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Farm Size-Productivity Relationship: Empirical Evidence from an Agriculturally Developed Region of Himachal Pradesh

H. R. Sharma and R. K. Sharma*

I

INTRODUCTION

The farm size-productivity relationship debate is one of the most important debates in the Indian agricultural economics literature. When the debate concluded in the mid-seventies, there was a near consensus among scholars that small farms are more productive as compared to their large counterparts. In fact, the impact of the debate was so pervasive that Michael Todaro observed: "Evidence on a wide range of third world countries.... clearly demonstrates that small farmers are more efficient producers of most agricultural commodities" (Todaro, 1981, p. 262). Likewise, commenting on the policy implications of the inverse farm size-productivity debate, Berry and Cline remarked: "The central policy implication of the analysis is that land redistribution into the family farms (assuming it to be small) is an attractive policy instrument for raising production and improving rural employment and equality of income distribution" (Berry and Cline, 1979, p. 134). The widespread empirical evidence on the inverse farm-size productivity relationship provided theoretical and logical support to the numerous land reform measures and small farm bias in development strategy in a number of developing countries including India.

More recently, some scholars have argued that the much-publicised inverse farm size-productivity relationship has either weakened or has even disappeared on account of numerous changes witnessed in Indian agriculture since the mid-seventies. It has been argued that technological backwardness, an essential condition for inverse farm size-productivity relationship, no longer holds true for many parts of the country. Indian agriculture, over the years, has experienced important changes having serious implications for the farm size-productivity relationship. Firstly, new agricultural technology has spread and permeated more thoroughly both across the regions and crops. It is argued that with the spread of new agricultural technology, family labour, which was considered to be the main determinant of inverse relationship, becomes less important in affecting farm productivity. Instead, the use

* Department of Agricultural Economics, Himachal Pradesh Agricultural University, Palampur –176062, Kangra (H.P.).
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of chemical fertilisers, high yielding variety seeds (HYVs), etc., becomes more important to which the large farmers have more easy access. Secondly, capital formation, both in the public and private sector, has increased leading to an increase in irrigation and other infrastructural facilities. The credit and extension facilities have also expanded significantly. Thirdly, the launching of the process of liberalisation at home and the World Trade Organisation at the international level also has profound implications. For example, the subsidies on fertilisers and other inputs are being gradually withdrawn affecting the small farmers more than their large counterparts. Also, the agricultural sector is being gradually opened up and integrated with the world economy. These changes are encouraging the medium and large farmers to take their agriculture business more seriously in a cost-effective manner and thereby benefit from the higher international prices in commodities like wheat, rice, etc. Fourthly, rural non-farm employment opportunities have also expanded in recent times lessening the dependence of the small and marginal farmers on the agricultural sector. Fifthly, the tenancy relations have undergone qualitative changes. It is evident from the significant decline in the incidence of tenancy, replacement of share tenancy with fixed rent tenancy and the emergence of reverse tenancy, which is more pronounced in agriculturally developed regions. As a result, the tenancy relations today are more capitalist in nature as compared to those in the late sixties and the early seventies when the inverse farm size-productivity debate took place. It has been increasingly argued that these changes and developments lead to capitalist relations of production and as the process of capital deepening gets intensified, the inverse relationship breaks down (Ghose, 1979, Dyer, 1991 and 1996). All these changes warrant a fresh look at the farm size-productivity relationship.

II

THE DEBATE: A BRIEF REVIEW

The debate on inverse farm size-productivity relationship, which started with the publication of Sen's 1962 paper in *The Economic Weekly*, though concluded in the mid-seventies, continues to attract the attention of the scholars even today. Most of the studies during the first phase of the debate (1960-75) were based on the pooled data emanating from the Farm Management Survey Reports (FMSR). During this phase, while a majority of the scholars after analysing pooled/aggregate data from FMSR regarded inverse farm size-productivity relationship as a 'stylised fact' and more or less a universal phenomenon, there were a few others who argued that inverse relationship couldn't be considered universally valid (Rudra, 1982; Bhardwaj, 1974). Some scholars also analysed disaggregated farm level data emanating from FMSR. The conclusions were a mixed lot. While Rao (1966), Saini (1971) and Bhattacharya and Saini, (1972) found inverse relationship to be true, some others observed no relationship between farm size and yield, inputs used and cropping intensity (Rao, 1967, pp. 1989-91). In brief, when the debate concluded in the mid-seventies, there was a broad consensus among scholars that the small farm sector is more productive, some dissensions and disagreements notwithstanding.

