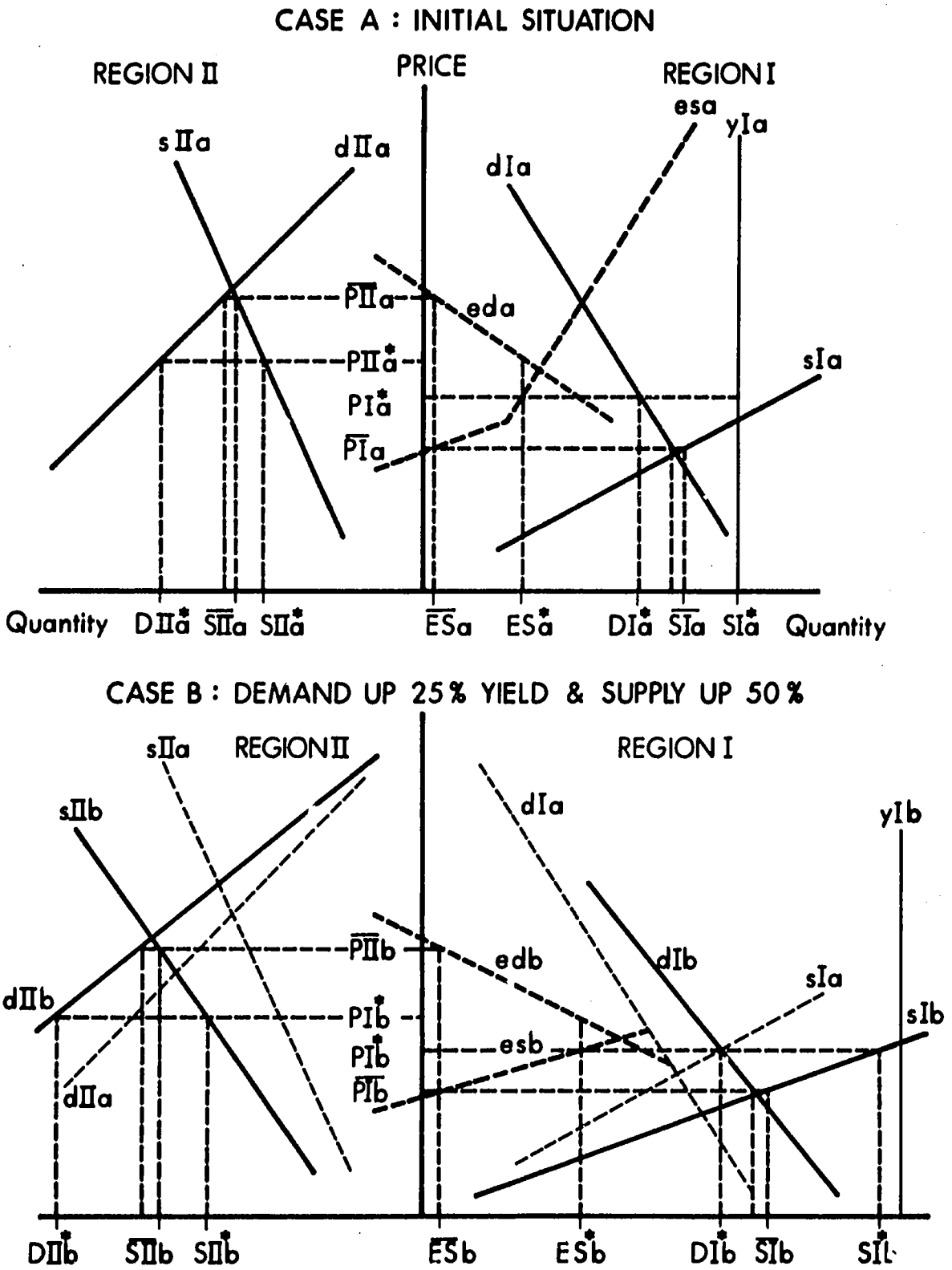
† The author gratefully acknowledges the comments and suggestions on an earlier draft from Drs.B.Harris, J.G.Ryan and H.P.Binswanger. The data used were largely collected by Dr.S.L.Bapna. The computer work was carried out by Mr.P.Parthasarathy Rao.

1. Polanyi (23), p.64
2. Club of Rome etc.
3. Fromm(8)
4. Heierli (14)

FIGURE 1: ONE-CROP-TWO REGIONS TRADE WITHOUT AND WITH RESTRICTION[1/] IN TRADE



1/ 10% OF QUANTITY TRADED UNDER UNRESTRICTED CONDITION

Table 4: Optimal Allocation and Trade of Three Competing Crops among Three Regions without and with Restrictions[1] in Trade

Case A: Low Yields and High Costs of Production

REGION	ANDHRA PRADESH		MADHYA PRADESH		MAHARASHTRA		ALL THREE REGIONS	
	Free	Restr	Free	Restr	Free	Restr	Free	Restr
AREA (1000 ha)								
Rice	2665	*2644*	5305	*5016*	1144	*1469*	9114	*9129*
Sorghum	2335	*2238*	2350	*2190*	6513	*6262*	11198	*10690*
Chickpea	--	*118*	1345	*1115*	343	*269*	1688	*1502*
Total	5000	*5000*	9000	*8321*	8000	*8000*	22000	*21321*
PRODUCTION (1000 t)								
Rice	4164	*4132*	4349	*4112*	1179	*1515*	9712 (100)	*9759 (100)*
Sorghum	1062	*1017*	1487	*1386*	2042	*1960*	4591 (100)	*4363 (95)*
Chickpea	--	*44*	915	*758*	105	*82*	1020 (100)	*884 (87)*
Total	5225	*5193*	6751	*6256*	3326	*3557*	15301 (100)	*15006 (98)*
PRICE (Rs/Qtl)								
Rice	114	*105*	115	*76*	119	*200*	116[2]	*110[2]*
Sorghum	109	*68*	110	*69*	114	*157*	112[2]	*110[2]*
Chickpea	196	*477*	193	*76*	191	*74*	194[2]	*113[2]*
TRADE (1000 t)								
Rice					186			
					1244		1430	
						143		*143*
Sorghum					375			
					510		885	
						23		
						65		*88*
Chickpea	330							
	56						386	
		19						
		20						*39*

[1]Total trade in each of the commodities restricted to 10% of the quantities traded under unrestricted conditions.
[2]Weighted average price of quantities consumed.

This can be verified because $SI^*_b + SII^*_b > \overline{SI}_b + \overline{SII}_b$; i.e., total quantity produced is reduced; moreover, comparison of the effects of trade restrictions in the two cases A and B shows that production falls proportionately more under high-yield conditions.

