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ARTICLES

New Technology in Agriculture and Changing Size-Productivity Relationships: A Study of Andhra Pradesh

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Agrarian structure is undoubtedly one of the most important determinants of farm efficiency. In recent times, two diagonally opposite arguments are put forward regarding its role in agricultural development. One school of thought is of the opinion that tenancy rights and land distribution (land reforms) would lead to higher land productivity and employment. Underlying this hypothesis is the 'stylised fact' of inverse relationship between farm size and productivity.[1] Conversely, it is observed that the expansion of large capitalised farms would result in efficient production conditions. This argument has its roots in the belief that the advent of green revolution has weakened the existing size-productivity relationship in favour of large farmers who are modern and dynamic while the small and marginal farmers are left behind as backward and inefficient.[2]

It is in this background that the present paper makes an attempt to test the following hypotheses at a disaggregate level. The main hypotheses are: (1) Whether the size productivity relationship has weakened with the advent of green revolution or not, especially in the absence of irrigation and cropping intensity differentials across size classes. (2) If this relationship has weakened, whether the earlier size-productivity relationship has re-established itself due to the operation of 'S' curve relating the percentage of farmers adopting an innovation to time. And (3) to analyse the factors responsible for the existing size-productivity relationship. Various theoretical considerations underlying the size-productivity relationship are examined in Section I. The data and methodology are discussed in Section II while the results are presented in Section III. Section IV discusses the policy implications of the results.

I

THEORETICAL BACKGROUND

A review of the size-productivity question suggests that the land, labour and capital based arguments explain the size-productivity relationship to a large extent, though no single proposition suffices it. This may be mainly due to the variations in the socio-economic and climatic conditions across the regions of the sub-continent. On the whole, three important issues emerge from the literature: The soil quality plays an important role in explaining the size-productivity relationship. In this regard, the use of crop intensity, level of irrigation, etc., as proxies for quality of land may not be appropriate as they are linked with labour and capital market imperfections (see Berry and Cline, 1979; Sen, 1981; Bhalla and Roy, 1988).

The second issue pertains to the utilisation of labour. The relationship between farm size and labour use needs to be examined in the context of technological change. An interesting

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aspect is whether the overall shift in the labour demand due to new technology has an uniform impact across size classes or not and the role of labour saving mechanisation in altering the relationship between farm size and labour use, especially hired labour. Another connected issue is that of relative use of hired labour across size classes, *i.e.*, whether the shift in labour demand has caused any distortion in the hitherto observed positive relationship between farm size and hired labour use (see Desai and Mazumdar, 1970; Rudra, 1973; Bhalla, 1979; Sen, 1981; Reddy, 1987).

The third issue relates to the intermediary inputs like material inputs, bullock labour, etc., with regard to their role in explaining the overall size-productivity relationship. The relationship between farm size and the use of these inputs, especially material inputs, needs to be tested in order to examine the influence of capital market imperfections on the intensity of their usage. It would be interesting to note whether the advent of cash inputs like fertilisers has reinforced the market imperfections. Besides, the economic efficiency in terms of net profit per unit of land is also vital in explaining the farm size-productivity relations. The profit making tendencies of the big farmers compared to small farmers, if tested, may give some clues regarding the 'mode of production' aspect of the size-productivity debate (see for discussion in this regard, Sen, 1966; Khusro, 1973; Bharadwaj, 1974; Mehra, 1976; Bhalla, 1979; Sen, 1981; Carter, 1984; Reddy, 1990; Deshpande and Reddy, 1990).

II

DATA BASE AND METHODOLOGY

Keeping the issues raised in the preceding discussion in focus, an attempt is made to test some of the relevant hypotheses with the help of cost of cultivation data for the state of Andhra Pradesh, India. Andhra Pradesh has got distinct regions in respect of modes of production, agro-climatic conditions, levels of technology, etc. There are marked variations in the adoption of high-yielding varieties (HYVs) of rice in various regions. Commercialisation of agriculture is conspicuous in the South Coastal Andhra region as compared to Telangana region. Capitalistic mode of the semi-feudal type agriculture took shape in the Coastal Andhra region even during the British period. Growth of capitalist agriculture was weak in Rayalseema and North Telangana regions, whereas feudal, semi-feudal and extra economic forms of exploitation are strong in Telangana region when compared to Andhra region in general, and Coastal Andhra in particular (Rao, 1984). Thus the agricultural economy of Andhra Pradesh provides a varied background for examining the above issues. The data have been drawn from the "Comprehensive Scheme for Studying the Cost of Cultivation of Principal Crops".[3]

The sample size covered under the scheme in Andhra Pradesh is 400 households, distributed among 120 villages from 40 tehsils (cluster), belonging to five regions. Cost accounting method has been adopted for the collection of household level data. The data collected are very detailed covering all inputs and outputs of all the crops grown on the selected holdings. For the present purpose the data are obtained from the primary schedules which have not yet been used for this kind of study.[4] And the data were obtained for four points in time, *i.e.*, 1971-72, 1972-73, 1976-77 and 1977-78.

As a first step in the analysis, the data from the first two years (1971-72 and 1972-73) and the last two years (1976-77 and 1977-78) are pooled. These two periods are used to test the following hypotheses:

H_1 = The inverse relationship between farm size and land productivity has weakened with the advent of the green revolution which was set off in the late 1960s.[5]

H_2 = The initial inverse relationship between farm size and land productivity has been re-established in the later years due to the operation of 'S' curve relating to the percentage of farmers adopting new technology.