It can be verified that:

$$SI^*_b - \overline{SI}_b > SII^*_b - \overline{SII}_b \quad \text{and}$$

that $$\frac{\overline{SI}_b + \overline{SII}_b}{SI^*_b + SII^*_b} < \frac{\overline{SI}_a + \overline{SII}_a}{SI^*_a + SII^*_a}.$$

In the more complex three-region-three-crop version; the model generates results as summarized in Table 5. In this case the imposition of trade restrictions causes:

total output of rice to decrease by 1%,

total output of sorghum to decrease by 7%,

total output of chickpea to decrease by 15%, and

total output of all food grains to decrease by 4%.

Comparison of the two cases shows the impact of trade restrictions. Under conditions of low yields and high production costs (case A) trade restrictions have a measurable but comparatively small impact; aggregate productivity of all food grains is decreased by only about 2%. If, however, with population growth, demand functions are shifting to the right, and if at the same time, new technologies are adopted which increase yields and shift supply functions to the right (Case B), then regional specialization and interregional exchange increase, and consequently aggregate production rises considerably.

Under such circumstances a restriction of the interregional trade as described above decreases aggregate production of all food grains by about 4%; i.e., about twice the percentage decrease under the initial or low demand, traditional supply conditions.

These cases demonstrate that under increased supply and demand conditions total aggregate production may be higher - even with restricted trade - than production under low-yield conditions with unrestricted trade. Thus the technological advance assumed in shifting the supply constraints in case B increases production over case A despite the restrictions in trade. However, the trade restrictions are more harmful under the improved technology case B because they considerably depress total production below the possible level with unrestricted trade.

2.1.2 IMPLICATIONS

These results illustrate - to some extent - what might have been the effects of the food policies pursued in India over the past decade. In Figure 2 the attempt is made to summarize Indian food policies over the past two decades. Based upon the statements on movement restrictions and price policies published by the Government of India[1/] a chart was assembled which depicts over the years the statewise changes in food grain movement restrictions, together with figures of the All-India production and procurement of food grains. This chart shows that, after a period of relatively free movements, from 1956 to 1958, private food grain trade in wheat and rice was allowed only within certain zones constituted by three or four neighbouring states, while interzonal trade was restricted to be the monopoly of a central government agency - the Food Corporation of India (FCI).

1/ Government of India, (9) and (10).

Table 5: Optimal Allocation and Trade of Three Competing Crops among Three Regions without and with Restrictions[1] in Trade

Case B: Demand[2] and Supply[3] increased

REGION	ANDHRA PRADESH		MADHYA PRADESH		MAHARASHTRA		ALL THREE REGIONS	
	Free	Restr	Free	Restr	Free	Restr	Free	Restr
AREA (1000 ha)								
Rice	2601	*2474*	5314	*5030*	1099	*1449*	9014	*8953*
Sorghum	2399	*2381*	2367	*2055*	6569	*6298*	11335	*10734*
Chickpea	--	*144*	1273	*1018*	331	*254*	1604	*1416*
Total	5000	*4999*	8954	*8103*	7999	*8001*	21953	*21103*
PRODUCTION (1000 t)								
Rice	6050	*5754*	5478	*5186*	1505	*1985*	13032 (100)	*12925 (99)*
Sorghum	1481	*1470*	2254	*1957*	2566	*2460*	6301 (100)	*5887 (93)*
Chickpea	--	*69*	1299	*1038*	124	*95*	1423 (100)	*1203 (85)*
Total	7531	*7293*	9031	*8181*	4195	*4540*	20756 (100)	*20014 (96)*
PRICES (Rs/Qtl)								
Rice	100	*78*	101	*75*	105	*193*	102[4]	*96[4]*
Sorghum	96	*48*	97	*49*	101	*156*	99[4]	*96[4]*
Chickpea	149	*462*	146	*32*	144	*30*	147[4]	*76[4]*
TRADE (1000 t)								
Rice					769		1967	
					[illegible]3			
						197		*197*
Sorghum					505		1405	
					900			
						42		
						99		*141*
Chickpea	490						546	
	56							
		43						
		11						*54*

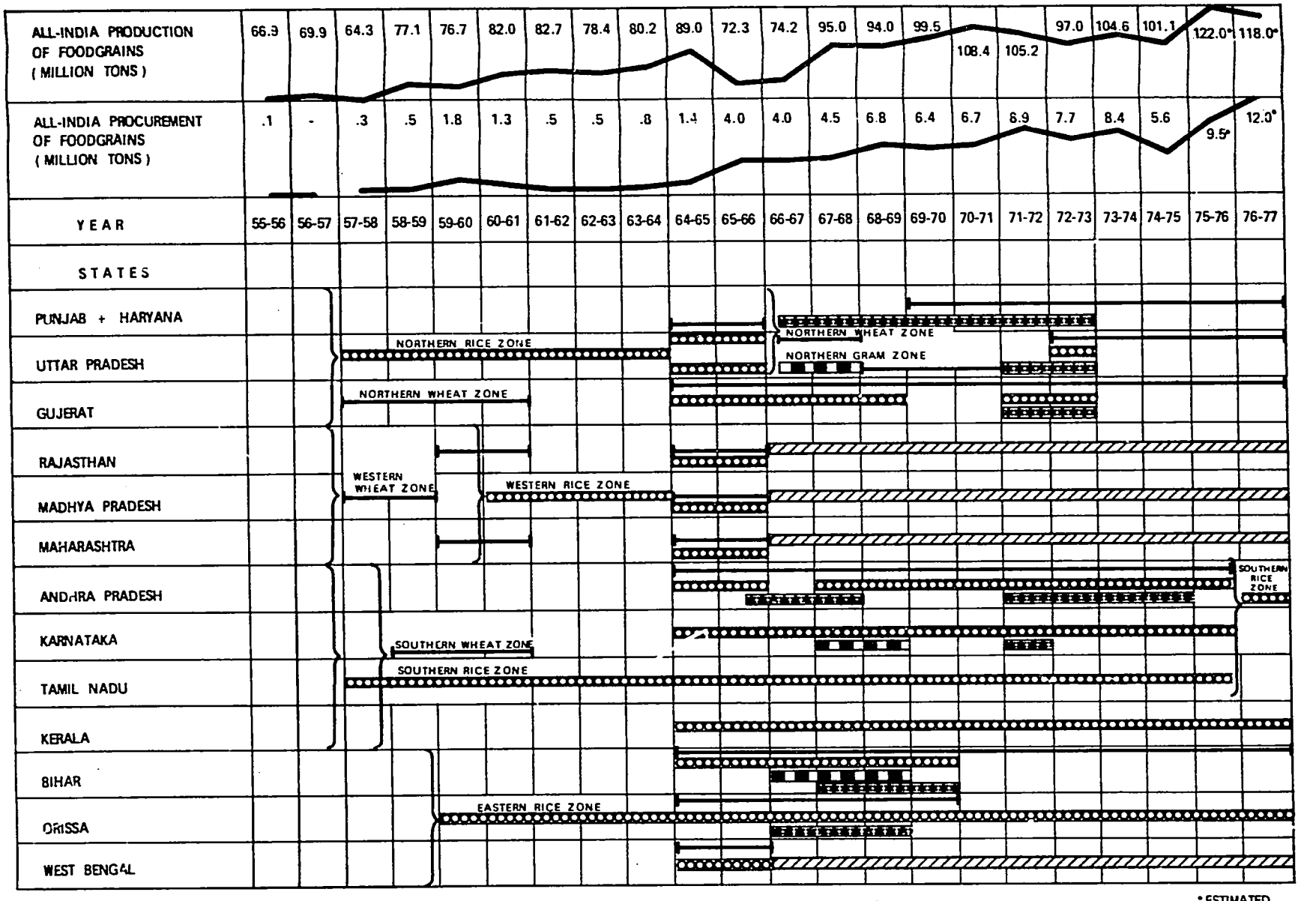
[1]Total trade in each of the commodities restricted to 10% of the quantities traded under free conditions.

[2]Demand increase of each crop: 25%.

[3]Yields and Supply of each crop increase: 50% for the state with the highest yield increases for other states are 50% adjusted proportional to ratio of state's yield to highest yield.

[4]Weighted average prices of quantities consumed..

FIGURE : 2 ALL-INDIA PRODUCTION AND PROCUREMENT OF FOODGRAINS AND STATEWISE SUMMARY OF FOODPOLICIES INVOLVING TRADE RESTRICTIONS FOR DIFFERENT FOODGRAINS



Unfortunately, it is not known to which degree the FCI distribution systems effectively reduced interregional trade. These zonal restrictions, after a temporary relaxation for wheat during the three years (1961 to 1963), were considerably tightened when in 1964-65, individual states became separate food zones, and when after 1966, in addition to wheat and rice in many states, pulses, coarse grains, and sometimes "all food grains" were included under the movement restrictions. These measures were intended to keep prices down in surplus states and to generate larger quantities for procurement through the FCI; as the chart shows, procurement quantities did indeed increase. At the same time new technologies were introduced which triggered the "green revolution" and aggregate production went up despite sometimes very stringent curbs on interstate movement of food grains. The statewise food zones continued (with a brief interval of relaxations by some states around 1969-70) until early 1977. In February, 1977, the southern rice zone was reinstated and in September 1977, wheat trade was completely decontrolled.

These recently announced relaxations of earlier trade restrictions - if allowed to continue - will have the effect of increasing aggregate food grain production over and above what it would have been. This is especially so as, in most states, HYV's fertilizers and other new technologies have only just begun to be adopted, and this tends to widen the differences in comparative advantages among regions (see Appendix IV). As demonstrated in the model, this will induce and/or speed up the process of regional reallocation of crop production and will lead to changes in cropping patterns, including introduction of new crops.

Referring to the model results we can trace out some of the associated <u>welfare impacts of liberalizing the inter state food grain trade</u>:

1. The weighted average prices of the commodities are higher under free-trade conditions. This implies that - *ceteris paribus* - free movement would

shift the terms of trade in favor of agriculture[1] ; the more advanced the agricultural technology, the more favorable the terms of trade will become (compare average prices in cases A & B).

2. Prices in deficit regions will fall considerably (e.g.Maharashtra) while in surplus regions prices will increase (e.g.Madhya Pradesh) as movement restrictions are relaxed.

3. For some regions which have a comparative disadvantage in the production of certain crops (e.g.Maharashtra for rice), the price decrease will cause a cutback in production which may or may not be offset by increases in the production of other crops, so that for an individual region, an overall decrease in food grain production could be the result.

In view of these considerations it remains relevant for the regional policy maker to ask whether under free trade the gains in aggregate productivity - as demonstrated above - are worth their political implications.[2] However, given the methodology of quantifying these impacts under a set of assumed conditions, some of the guesswork required earlier[3] is reduced[4] so that for his choice among the options, the decision maker can rely on some quantitative insight into the impacts of his decision.

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1 An index based on the simple average of prices would have shown the opposite (see Tyagi (38)).

2 For an excellent discussion of the issues involved see e.g.R.Krishna (17).

3 For instance when justifying zonal food policies, Dantwala said "The economic balance sheet of such disincentive in surplus states and incentives in deficit states is anybody's guess". (Dantwala (5)).

4 It must be emphasized that the above model results rest upon assumptions, some of which may or may not be correct. For instance, the trade restrictions of 10% of optimal quantities traded are likely to be too strong; however, a more realistic figure of perhaps 20% to 30% would have indicated just the same tendencies; the overall loss in aggregate productivity would have been around 1.5% in case A and 3% in case B, still sizable quantities.

2.2 IMPACT OF MARKET FACILITIES ON AGGREGATE PRODUCTIVITY

The above activity analysis model must remain an abstract approach as long as the data and assumptions incorporated have to be chosen on a more or less arbitrary basis. As soon as elasticity estimates have been generated which reliably reflect supply and demand conditions in individual states, more firm statements about normative aspects of food grain policies can be made. For the time being, the main use of such models is didactic.

2.2.1 The Estimation Model

In contrast to this, the following approach measures the actual causal effects between market facilities (number of regulated markets and length of roads) together with other inputs and physical factors, and aggregate agricultural productivity. Data were collected on 20 districts of Andhra Pradesh over 7 years. A causal relationship between market facilities and aggregate productivity is hypothesized to exist if a lagged effect on productivity of market facilities can be shown to be significant and different from nonlagged data. The estimation model was run using generalized least squares on cross-section-time-series[1] of the following variables:

$$AP_{d,t} = f\,(MK_{d,t+e},\ RD_{d,t+e},\ RN_{d,t},\ IR_{d,t},\ FT_{d,t},\ HY_{d,t})$$

where $AP_{d,t}$ = Aggregate productivity in terms of deflated monetary value of output in Rs/ha of cultivated area, in district d in year t;

$MK_{d,t+e}$ = Number of regulated markets per 100 km^2 of geographical area in district d in year t+e, where e is the lag which was varied between +2, +1, 0, -1, -2 and -3. (The higher the density of markets, the higher -- at a decreasing rate -- the aggregate productivity; expected signs of the backward-lagged variables positive in the linear term, and negative in the squared term).

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1 Barah (2)

$RD_{d,t+e}$ = Length of surfaced roads per 1,000 km^2 of geographical area in district d in year t+e, where e is the lag which was varied between +2, +1, 0, -1, -2 and -3. (The higher the density of roads, the higher the aggregate productivity; expected sign of the backward-lagged variables positive).

$RN_{d,t}$ = Annual rainfall in mm in district d in year t. (With increases in annual rainfall, aggregate productivity should increase at a decreasing rate; expected signs of a linear term positive and of a squared term negative).

$IR_{d,t}$ = Irrigated area in percent of total cropped area in district d in year t. (The higher the percentage of irrigation, the higher the aggregate productivity; expected sign positive).