Irrigated paddy growing households in the state are chosen for the analysis due to the following reasons: To control the soil quality variable which plays an important role in the size-productivity relationship. This has to be resorted to in the absence of data on soil quality, *i.e.*, soil texture and depth. Variations in soil quality can be minimised to a larger extent by taking paddy crop alone because in all the regions the best possible lands are allotted to paddy due to its importance in the food basket. The selection of irrigated paddy also controls irrigation factor which again is one of the important determinants of small farm efficiency. Besides, paddy is the only crop where the new technology has made a clear dent and hence gives scope for separate analysis of HYV paddy and local paddy.

Further, the analysis of a single crop helps us in measuring the output in physical units as well as in value terms whereas the computation of total farm output (all crops) requires the conversion of each crop output into value terms.

The basic equations estimated in the analysis are of log-linear form. The double log formulation is preferred due to its scale free nature which can directly be used for comparing the data pertaining to two points in time (Bhalla and Roy, 1988, pp. 60 and 67).

$$\text{Log}(Y_i) = \text{Log}\,\alpha_i + \beta_i \,\text{Log}(FS_i) + \mu_i \qquad \ldots\ldots (1)$$

where Y_i represents the yield per hectare of paddy (in quintals as well as rupees) of the i-th farmer and FS_i is the farm size of the i-th farmer. Here, farm size is defined as:

$$FS_i = AO_i - ALI_i + ALO_i = AOR_i$$

where AO_i = area owned (in hectares) of the i-th farmer, ALI_i is the area leased in by the i-th farmer; ALO_i is the area leased out by the i-th farmer and AOR_i is the area operated by the i-th farmer which is termed as farm size.

In order to explore the probable explanations for the existing farm size-productivity relationship, derived from equation (1), an attempt is made to examine the relationship between farm size and input use which includes human labour, bullock labour, machine labour and material inputs. Apart from this, the relationship between farm size and net profit per hectare is also analysed. These formulations are:

$$\text{Log}\,Z_i = f\,(\text{Log}FS_i) + \mu_i$$

$$\text{Log}\,Z_i = \text{Log}\,(TLU_i/FLU_i/HLU_i/TBL_i/OBL_i/HBL_i/VTU_i/TEX_i/VNP_i)$$

where TLU_i is the total labour used per hectare on i-th farm, in man-days.
FLU_i is the family labour used per hectare on i-th farm, in man-days.
HLU_i is hired labour used per hectare on i-th farm, in man-days.
TBL_i is the total bullock labour used per hectare on i-th farm, in pair-days.

OBL_i is the owned bullock labour used per hectare on i-th farm, in pair-days.
HBL_i is the hired bullock labour used per hectare on i-th farm, in pair-days.
VTU_i is the value of tractor usage per hectare on i-th farm, in rupees.
TEX_i is the total expenditure per hectare on i-th farm, in rupees.
VNP_i is the value of net profit per hectare on i-th farm, in rupees.

These formulations help us in testing the labour based hypothesis, capital based hypothesis through input use pattern and mode of production hypothesis, *i.e.*, large farmers tend to maximise profits whereas small farmers tend to maximise output. All these specifications are examined with respect to each of the regions in Andhra Pradesh for two points in time, *i.e.*, 1971-73 and 1976-78. The results are presented for local as well as HYV paddy separately in order to capture the size-productivity relationship in the context of new technology.

Before going into the analysis of size-productivity relationship, it would be useful to discuss some of the basic characteristics of the five regions of Andhra Pradesh. These characteristics are presented in Table I in terms of farm size, use of labour, material inputs, tractor, levels of irrigation and spread of HYV. The data indicate that there are wide variations across the regions with respect to level of usage of all inputs. Moreover, there was an upward shift in the use of all the inputs in almost all the regions over the period of five years. These shifts are more prominent in the case of modern inputs like material inputs and spread of HYV. The demand for labour also increased considerably. Interestingly, the use of tractor is limited to some regions only, especially to South Coastal Andhra region which is one of the most developed regions in the country. However, the usage of tractor does not seem to have much bearing on human labour use though it may be observed in the case of bullock labour. Similarly, the proportion of hired labour use is the highest in this region which has also got the highest proportion of its area under HYV coupled with higher levels of irrigation. It is interesting to note that the percentage of area under irrigation among the sample

TABLE I. BASIC CHARACTERISTICS OF THE REGIONS

Region	Average farm size (ha)		Use of material inputs (Rs./ha)		Use of human labour (man-days/ha)		Use of bullock labour (pair-days/ha)		Use of tractor (Rs./ha)		Percentage of area under HYV		Percentage of area under irrigation	
	P-I	P-II	P-I	P-II	P-I	P-II	P-I	P-II	P-I	P-II	P-I	P-II	P-I	P-II
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1. North Coastal Andhra	1.31	1.21	196	551	93 (46)	198 (68)	17	26	0	0	9	34	40	39
2. South Coastal Andhra	1.59	1.47	341	1,147	98 (71)	174 (73)	13	12	44	105	21	48	62	58
3. Rayala-seema	2.56	2.23	436	735	121 (74)	125 (69)	25	20	0	17	8	23	25	24
4. South Telangana	2.88	2.30	301	453	105 (60)	143 (52)	23	32	0	Neg.	17	17	16	25
5. North Telangana	1.76	1.66	142	786	71 (57)	189 (49)	20	32	0	10	21	31	19	27

Notes: P-I = Period one (1971-73); P-II = Period two (1976-78).
Data on material inputs, labour use and tractor are based on sample households.
Figures in parentheses are percentages of hired labour to total.

households has shown a marginal decline over the period in South Coastal Andhra region despite the fact that there is a substantial increase in irrigation under filter points, especially after the green revolution. This may be due to the distributional (spatial) constraints of irrigation development with regard to canal as well as lift irrigation.