$FT_{d,t}$ = Fertilizer use in kg/ha of cultivated area in district d in year t. (With increases in fertilizer use aggregate productivity should increase at a decreasing rate; expected signs of a linear-term positive and of a squared-term negative).

$HY_{d,t}$ = Area under high yielding varieties in percent of total cropped area in district d in year t. (The higher the percentage of high yielding varieties, the higher aggregate productivity; expected sign positive).

2.2.2 Empirical evidence for causal effect of markets on aggregate productivity

Model application in functional forms as presented in Table 6 gives estimated coefficients for the different lags on market facilities. Equation (1) measures the joint impact of the variables with different lags, in order to establish the direction of causality between markets and aggregate productivity.[1] While the coefficient for markets in year t-1 shows a significantly positive relationship between markets and aggregate productivity, the coefficients of markets with zero and positive lags are insignificantly different from zero. Somewhat unexpectedly, the equation shows markets in year t-3 to be negatively related to productivity. However, a negative coefficient for market densities several years earlier is quite plausible in view of the fact that market density over time changes in a cumulative way in the positive direction only. In other

1 Sims (33)

Table 6 : Aggregate Productivity[1] as Function of Market Facilities and Other Inputs

Variables	Estimated Equations[2]		
	1	2	3
MK_{t-3}	-1233 (-2.1)	-1019 (-2.9)	-32 (-0.04)
$(MK_{t-3})^2$	--	--	-96352 (-1.3)
MK_{t-2}	436 (0.9)	--	--
MK_{t-1}	761 (1.7)	793 (2.9)	1352 (2.4)
$(MK_{t-1})^2$	--	--	-31424 (-1.2)
MK_t	-607 (-1.4)	--	--
MK_{t+1}	536 (0.8)	--	--
MK_{t+2}	18 (0.03)	--	--
RD_{t-3}	-12 (-0.5)	--	--
RD_{t-2}	-29 (-1.1)	-31 (-2.0)	-34 (-2.0)
RD_{t-1}	-9 (-0.3)	--	--
RD_t	19 (0.6)	--	--
RD_{t+1}	15 (0.4)	--	--
RD_{t+2}	27 (0.9)	44 (2.7)	49 (3.0)
RN_t	.035 (1.4)	.048 (2.3)	.047 (2.3)
$(RN_t)^2$	-.00002 (1.4)	-.000025 (2.3)	-.00003 (-2.3)
IR_t	39.4 (4.1)	42.1 (5.9)	47.5 (6.2)
FT_t	-.147 (-0.7)	-.192 (-1.2)	-.136 (-0.8)
$(FT_t)^2$	.003 (1.2)	.004 (1.9)	.004 (1.5)
HY_t	.068 (1.7)	.042 (1.4)	.029 (0.9)
$\bar{R}^2$	.87	.87	.87

1 in year t, from 1968-69 to 1971-72.

2 t-values in brackets.

words, regulated markets are being added but they do not disappear.[1] Consequently, in an estimation equation which includes all of the lags simultaneously, it is consistent that prior to those lags for which market density has a positive effect upon productivity, there must be some period for which a negative relationship between markets and productivity exists; i.e. prior to adding new markets which causes productivity to rise, market density has to be low and this low density of the past period is associated with high productivity later.[2] What remains surprising, however, is that this negative lag is found already in year t-3, indicating a fairly short gestation period of market regulation, and its almost immediate impact already after one year on productivity.

While the density of regulated markets in year t-1 has a consistently significant causal relationship with productivity, the insignificant coefficients on road density show that there is no clearly measurable relationship between roads and productivity in this data set for Andhra Pradesh. Negative signs for roads in the past and positive signs for roads in the future — eventhough they are insignificant — hint at a causal relationship of the opposite direction; i.e., present aggregate productivity might influence when and where roads are to be built in future.

Among the remaining variables, the coefficients for irrigation and high yielding varieties are positive and significant. Rainfall has the expected signs, although these are insignificant. Fertilizer is insignificant.

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1 At least not during the period of our observations.

2 Unfortunately the time-series on markets is too short to extent the lagging further.

The results of the above estimation equation (1) for the given data set allow us to accept the hypothesis that there is a causal impact of markets on productivity. However, they lead us to reject the hypothesis of roads having a causal impact upon productivity; instead, it would appear as if roads are being built following the incidence of productivity increases.

2.2.3 Implications of the results

Given this result, it is interesting to estimate in separate equations the coefficients for only those lags which would appear to be most relevant in determining the causal relationships more clearly. In other words, attention is focussed on the impact of only two of the market lags and two of the road lags which have the highest t-values in equation (1). The results are presented in equation (2), clearly showing that roads in year t-2 are negatively and in year t+2 positively related to aggregate productivity, while markets in year t-3 are negatively but in year t-1 positively related to aggregate productivity. The high significance of these estimates confirms the earlier statement that markets have had a causal effect upon productivity while for roads the effect was rather of the opposite direction, i.e. roads have followed when and where production increased.

The linear relationship between markets in year t-1 and productivity implies an indefinite impact of more markets leading to more production. However, logically it is must be expected that increases in market density can only be beneficial upto some optimal point beyond which further markets would cause production to decrease. In view of this expectation a squared term for the two market variables was entered, so that the position of this optimal point could be determined.

The results[1] presented in equation (3) show that the coefficient generated for the squared term of the market variable in year t-1 is negative (even though it is significant only at the 25 percent level); it indicates that the increasing effect of density in regulated markets on productivity decreases as density increases. Following a graphical presentation (see Fig.3), this effect can be interpreted that *ceteris paribus*, an increase in market density from say 11 to 12 markets per 10,000 km^2 would increase aggregate productivity by 6.2 Rs/ha of cultivated area; this would amount to nearly 1% of the average productivity in 1974 of 674 Rs/ha.

For the average district in Andhra Pradesh with 580,000 ha of cultivated area, the addition of one market per 10,000 km^2 would cause an increase of more than 3.5 million rupees in annual aggregate productivity.[2] The optimum point of this curve lies at a market density of about 22 markets per 10,000 km^2, which is well above the existing market densities which average at 11.5 markets per 10,000 km^2 ranging between 3 and 23 in 1974 in Andhra Pradesh.

3. CONCLUSION

The effect which regulated markets have on aggregate productivity can be explained by the locational shifts in cropping patterns which they cause. The

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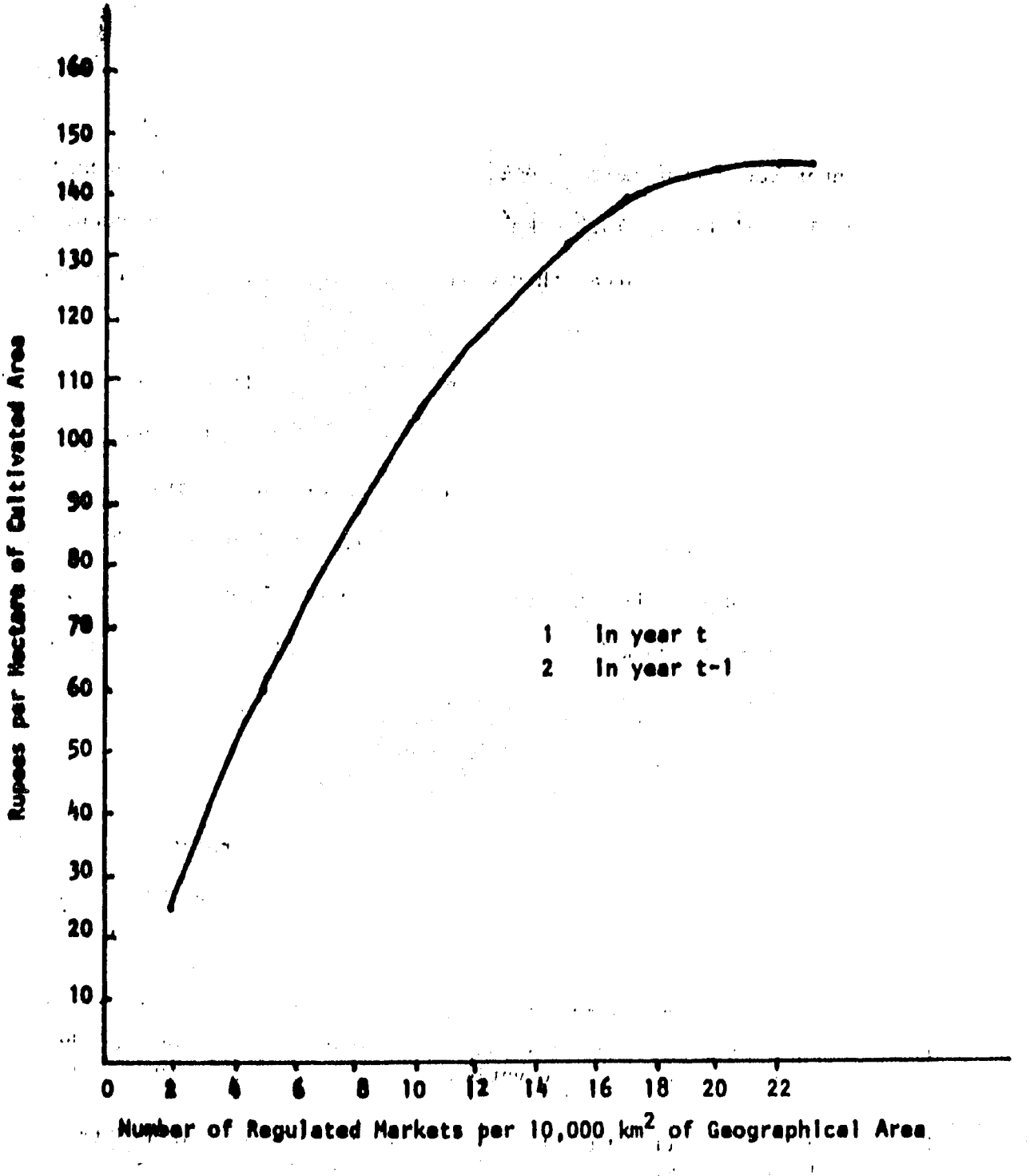
1 The generalized least squares model separates the location and the time effect contained in the observations. These are summarized in Appendix V.

2 The cost of establishing a regulated market yard is estimated to be about 2.0 million rupees.

FIGURE 3 : AGGREGATE PRODUCTIVITY[1] AS A FUNCTION OF MARKET DENSITY[2] IN ANDHRA PRADESH



principle of comparative advantage which was shown above to cause aggregate food grain production to increase when interstate trade barriers are removed, operates also at the local level when local trade barriers are removed. With the establishment of regulated markets, distance to the market is reduced; price information is improved; and competition among traders is strengthened. In addition, there are secondary effects which are associated with market development; such as, easier access to inputs (seeds, fertilizer, credit, extension), and inducement to become aware of comparative advantages. Synthesis of the above results suggests that the removal of interstate trade restrictions, as announced in 1977, will not show its impact before 1979 allowing for at least a one to two year lag for rebuilding private marketing channels, for triggering reallocation of cropping systems, and for setting locational shifts into motion. The dezoning of the food grain trade - if implemented and allowed to continue within all states - can be expected to produce measurable effects on aggregate productivity from 1979 onwards. Given the persistently low level of commercialization[1] of Indian agriculture and the minimal locational shifts in cropping patterns which have occurred during the past decade according to Narain (20), it would not be surprising if subsequently the reallocation effects turned out to be quite substantial. Further advance of new technologies from ongoing research in national and international research organizations would tend to enforce this envisaged development.

A number of questions emerge from this analysis which need to be answered by further research efforts:

(1) What will be the effect of additional commercialization on small farmers?

A study is underway in Mahbubnagar district which aims among other things at determining the impact of market access on small vs. large farmers.

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1 Estimated market arrivals in percent of production in 1974-75 are: wheat, 24%; rice, 22%, sorghum, 11%; and chickpeas 28% (Government of India, (9) 1977, p.16).

Our hypothesis is that lack of market access affect small farmers more adversely than it does large farmers (Pesneaud and von Oppen [21]).

(2) Will less restricted movement of food grains not increase regional inequalities and therefore make people in some areas worse off?

The hypothesis would be that price policies and procurement systems which depress aggregate productivity are probably expensive measures for trying to rationalize regional inequalities (Harris [12]).

(3) Considering the postulated high payoff from investments into market facilities, is the existing approach of regulated marketing which dates back to recommendations made by the Royal Commission on Agriculture in 1928, still the best approach, or should there be modifications?

It is possible that the existing legislation for market regulation is in the way of establishing additional market yards, because a new market starts as a subyard, and the creation of a subyard depends upon the agreement of the market committee of the main yard, who - it could be assumed - may be reluctant to allow diversion of trade flows from the main yard. Also, forcing transactions to take place only in notified market yards leads to a concentration of processing capacities in places where these might not be optimally located from a cost-minimizing point of view.

(4) Are the gains from improved market facilities so far demonstrated for Andhra Pradesh also to be had in other areas?

Indications are from an ongoing market survey in semi-arid tropical India that probably Andhra Pradesh is one of the best developed states as far as market infrastructure is concerned. But data collection is underway to extend the above analysis to other states in India. [V.T. Raju (25)].

(5) If restrictions on interstate movements of food grains have really affected aggregate agricultural production in India, then this effect should be measurable.

Similar to the approach applied on data for districts in Andhra Pradesh the analysis should be done on the basis of statewise data of All-India by including a variable for measuring the severity of restrictions in food grain movements by states. Data are presently being assembled to test the above hypothesis.