The spatio-temporal variations indicate that there is a distinct difference between Rayalaseema and South Telangana, on the one hand and other regions, on the other. When compared to other regions, these two have larger farm size in both the periods. With regard to input use intensity, these two regions have slackened over the period while others have moved faster. For instance, Rayalaseema region which ranked first in material input use per acre dropped to the third position in the second period and South Telangana from the third position to the last. In the case of human labour use they slided from first and second to fourth and fifth respectively. With regard to HYV adoption also, these two regions have fared badly when compared to others, as they occupy the last two ranks in the second period. The low input intensities in these two regions may be attributed, besides other factors like crop patterns, soil characteristics, etc., to the low level of irrigation in these regions in the second period.

III

FARM SIZE AND LAND PRODUCTIVITY

The elasticities of output in quantity as well as value terms for both the periods and varieties (local and HYV) are presented in Table II. The results indicate that in the case of local paddy the relationship between farm size and productivity is not conclusive in the first period (1971-73) at the regional level. Out of the five regions, three have positive elasticities while the others have negative ones though none of them is statistically significant. However, at the aggregate level (state), the coefficients revealed a negative association though it is significant only in value terms. This indicates that the results of the aggregate (state level) analysis do not hold good at the disaggregate (region level) level. The significance of the elasticity in value terms reveals that price differentiation is prevalent across size classes and the prevailing inverse relationship is more due to the price variations than due to the variations in physical output. In this connection, it is interesting to note that small farmers have the price advantage which goes against the widely believed argument that small farmers receive lower prices for their produce due to (1) low quantities, (2) distress sale, (3) lack of storage facilities, (4) lack of proper information and knowledge, etc. But, the contrary evidence in the present case is hard to explain at this juncture and needs further probing at the primary level. However, varietal and quality differences across size classes, apart from the aggregation problems, may be the plausible reasons for the small farmer price advantage. But, in the absence of information in this regard, it is hard to explain.

However, the scenario seems to have changed in the second period (1976-78) where the elasticities in two of the regions turned out significant with negative signs. It can be observed that there is a clear reversal in the farm size-productivity relationship over the period at the regional level. Though the reversal of the relationship is limited to North and South Coastal Andhra regions, the variations in technology adoption (HYV) coupled with low irrigation levels might be the reason for the non-significant negative relation in other regions. Even in terms of material and labour inputs, while South Coastal Andhra ranks first in material inputs and tractor use, North Coastal Andhra ranks first in labour intensity (see Table I). At

the state level also, the inverse relationship has become more prominent as coefficients of quantity as well as value of output turned out significant. At the regional level also, the analysis revealed that small farmers performed better even in terms of physical quantity.

TABLE II. ELASTICITIES OF OUTPUT IN QUANTITY AND VALUE (PER HECTARE) WITH RESPECT TO FARM SIZE (LOCAL PADDY AND HYV PADDY)

	1971-73		1976-78		Number of observations	
Local paddy	Quantity (quintal)	Value (Rs.)	Quantity (quintal)	Value (Rs.)	1971-73	1976-78
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. North Coastal Andhra	1.93	0.03	-0.60***	-0.004	27	24
	(0.95)	(1.15)	(1.73)	(1.62)		
2. South Coastal Andhra	0.69	0.01	-0.69***	-0.004	144	176
	(1.63)	(1.26)	(1.75)	(0.82)		
3. Rayalaseema	0.80	0.002	-0.44	-0.002	38	79
	(1.21)	(0.32)	(0.96)	(0.49)		
4. South Telangana	-0.84	-0.01	0.24	0.005	43	32
	(1.21)	(1.21)	(0.36)	(0.78)		
5. North Telangana	-0.23	-0.01	0.21	0.002	33	58
	(0.29)	(0.84)	(0.44)	(0.54)		
Andhra Pradesh	-0.19	-0.01*	-0.29*	-0.004*	317	337
	(0.92)	(3.46)	(3.26)	(2.51)		
HYV paddy						
1. North Coastal Andhra	-0.38	0.004	-0.22	-0.01**	7	18
	(1.40)	(0.19)	(0.50)	(2.31)		
2. South Coastal Andhra	0.10	-0.004	-0.42	-0.003	96	59
	(0.21)	(0.54)	(0.70)	(0.37)		
3. Rayalaseema	-1.53	0.01	0.86	0.02***	12	34
	(0.79)	(0.28)	(0.76)	(1.83)		
4. South Telangana	-0.78***	-0.01*	-1.03*	-0.01*	24	22
	(1.83)	(2.86)	(2.61)	(2.80)		
5. North Telangana	1.12	0.01	-1.30*	-0.14*	9	34
	(0.97)	(0.72)	(2.49)	(2.80)		
Andhra Pradesh	-0.52	-0.01*	-0.56***	-0.01	148	167
	(0.92)	(3.46)	(1.78)	(1.51)		

Figures in parentheses are 't' values.
* and *** indicate levels of significance at 1 and 10 per cent respectively.

Similarly, the analysis of HYV paddy also supports the inverse relationship hypothesis to some extent though it is not an universal phenomenon. As in the case of local paddy, here also the relationship has become more prominent in the second period. It may be noted that in quantity terms only two regions, North and South Telangana, turned out significant while in value terms three regions - North and South Coastal Andhra, besides Telangana - turned out significant. This indicates that small farmers in North Coastal Andhra region seem to have some price advantage which is true at the aggregate level for both HYV and local paddy in the first period. Interestingly, in one of the regions the relationship has turned out to be positive and significant in the later period. On the whole, the inverse relationship can be observed in four out of five regions with significant coefficients in three, while it is positively significant in one of the regions. The analysis of HYV paddy also revealed that the state level analysis may not hold good at the disaggregate level. Though the inverse relation in quantity terms is present in four of the five regions, it is significant in only two

regions where the number of observations is only 56 out of 167. This may be the reason why the relationship has weakened at the state level (*i.e.*, significant at 10 per cent level only).

The present analysis, thus, after taking into account the influence of irrigation and crop intensity (and even land quality to some extent) also supports the inverse relationship hypothesis in a majority of the regions for the second period. At the same time, it also proves that the phenomenon is not universal. However, the existence of the inverse relationship in a majority of the regions itself is a strong evidence in the absence of irrigation and cropping intensity differentials across size classes because a number of studies have proved that these two factors are the main sources of small farm efficiency. Apart from this, our analysis also indicates that the advent of new technology has weakened the inverse relationship in the earlier years when its spread was limited, but it appears to be re-establishing with the wider spread of technology in the later period. This may be attributed to the operation of the well-known 'S' curve which explains the percentages of farmers adopting an innovation over time. It is argued that though large farmers are likely to be the first to adopt new technology, small farmers are likely to follow it soon (Berry and Cline, 1979). This hypothesis can be tested in two ways in the present study, *i.e.*, by comparing local paddy with HYV paddy and by comparing both the periods. In both the cases, it can be observed that the inverse relationship is more prominent on the HYV farms and in the later period. Further, the farm size-productivity relation is examined with regard to total paddy also, *i.e.*, local and HYV together, which may be more relevant in the present context. The estimates more or less re-emphasises our arguments (see Table III). The relationship was significant and negative in only one of the regions (South Telangana), both in quantity and value terms, in the first period. In fact, it did not turn out significant even at the state level. Whereas in the second period, the inverse relation was significant at the state level as well as in two of the regions in quantity terms and in one region in value terms. However, it may be noted that the low prominence of the inverse relationship in the case of total paddy when compared to HYV paddy may be due to the aggregation bias. From the above analysis, it can be deduced

TABLE III. ELASTICITIES OF OUTPUT IN QUANTITY AND VALUE TERMS (PER HECTARE) WITH RESPECT TO FARM SIZE (TOTAL PADDY)

Region	1971-73		1976-78	
	Quantity (quintal)	Value (Rs.)	Quantity (quintal)	Value (Rs.)
(1)	(2)	(3)	(4)	(5)
1. North Coastal Andhra	-0.18	-0.12	-0.39	-0.28
	(1.24)	(0.85)	(1.39)	(1.12)
2. South Coastal Andhra	-0.01	-0.01	-0.19**	-0.11
	(0.20)	(0.18)	(2.11)	(1.38)
3. Rayalaseema	0.03	-0.11	-0.39*	-0.33*
	(0.30)	(1.42)	(3.01)	(2.54)
4. South Telangana	-0.15**	-0.19**	-0.06	-0.11
	(2.04)	(2.15)	(0.26)	(0.50)
5. North Telangana	-0.12	-0.11	-0.09	-0.07
	(0.88)	0.94	(0.56)	(0.47)
Andhra Pradesh	-0.04	-0.03	-0.019*	0.015*
	(1.03)	(0.81)	(3.70)	(2.50)

Figures in parentheses are 't' values.
* and ** indicate levels of significance at 1 and 5 per cent respectively.

that new agricultural technology is size neutral in the long run as far as its impact on production is concerned. At this juncture, it would be interesting to look into the factors responsible for this relationship.

(i) Farm Size and Labour Use

The elasticities of human and bullock labour for local and HYV paddy for both the periods are presented in Tables IV and V. The coefficients are dominated by negative signs

TABLE IV. ELASTICITIES OF HUMAN AND BULLOCK LABOUR WITH RESPECT TO FARM SIZE (LOCAL PADDY)

Region	Human labour (man-days)					
	1971-73			1976-78		
(1)	Family (2)	Hired (3)	Total (4)	Family (5)	Hired (6)	Total (7)
1. North Coastal Andhra	-0.01	0.09	-0.08	0.09	-0.21**	-0.09**
	(0.05)	(0.95)	(0.90)	(1.01)	(2.10)	(1.69)
2. South Coastal Andhra	-0.52*	0.15	-0.14***	-0.51*	-0.05	-0.26*
	(4.92)	(1.51)	(1.89)	(3.94)	(0.32)	(2.84)
3. Rayalaseema	0.19	0.23	0.18	-0.13	-0.14***	-0.16*
	(0.62)	(1.32)	(1.32)	(1.43)	(1.88)	(2.61)
4. South Telangana	-0.25	0.19	-0.12	-0.31*	0.06	-0.09
	(1.59)	(0.87)	(0.81)	(2.52)	(0.50)	(1.10)
5. North Telangana	-0.10	0.37***	0.15	-0.24	-0.16	-0.15
	(0.75)	(1.66)	(0.12)	(1.63)	(0.91)	(1.58)
Andhra Pradesh	-0.29*	0.09	-0.13*	-0.19*	-0.18*	-0.10*
	(4.03)	(1.33)	(3.22)	(4.29)	(3.62)	(3.85)
Region	Bullock labour (pair-days)					
	1971-73			1976-78		
	Owned	Hired	Total	Owned	Hired	Total
1. North Coastal Andhra	0.06	-1.74*	-0.66	-0.24	0.73	-0.23
	(0.12)	(2.74)	(1.61)	(1.43)	(1.01)	(1.34)
2. South Coastal Andhra	-0.78**	-1.84*	-1.28*	-0.24*	3.18*	-1.29
	(2.13)	(3.57)	(4.13)	(0.55)	(4.29)	(2.96)
3. Rayalaseema	1.73***	-0.85	0.46	-	-0.11**	-0.11**
	(1.80)	(0.86)	(0.64)		(2.05)	(2.05)
4. South Telangana	-0.33	3.90**	-0.28	-0.33	-0.32	-0.35
	(1.43)	(1.98)	(1.20)	(1.33)	(0.79)	(1.45)
5. North Telangana	-0.12	-	-0.12	0.29	-0.02***	0.07
	(0.66)		(0.66)	(0.74)	(1.95)	(0.16)
Andhra Pradesh	0.19*	-0.09	-0.07	-0.09	-0.03	-0.02
	(2.60)	(0.70)	(1.48)	(1.62)	(0.24)	(0.70)