4. SUMMARY

Agricultural market researchers in the past have not paid much attention to the impact which agricultural marketing channels exert on aggregate productivity. Agricultural marketing systems which reduce or remove the constraint of satisfying home consumption requirements and thus induce regional and personal specialization in cropping systems according to the principle of comparative advantage, cause aggregate productivity to increase. The potential to increase aggregate productivity due to market exchange is particularly high in countries or regions such as the semi-arid tropics which depend largely upon subsistence agriculture.

A methodology to measure the market effect on productivity is proposed involving (1) activity analysis with the help of an interregional trade model and (2) regression analysis measuring the causal effect which market facilities have on aggregate productivity.

The interregional trade model is applied for a three-region-three-crop case. It demonstrates how trade restrictions depress aggregate productivity the stronger, the more advanced agricultural technologies are. Indian food policies which were highly trade restrictive in the past are discussed in view of this model result.

Analysis of district data for Andhra Pradesh shows a significant causal effect of regulated markets on aggregate productivity. A lag of one to two years between market regulation and productivity increase is found to exist.

Considering the fact that during 1977 interregional trade in food grains has been liberalized in most states of India, it can be expected that - if this liberal food policy continues - its effect should manifest itself in measurable productivity increases after a lag of one to two years.

Further research is required and under way to establish the effects of commercialization on issues such as effects on small vs. large farmers; regional redistribution of gains; appropriateness of legislature on market regulation; and other topics.

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Appendix I

MATHEMATICAL FORMULATION OF A SPATIAL EQUILIBRIUM CROP ALLOCATION MODEL[1]

(1) Notation

NW	=	net social welfare
ℓ_i^f	=	intercept of the demand function of commodity f in region i ;
Y_i^f	=	quantity demanded of commodity f in region i ;
w_i^f	=	slope coefficient of demand for commodity f in region i ;
k_i^f	=	intercept of supply function of commodity f in region i ;
X_i^f	=	quantity supplied of commodity f in region i ;
v_i^f	=	slope coefficient of supply function of commodity f in region i ;
t_{ij}^f	=	transportation cost of shipping one unit of commodity f from region i to region j ;
X_{ij}^f	=	quantity shipped of commodity f from region i to j ;
L_i	=	land available in region i for cultivating commodities 1 through h ;
r_i^f	=	land requirement (inverse of yield) of commodity f in region i ;

(2) Problem formulation

The objective is to maximize the following nonlinear function of net social welfare, NW:

$$NW = \sum_{ijf}\sum\sum [\ell_i^f Y_i^f - \tfrac{1}{2} w_i^f (Y_i^f)^2 - k_i^f X - \tfrac{1}{2} v_i^f (X_i^f)^2 - t_{ij}^f X_{ij}^f]$$

1 For details on the mathematical background of spatial equilibrium models, see Takayama and Judge, 1971, (36).

subject to the following two constraints:

(a) Commodity Flows:

$$Y_i^f \leq X_i^f - \sum_j X_{ij}^f + \sum_j X_{ji}^f$$

(b) Land Availability

$$L_i \geq \sum_f r_i^f X_i^f$$

If the Lagrangean form of this problem is written out and the appropriate Kuhn-Tucker conditions are formulated, the following set of equations evolves, which is interpreted as follows:

a. Land availability: The amount of land available in each region is restricted and the sums of total production of each crop divided by yield for each region cannot exceed the amount of land available.

$$r_i^1 X_i^1 + r_i^2 X_i^2 + \ldots + r_i^h X_i^h \leq L_i \qquad (1)$$

where r_i^f = land requirement in ha per ton

L_i = land available for crop production in ha.

b. Commodity Flows: The amount of commodity f consumed in region i cannot exceed the quantities produced minus outshipments plus inshipments

$$Y_i^f \leq X_i^f - \sum_j X_{ij}^f + \sum_j X_{ji}^f \qquad (2)$$

c. Demand functions: The consumer price Py_i^f commodity f in region i is equal to the quantity consumed Y_i^f times a slope coefficient w_i^f and a constand term ℓ_i^f.

$$Py_i^f = \ell_i^f - w_i^f Y_i^f \qquad (3)$$

d. <u>Supply functions</u>: The producer price Px_i^f of commodity f in region i is equal to the quantity produced X_i^f times a slope coefficient v_i^f and a constant term k_i^f minus the price of land $P\ell_i$ times the yield inverse r_i^f.

$$Px_i^f = k_i^f + v_i^f X_i^f - r_i^f P\ell_i \tag{4}$$

It is interesting to note that the logic of the quadratic program requires the entering of the imputed shadow price of land times the yield inverse as an output price-determining factor.

e. <u>Transport Costs</u>: The difference between consumer price Py_i^f and producer price Px_j^f of the same commodity in another region j, has to be less than or equal the cost of transporting commodity f from region i to region j.

$$Py_i^f - Px_j^f \leq t_{ij}.$$

Appendix II

Derivation of supply and demand elasticities and other data used in the Crop Allocation Model

1. **Elasticities:** Numerous estimates of *supply elasticities* for different crops in India are available. But these differ widely for each crop depending upon the model and the specification of the variables used. We have chosen those estimates which appear reasonable on the basis of our knowledge of the situation in India. In contrast to estimates of supply elasticities only very few estimates of *demand elasticities* have been initiated and these mainly for rice and wheat. In addition, some information on demand elasticities could be drawn from some estimates of price flexibility coefficients.

After examining the available estimates we have decided to base the models on the coefficients as presented in Table I.

Table I : Basic Elasticity Coefficients

Crop	Supply Elasticity			Demand Elasticity		
	Andhra Pradesh	Madhya Pradesh	Maha-rashtra	Andhra Pradesh	Madhya Pradesh	Maha-rashtra
Rice	0.40	0.20	0.50	-0.40	-0.60	-0.60
Sorghum	0.20	0.25	0.10	-0.50	-0.40	-0.30
Chickpea	1.00	0.10	0.10	-1.00	-0.40	-0.60

These coefficients were used to derive initial price flexibility coefficients and slopes and intercepts of the price equations in different states.

The elasticities computed on the basis of the results from the model runs (see Table II) reveal that in most cases our initial estimates lie somewhere between the 'restricted' and the 'unrestricted' solutions.

2. Derivation of slopes and intercepts of demand and supply functions:

Assume the following supply function :

$S = a + bP$

where S is average production

a and b are regression coefficient; and

P is average price;

This can be written as

$-bP = a - S$ or

$p = -\frac{a}{b} + \frac{1}{b}s$.

By setting

$\frac{a}{b} = k$ we define the price intercept and by setting

$\frac{1}{b} = v$ we define the slope coefficient of supply (See Appendix I)

From the available estimates of elasticities of supply and demand (es) given above k and v were obtained as follows:

$es = b \cdot \frac{P}{S}$, and thus

$b = es\frac{S}{P}$. Since

$v = \frac{1}{b}$ as shown above, therefore

$v = \frac{P}{esS}$. Since

$k = \frac{a}{b}$, as shown above, therefore

$k = P(\frac{1}{es} - 1)$.