Figures in parentheses are 't' values.
*, ** and *** indicate levels of significance at 1, 5 and 10 per cent respectively.
Number of observations are same as in Table II.

for human as well as bullock labour for both the varieties. It can be observed from the table that the inverse relationship has become prominent in the later period. In most of the cases the inverse relationship between farm size and labour (human and bullock) use corresponds with the size-productivity relationships observed in Table II. The exceptions in this regard are South Coastal Andhra region and Rayalseema region. These two regions have displayed

positive association between farm size and productivity (in the case of South Coastal Andhra it was for local paddy in the first period and for Rayalseema it was for HYV paddy in the second period) while their respective labour use coefficients have revealed significantly negative coefficients with respect to farm size. This indicates that land productivities of small farmers in these two regions are lower despite the higher usage of labour. However, this phenomenon may be attributed to the higher usage of tractor on large farms as a substitute for labour.

TABLE V. ELASTICITIES OF HUMAN AND BULLOCK LABOUR WITH RESPECT TO FARM SIZE (HYV PADDY)

Region	Human labour (man-days)					
	1971-73			1976-78		
(1)	Family (2)	Hired (3)	Total (4)	Family (5)	Hired (6)	Total (7)
1. North Coastal Andhra	-0.13	-0.56	-0.02	-0.11	-0.11**	-0.09**
	(0.25)	(0.90)	(2.49)	(-1.21)	(1.76)	(2.05)
2. South Coastal Andhra	-0.41***	-0.002	-0.29***	-0.45**	-0.38	-0.36**
	(2.24)	(0.01)	(1.87)	(2.07)	(1.29)	(2.26)
3. Rayalaseema	-	0.19	0.19	-0.51*	-0.27	-0.48*
		(0.45)	(0.45)	(2.60)	(1.43)	(3.42)
4. South Telangana	-0.99	-0.01	-0.07	-0.26*	-0.09	-0.16*
	(0.98)	(0.04)	(0.82)	(3.67)	(0.51)	(2.42)
5. North Telangana	-0.98	-	-0.98	-0.53*	-0.08	-0.19***
	(1.29)		(1.29)	(2.66)	(0.42)	(1.65)
Andhra Pradesh	-0.29*	-0.11	-0.09	-0.31*	-0.20**	-0.24*
	(2.39)	(0.93)	(1.01)	(4.82)	(2.13)	(4.97)
Region	Bullock labour (pair-days)					
	1971-73			1976-78		
	Owned	Hired	Total	Owned	Hired	Total
1. North Coastal Andhra	0.14	-0.14	0.37	-0.16***	-0.63***	0.47**
	(1.37)	(1.36)	(0.17)	(1.75)	(1.76)	(2.00)
2. South Coastal Andhra	0.04	-1.78	-0.96***	-1.72**	-7.13*	-2.22*
	(0.06)	(2.35)	(1.67)	(2.16)	(2.69)	(2.95)
3. Rayalaseema	2.11	0.72	1.04	-0.64*	-0.72	-1.38***
	(1.01)	(0.42)	(0.87)	(0.92)	(0.85)	(1.85)
4. South Telangana	-0.02	4.78*	0.02	-0.19***	-	0.19***
	(0.11)	(2.45)	(0.08)	(1.79)		(1.79)
5. North Telangana	-1.48	-	-1.48	0.08	-6.24	0.05
	(0.85)		(0.85)	(0.17)	(0.87)	(0.11)
Andhra Pradesh	-0.03	-0.41	-0.14	-0.29*	-1.04***	-0.35*
	(0.11)	(0.75)	(0.49)	(2.42)	(1.88)	(2.90)

Figures in parentheses are 't' values.
*, ** and *** indicate levels of significance at 1, 5 and 10 per cent respectively.
Number of observations are same as in Table II.

But this argument may not be a very convincing one as this particular phenomenon of lower land productivity with higher labour use cn small farms is not observed in the case of HYV paddy or even local paddy in the second period for the South Coastal Andhra region where the usage of tractor is the highest. Hence, the explanation may lie in the specific characteristics of the regions. In other words, apart from the input intensities, the factors like combination of modern inputs like fertiliser, tractor, etc., on the one hand, and the type

and quality of irrigation, on the other, vary from region to region. For instance, in Rayalaseema well irrigation is predominant and is mostly controlled by large farmers. Given the high reliability and quality of irrigation from such a source, land productivities may still be in favour of larger farmers. For, in this region small and marginal farmers largely depend on water markets (Reddy, 1991).