The same procedure was used for deriving the intercept (ℓ) and slope coefficient (w) of the demand functions. Data related to average prices and average quantities produced were taken from the Bulletin on Food Statistics, Government of India. Prices used were wholesale prices. The information regarding consumption per capita in different states was taken from the National Sample Survey reports. The N.S.S. estimates are generally over-estimates and therefore, wherever estimates appeared abnormally high, the estimates were adjusted taking into account normal export or import of the commodity concerned.

Appendix III

Price Elasticities Derived from Optimal Solutions

Because of the linearity of the demand and supply function, price elasticities change from one solution to the next according to changes in quantities and prices. The following Table II summarizes the price elasticities which accompany the optimal solutions presented in the text.

The linearity assumption is a serious shortcoming of the spatial equilibrium model based on simple quadratic programming. Work is underway to overcome this shortcoming either :

(1) by using an iterative procedure in which quadratic programming is applied on sets of demand and supply functions which are defined as tangents to exponential functions and thus approximate constant elasticities; or

(2) by simply using restricted transportation problem algorithm, with restrictions representing non-linear price-quantity relationships.

Table II : Price elasticities of supply and demand accompanying the optimal solutions in Case A and B

	Case A				Case B			
	Demand		Supply		Demand		Supply	
	Unrestricted[1]	Restricted	Unrestricted[1]	Restricted	Unrestricted[1]	Restricted	Unrestricted[1]	Restricted
RICE								
Andhra Pradesh	-0.5	-0.44	0.55	0.51	-0.42	-0.29	0.49	0.41
Madhya Pradesh	-0.82	-0.43	0.24	0.17	-0.65	-0.42	0.21	0.17
Maharashtra	-0.53	-1.42	0.58	0.75	-0.44	-1.30	0.53	0.74
SORGHUM								
Andhra Pradesh	-1.19	-0.51	0.29	0.19	-0.93	-0.32	0.25	0.12
Madhya Pradesh	-0.94	-0.44	0.30	0.20	-0.75	-0.28	0.27	0.15
Maharashtra	-0.78	-1.53	0.15	0.22	-0.64	-1.50	0.14	0.22
GRAM								
Andhra Pradesh	-0.55	-6.23	---	3.20	-0.37	-5.03	---	2.52
Madhya Pradesh	-0.44	-0.13	0.32	0.15	-0.30	-0.05	0.26	0.07
Maharashtra	-0.46	-0.13	0.22	0.11	-0.29	-0.05	0.17	0.05

1 Same as in Table 2 in the text, p.7-B.

Appendix IV

Assumption of proportional adoption of new technologies

The assumption is made on page 8 of this paper that the state-wide adoption of yield-increasing technologies would be such as to generate a full yield increase in the state with the highest yield, and proportionately yield increases in the other states. This assumption was formulated on the basis of yield data for wheat.

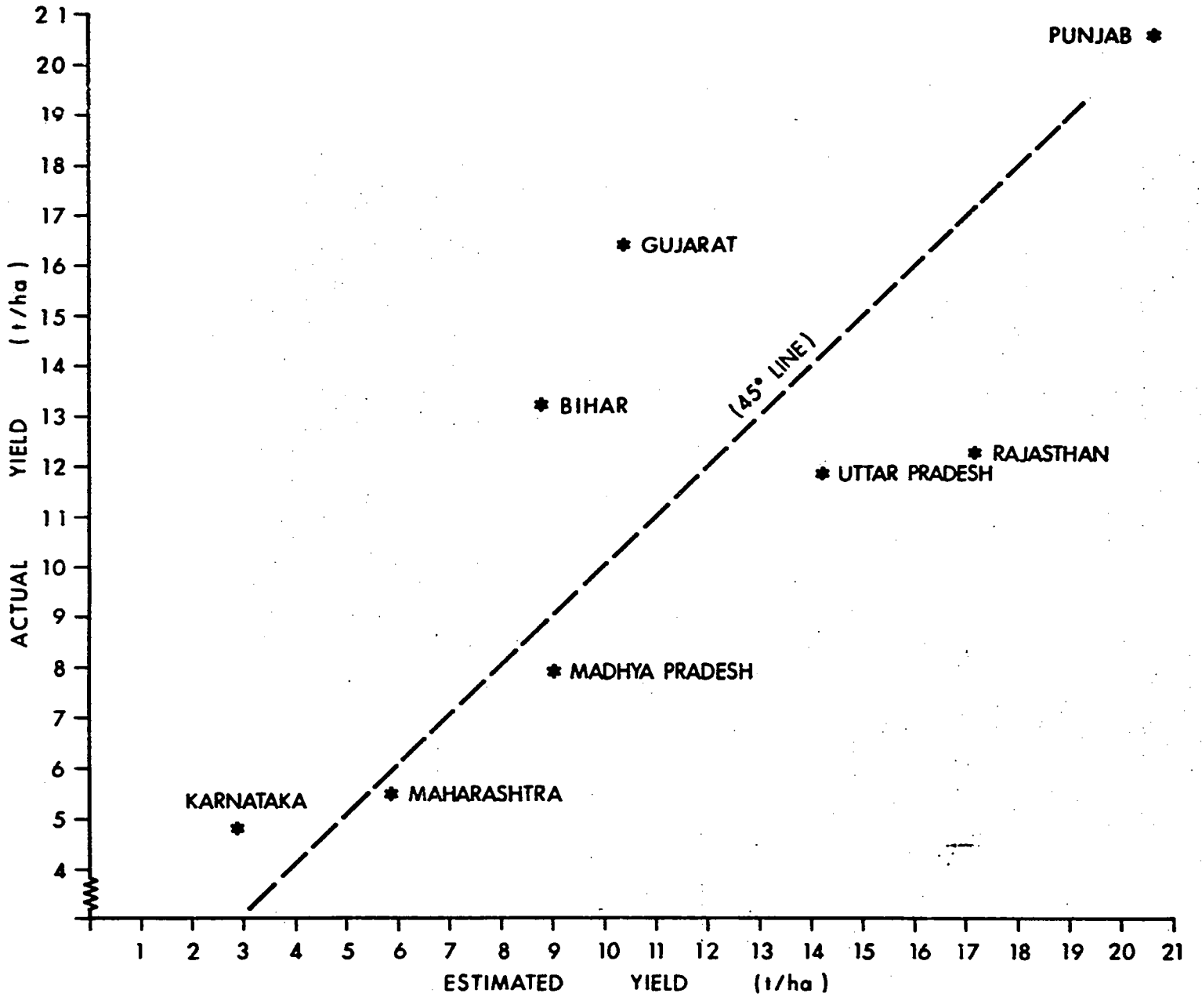
Table III shows average yields for the period of 1954-55 to 1958-59 for major wheat producing states in India and the proportional yields of other states in comparison to Punjab, which had the highest yields. Assuming a 100% yield increase in Punjab and proportionately lower yield increases in the other states, generates estimates which are approximately correct, as a comparison shows between actual average yields for the period 1970-71 to 1974-75 and estimated yields (see Figure 4). Changes in other factors such as input supplies and marketing facilities (relative to Punjab) are responsible for the minor deviations, but these can be neglected for the purpose of our study.