The present analysis supports the argument that small farms are more productive consequent to higher usage of labour per unit of land. This higher labour intensity is often attributed to labour market dualism where small farmers depend mostly on cheap family labour with low opportunity cost while large farmers depend on hired labour. But our analysis indicates that small farmers use not only more of family labour but also hired labour when compared to large farmers. It can be observed from Tables IV and V that except in the case of local paddy in the first period, in all other cases the relationship between farm size and hired labour use is negative. This inverse relationship, in fact, has become prominent and stronger in the later period. This indicates that small farmers are using more labour per unit of land rather by choice than by compulsion which was hitherto attributed to the low opportunity cost of family labour. The higher labour intensity may be a result of technological change which has shifted the labour demand function upwards over the period (Reddy, 1992). Small farmers who cannot afford to go for labour displacing mechanical devices like tractors might have resorted to employing more of wage labour. On the other hand, large farmers would have either adopted labour saving techniques or sacrificed the land productivity in view of supervision problems related to hired labour.[6] Therefore, the hitherto believed proposition that small farms are more labour intensive because of their family labour component is no longer valid. However, it may be noted that this may not be an universal phenomenon.

However, the relatively higher use of hired labour on small farms does not rule out the labour market dualism if the allocation of labour input is not efficient on small farms. This is likely to happen because the demand for hired labour may be seasonal which is usually of short duration. While the lean (which is usually long) season may still force the family labour to stick to their own land pushing the marginal productivities down. In order to examine this aspect, we have presented below the average and marginal productivities of labour for various size classes in Andhra Pradesh for the period 1976-78. It can be observed from Table VI that the average and marginal productivities are higher than the market

TABLE VI. AVERAGE AND MARGINAL VALUE PRODUCTIVITIES OF LABOUR IN PADDY CULTIVATION IN VARIOUS SIZE CLASSES (SUB-GROUPS) IN ANDHRA PRADESH (1976-78)

Sub-group	Average productivity (Rs.)	Marginal productivity* (Rs.)	Labour use per hectare (man-days)	Money spent on tractor per hectare (Rs.)
(1)	(2)	(3)	(4)	(5)
I (Lowest size class)	24.12	37.65	186	37
II	24.06	30.45	194	53
III	25.65	22.27	169	41
IV	36.08	NS	167	54
V (Highest size class)	52.28	120.61	157	206

Source: Reddy (1987).
Notes: NS = Not significant; wage rates are below Rs. 10 in all the sub-groups.
* Marginal productivities are computed with the help of simple linear regressions.

wage rate. It can also be observed that marginal value productivities of labour (MVP_i) have showed a declining trend upto the fourth sub-group. In fact, in the fourth sub-group the MVP is not significantly different from zero. But the largest size class recorded the highest MVP of labour. This may be attributed to the higher intensity of tractor usage in this particular group which is four times higher than any other group (see Table VI). Therefore, the usage of tractor not only displaces labour but also enhances the productivity of the remaining labour.

The present analysis thus rules out the existence of labour market dualism in the sense that MVP of labour will be less than the market wage rate on small farms as they are forced to use more of family labour consequent to low opportunity cost. Our analysis has not only indicated that small farmers use more labour due to the demand push rather than due to the lack of employment opportunities outside, but also showed that MVP of labour is higher than the market wage rate for all the size classes except one. This indicates the possibility of higher labour intensity in rice cultivation. However, these higher productivities may be due to the simultaneous working of other complementary inputs like fertilisers and also due to farm mechanisation. Higher usage of material inputs may be the main reason for high MVP/wage ratios in the case of small farmers, whereas tractorisation also may play an important role in the case of large farmers. On the whole, it may be argued that the new agricultural technology has helped the farmers, especially small, in keeping their labour as well as land productivities high. This is mainly carried out through some of the complementary inputs which are more capital intensive and, sometimes, beyond the reach of small farmers due to their disadvantageous position in the capital market. However, this needs to be verified.

(ii) Farm Size and Input Use

For the purpose of analysing the relationship between farm size and input use, we have taken all the important determinants in value terms as indicated earlier. Fertilisers form a major proportion (about 75 per cent) of these inputs and hence these inputs are capital intensive. Besides, money spent on tractor per hectare is also a capital intensive input. The elasticities of material inputs and tractor use are presented in Table VII for local and HYV paddy. The elasticities indicate that though there appears to be an inverse relationship in a majority of the regions, the coefficients are significant only in a few of them. It is interesting to note that the inverse relationship is stronger in the case of local paddy than for HYV paddy, in both the periods. In fact, there exists a positive association, though not significant, for HYV paddy in the first period. This indicates that small farmers are either restraining themselves from using higher doses of fertilisers or the capital market disadvantages are forcing them to use less of cash inputs. This is more so in the case of HYV paddy which requires more of these inputs. Moreover, our analysis also indicates that large farmers may be concentrating more on HYV paddy which is more responsive to fertilisers than local paddy whereas the vice versa is true in the case of small farmers. A plausible explanation may be that large farmers are trying to compensate the low labour (human as well as bullock) intensities on their farms with tractor. The usage of tractor is associated with large farms in all the regions where they are in use. The positive relationship between farm size and tractor

use is much stronger in the second period, that too in the regions where its use is more. The capital intensive nature of tractor makes it size biased. Additionally, large farmers are expected to resort to tractor to avoid the problems of supervision (Sen, 1981).

TABLE VII. ELASTICITIES OF MATERIAL INPUTS AND TRACTOR USE WITH RESPECT TO FARM SIZE (LOCAL PADDY AND HYV PADDY)

	1971-73		1976-78	
Local paddy	Material inputs (Rs. per ha)	Tractor used (Rs. per ha)	Material inputs (Rs. per ha)	Tractor used (Rs. per ha)
(1)	(2)	(3)	(4)	(5)
1. North Coastal Andhra	-0.76	-	-0.12	-
	(1.20)		(1.36)	
2. South Coastal Andhra	0.01	0.11*	-0.02***	0.11*
	(0.36)	(2.54)	(1.69)	(3.26)
3. Rayalaseema	0.05	0.04	-0.01	0.06
	(1.43)	(0.04)	(0.39)	(0.72)
4. South Telangana	-0.04	-	0.02	-
	(1.42)		(0.87)	
5. North Telangana	-0.02	-	-0.01	0.28
	(0.44)		(0.53)	(0.97)
Andhra Pradesh	-0.02**	0.01***	-0.01***	0.004*
	(2.05)	(1.66)	(1.84)	(2.59)
HYV paddy				
1. North Coastal Andhra	-0.04	-	-0.02*	-
	(0.19)		(3.89)	
2. South Coastal Andhra	0.003	0.09	0.02	0.20*
	(0.11)	(1.30)	(1.15)	(2.86)
3. Rayalaseema	-0.01	1.75	-0.003	0.80*
	(0.07)	(0.60)	(0.10)	(3.60)
4. South Telangana	-0.07*	-	-0.01	-
	(3.36)		(0.69)	
5. North Telangana	0.01	-	-0.05***	-
	(0.56)		(1.91)	
Andhra Pradesh	0.01	0.09	-0.01	0.24*
	(0.58)	(1.44)	(0.83)	(4.59)

Notes same as in Table V.

Though the inverse relationship does not seem to be universal, the present analysis provides more authentic evidence regarding small farm efficiency as it treats irrigation and crop intensity as exogenous variables. The present analysis, while agreeing with the labour based explanation for small farm efficiency, does not support the theory of labour market dualism. In this regard, it is observed that small farmers opt for more labour intensive cultivation mainly due to the upward shift in the labour demand rather than due to the low opportunity costs of family labour, whereas large farmers try to circumvent this with labour saving techniques like tractor. Moreover, the analysis also rejects the hypothesis of low marginal productivity on small farms though it reveals that marginal productivity of labour is the highest on large farms, where the usage of tractor is predominant. On the other hand, the relationship between farm size and material input use is also in favour of small farms but not as strong as in the case of labour. This indicates that the credit market imperfections could not influence the farmers to the extent of reducing the use of cash inputs. However,

the preceding analysis does not fully justify the argument of small farm efficiency in paddy cultivation as it gives only the behavioural pattern of the farmers and it does not provide the rationale behind it.

(iii) Farm Size and Profitability

Profitability, in the present context, is defined as value of net returns per unit of land which is obtained by deducting the total expenditure, including family labour (human and bullock) but excluding land, from the gross value of output. The elasticities of value of net profit and total expenditure for local paddy and HYV paddy for both the periods are presented in Table VIII. It can be observed from the table that the relationships vary considerably

TABLE VIII. ELASTICITIES OF MATERIAL INPUTS AND TRACTOR USE WITH RESPECT TO FARM SIZE (LOCAL PADDY AND HYV PADDY)

	1971-73		1976-78	
Local paddy	Total expenditure (Rs. per ha)	Net profit (Rs. per ha)	Total expenditure (Rs. per ha)	Net profit (Rs. per ha)
(1)	(2)	(3)	(4)	(5)
1. North Coastal Andhra	-0.04***	0.02***	-0.01	-0.003
	(1.70)	(1.77)	(1.37)	(1.09)
2. South Coastal Andhra	-0.01	0.004	-0.008	-0.001
	(0.87)	(0.82)	(0.95)	(0.29)
3. Rayalaseema	0.05***	-0.001	-0.01	0.007
	(1.81)	(0.12)	(1.60)	(0.37)
4. South Telangana	-0.03	-0.01	0.09	0.004
	(1.09)	(1.02)	(0.23)	(0.54)
5. North Telangana	0.02	-0.98	-0.006	0.005
	(0.49)	(0.98)	(0.64)	(0.98)
Andhra Pradesh	-0.02**	-0.01*	-0.01*	-0.002
	(2.17)	(2.83)	(2.79)	(0.74)
HYV paddy				
1. North Coastal Andhra	-0.14***	0.12	-0.02*	-0.002
	(1.75)	(0.52)	(4.83)	(0.76)
2. South Coastal Andhra	0.01	-0.01	0.02***	-0.01
	(0.52)	(0.83)	(1.71)	(1.25)
3. Rayalaseema	0.24	0.003	-0.04	0.03*
	(1.43)	(0.12)	(1.51)	(2.79)
4. South Telangana	-0.04*	-0.01**	-0.01	-0.01*
	(2.64)	(2.25)	(0.55)	(3.18)
5. North Telangana	0.01	0.02	-0.04*	-0.02**
	(0.19)	(0.71)	(2.38)	(2.31)
Andhra Pradesh	0.18	-0.01**	-0.01	-0.004
	(1.39)	(2.13)	(0.86)	(1.27)

Notes same as in Table V.

between local paddy and HYV paddy. In the case of local paddy, at the state level the relation between farm size and net profits is negative and significant, indicating that small farmers are earning higher profits despite their higher total expenditure. However, this does not seem to be the case at the regional level because in no region there was a significant inverse relationship though the sign of the coefficient is negative in three of the five regions. In fact, in North Coastal Andhra the relationship was positive (significant), indicating that large farmers earned more profits irrespective of their lower total expenditure. The situation in

the second period has become unfavourable to small farms as the relationship between farm size and net profit has turned out positive in more number of regions, though none of the coefficients is significant. Even at the state level the negative association between these two has become weak (non-significant). This indicates that the output advantages of the small farmers (second period, see Table II) are not carried over in terms of net incomes. Though small farmers may be gaining more on the farm business income front as these farmers use more of family labour (both human and bullock), in terms of net incomes labour saving technologies like tractor may be more profitable in the case of local paddy. This may be due to the low output response of local varieties to modern inputs when compared to HYVs.