Table III : Wheat yields

States	Actual Yields				Estimated[1] Yields	
	1954-55 - 1958-59		1970-71 - 1974-75			
	kg/ha	Proportion	kg/ha	Proportion	kg/ha	Proportion
Bihar	562	0.55	1316	0.64	871	0.42
Gujarat	654	0.63	1642	0.80	1066	0.52
Madhya Pradesh	572	0.56	790	0.38	892	0.43
Maharashtra	416	0.40	553	0.27	582	0.28
Karnataka	234	0.22	504	0.24	285	0.14
Punjab & Haryana	1031	1.00	2061	1.00	2062	1.00
Rajasthan	901	0.88	1234	0.60	1711	0.83
Uttar Pradesh	794	0.77	1186	0.58	1405	0.68

1 On the basis of 100% yield increase in state with highest yield (Punjab) and proportional increases in other states.

FIGURE 4 : ACTUAL AND ESTIMATED WHEAT YIELDS



Appendix V

Time and Location Effects

The combination of time-series and cross-section data by using the generalized least squares estimation approach generates measurements of the effects of time and location. These are listed in Table IV. They are interpreted in addition (or subtraction) to the intercept.

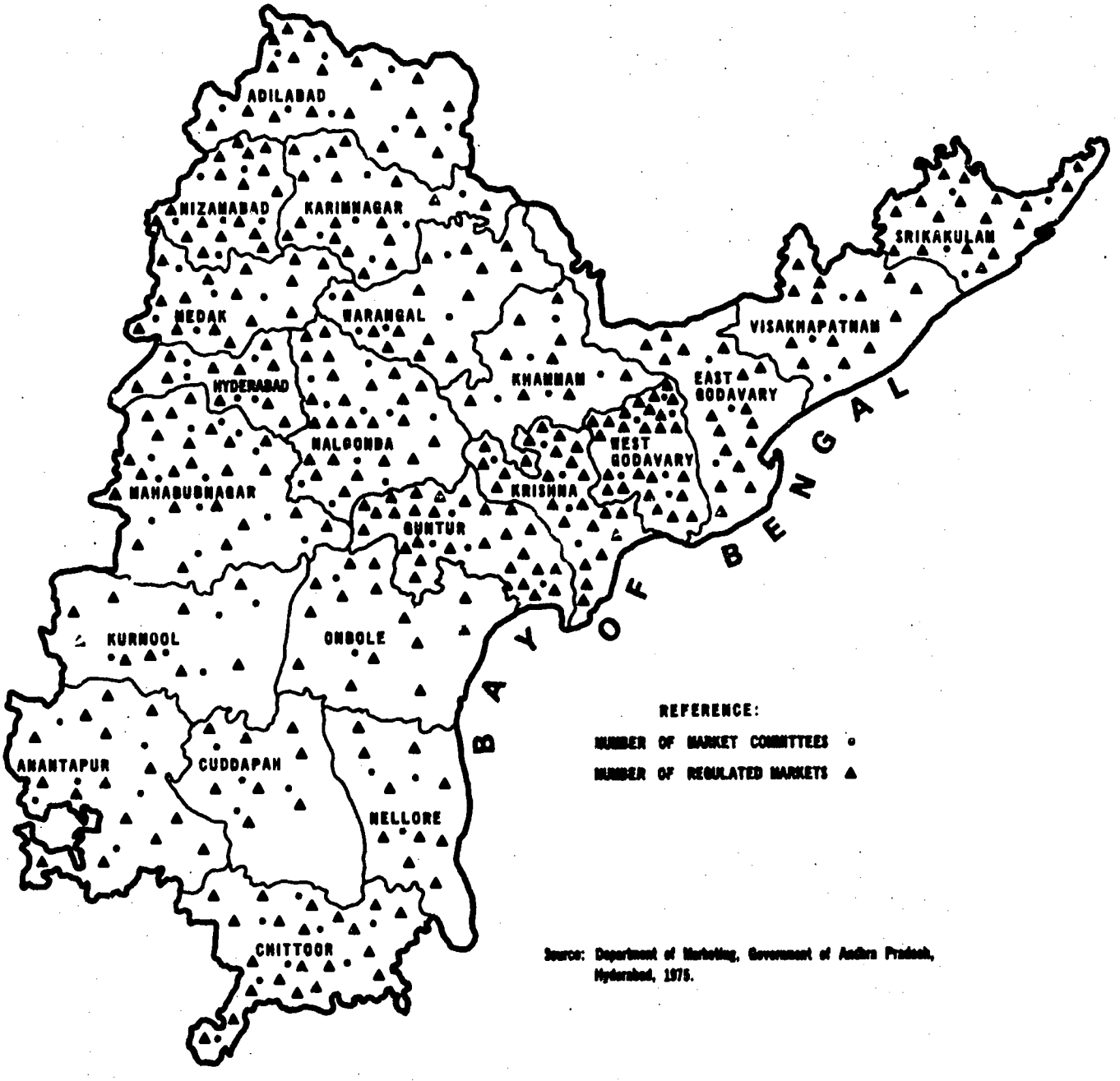
Table IV : Time and Location Effects[1]

Effects	Equation 1	Equation 2	Equation 3
YEARS		*Time Effects*	
1968-69	1.781	2.722	2.747
1969-70	1.589	-0.2049	0.0530
1970-71	-2.032	-3.1817	-3.378
1971-72	-1.338	0.6642	0.6749
DISTRICTS[2]		*Location Effects*	
SRI	-5.536	-4.483	-4.703
VIS	4.973	4.710	5.683
EGO	4.169	5.959	4.195
WGO	4.891	-5.730	-5.247
KRI	2.591	2.935	2.491
CUN	-2.056	-2.853	0.6473
NEL	-2.252	-2.969	-1.665
KUR	-2.851	-3.656	-3.284
ANT	1.542	1.651	2.869
CUD	0.3586	-0.5635	-0.0151
CHI	12.364	12.477	11.43
HYD	-0.5444	-1.674	-1.521
NZB	3.804	4.598	3.237
MED	0.1042	-0.1379	-1.406
MEB	-0.1036	0.3137	-0.2496
NLG	-6.454	-6.024	-7.426
WAR	-6.128	-5.793	-6.541
KHM	0.2139	0.5324	1.246
KRM	-1.762	-1.212	-2.033
ADB	2.457	1.920	2.296
Intercept	-16.18	-20.69	-26.56

1 Estimated equations are given in Table 6.

2 District names are abbreviated; for their location see Fig. 5.

FIGURE 5: MAP OF ANDHRA PRADESH



Source: Department of Marketing, Government of Andhra Pradesh, Hyderabad, 1975.

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