As far as HYV paddy is concerned, the situation seems to be slightly favourable to small farmers. In the first period, significant inverse relationship can be observed at the state level as well as in one of the regions (South Telangana). In the remaining regions, three showed positive association and one negative though none of them is significant. In the second period, four of the five regions revealed inverse relationships, of which two are significant, while one showed a significantly positive association. On the whole, the analysis of profits brings out clearly two important things: one is that though small farmers seem to be more of output oriented than their counterparts, their inclination for higher net returns cannot be ruled out. Secondly, the new agricultural technology as such, except tractor, does not appear to be biased against small farmers especially as its adoption spreads to small farmers also.

IV

SUMMARY AND POLICY IMPLICATIONS

This paper makes an attempt to test some of the hypotheses regarding agrarian structure and changing production relations in the context of new technology by taking up an intensive study of paddy cultivation in Andhra Pradesh with the help of cost of cultivation data, which has, so far, not been used for this purpose. The following issues have been examined at the regional level:

(1) The inverse relationship between farm size and land productivity has weakened with the advent of new technology.
(2) This inverse relationship is expected to be re-established in the process of technological change due to the operation of 'S' curve relating the percentage of farmers adopting an innovation to time.
(3) Small farmers use more of labour (both human and bullock) per unit of land. Whereas the use of family labour declines, the use of hired labour increases along with farm size.
(4) The use of non-labour inputs like material inputs and tractor is expected to be higher on large farms.
(5) Net returns per unit of land are expected to increase as the farm size goes up.

It is observed that the inverse relationship between farm size and productivity holds good in a majority of the regions, though this phenomenon is not found to be universal. Some of the interesting observations revealed in the analysis are: The existing inverse relationship between farm size and productivity is mainly due to the higher labour intensity on small farms, though the intensity of material inputs also influences the relationship to some extent.

However, the analysis does not support the hypothesis of labour market dualism because small farms use more labour per unit of land due to the higher requirements rather than due to compulsion arising out of low opportunity costs of labour. In fact, it is observed that the higher labour intensity on small farms is, to some extent, due to the availability of cheap family labour; the fact is that they also use more of hired labour. Further, the hypothesis of zero or lower (than market wage) marginal productivity of labour on small farms is also rejected. On the other hand, the higher labour productivities on large farms can be attributed to the higher usage of tractors.

It is also observed that the advent of new technology had weakened the inverse relationship to some extent in the early years when its spread was limited. But it appears to be re-establishing with the spread of new technology in the later period.

As far as the net returns to farming is concerned, the small farmers are not able to convert their output advantages into higher net profits due to their higher total expenditure especially in the case of local paddy. This may be due to the reason that small farmers try to maximise their output while large farmers try to maximise profits. The reasons for this may be: (1) small farmers produce more in order to meet the higher food requirements of a large family and (2) they may not be able to reduce their total expenditure by adopting labour substituting techniques like tractors as they cannot afford. However, small farmers' inclination for higher profits, as revealed in the case of HYV paddy, cannot be ruled out. In any case, the viability of small farmers in terms of net income is not as strong as in the case of output.

In the light of declining net incomes, especially of small farmers, the viability of farming needs to be improved.[7] This calls for development of new farming techniques not only with higher yield rates but also with low input-output ratios. Besides, the extension network has to be strengthened in order to educate farmers so that the viability of farming can be improved with the existing technology itself. The present analysis also suggests the possibility of enhancing productive employment in agriculture which is believed to be the key to accelerated development and abolition of mass poverty in most of the less developed countries. In this context, policies like land reforms, technical know-how, capital investment and adjustments in labour and product markets, etc., would be helpful in providing more employment to those with high income elasticity for food.

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NOTES

1. See, among others, for a review of literature, Berry and Cline (1979) and Sen (1981) and the recent studies of Deolalikar (1981), Rao and Chotigeat (1981), Carter (1984), Taslim (1989, 1990).

2. For instance, see Bhalla (1979) and Sen (1981).

3. For details, see Reddy (1987). The details are obtained from the note on "Technical Details of the Comprehensive Scheme for Studying the Cost of Cultivation of Principal Crops", provided by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, New Delhi.

4. For a detailed discussion and critical review of the data base and methodologies of earlier studies, see Rudra (1982) and Barbier (1984).

5. This hypothesis is based on the earlier studies which observed the inverse relationship in Andhra Pradesh agriculture on the basis of Farm Management Survey data. For instance, see Saini (1971) and Rani (1971).

6. For an interesting discussion on this aspect, see Sen (1981), Feder (1985) and Taslim (1989).

7. In this context, it may be noted that increasing costs in agriculture is gaining current in the recent past. For instance, see Vyas (1986), Nadkarni (1988) and Parthasarathy (1991).

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