A number of explanations have been put forward to explain the inverse farm size-productivity relationship. These can be classified into three categories: Firstly, explanations that attribute higher productivity on the small farms to the use of better quality inputs, for example, higher fertility on the small farms, superior and better techniques of production used by these farms, high management efficiency, higher impact of indivisible factors of production on the small farms, the effect of fragmentation on the small farms and disincentive of tenancy, absentee landlordship, etc. Secondly, the explanations which invoke the intensity of input use on the small farms like predominance of family labour which is cheaper on the small farms, more intensive use of labour, capital and current inputs on such farms, higher intensity of irrigation, the dominance of high value and more productive crops in the cropping pattern and the feedback of higher earnings on the productivity of labour on the small farms. Thirdly, a class based political economy explanation of inverse farm size-productivity relationship had also been advanced by some scholars (Patnaik, 1987; Bhardwaj, 1974).

The second phase in the farm size-productivity debate commenced around the eighties when the scholars increasingly started questioning the validity of inverse relationship either analysing the old data set from FMSR using more appropriate statistical tools or by incorporating some new variables like land quality, etc., or by using more recent data set. The basic argument of these studies is that with the spread of new agricultural technology, the inverse relationship has either weakened or even has got reversed. A study by Chadha (1978), using disaggregated data for 61 villages from different parts of Punjab, concluded that in the central and south districts, which had come under the spell of green revolution, the inverse relationship had disappeared. Similar results for Punjab were also reported by Roy (1981) and by Deolalikar (1981) for those districts in the country where the new agricultural technology had made much headway. Perhaps, taking note of numerous studies reporting heterogeneity and breakdown of inverse farm size-productivity relationship in some regions prompted Rudra and Sen (1980) to remark that the inverse relationship was yet not something that could be taken as an established fact. Later studies for different parts of the country confirmed either the breakdown or weakening of such relationship once the proper allowance was made for variables like soil quality, etc. For example, Bhalla and Roy (1988) using a large data set emanating from Fertiliser Demand Survey, found agro-climate and soil quality as important determinants of farm productivity. They concluded that if proper allowance was made for exogenous land quality variables, the inverse relationship weakened and, in many cases, it even disappeared. The breakdown of inverse relationship was also reported from the agriculturally developed regions in Egypt and from Indus valley area in Pakistan (Dyer, 1991; Khan, 1979). However, Carter (1984), even after controlling the effect of soil quality and other farm assets, found higher productivity on the small farms as compared to the large farms, which was mainly on account of higher input use like family labour per hectare by the small farms compared with large farms. Likewise, Cornia (1985) in a study of fifteen developing countries concluded: "Small farms are characterised by a more intensive use of land and by resource inputs per hectare than large estates. As a result, the land yields are significantly higher in small farms both for total farm area and for cultivated area." Reddy (1993), using the cost of cultivation data, examined the inverse farm size-productivity relationship for five different agricultural regions of Andhra Pradesh in the late seventies. He found weakening of inverse relationship with the advent of new agricultural technology, particularly in the initial years when its spread was more limited. More importantly, the study found that the inverse farm size-productivity relationship re-established itself with the more thorough spread of new agricultural technology in the later years. A more recent study, again based on the cost of cultivation data for the year 1989-90, reported the existence of inverse relationship and found that the inverse relationship had become stronger in the agriculturally developed regions of West Bengal as compared to that in the less developed regions (Chattopadhyay and Sengupta, 1997, pp. 172-175 and 1999, pp. 1147-1148). The findings of the study have, however, been questioned by Dyer (1998, pp. A-113-A-116) on different basis like the use of questionable data and methodology, exclusion of certain crops like potato, wheat, oilseeds, etc. In sum, the effect of the new agricultural technology and other changes as mentioned above on farm size-productivity relationship continues to be a moot point.

III

THE ISSUES

A critical review of the debate since it commenced in the early sixties down to the late nineties throws up the following main issues around which the debate has centred. Firstly, most of the studies both during the first and the second phase have used pooled/aggregate data. The size-class aggregates have been compared to establish the relationship between farm size and productivity. The size-class comparisons and the use of aggregate/pooled data subsume and even conceal the interplay of numerous factors which operate in a real world situation. The group aggregation might generate spurious statistical relationship. Though the later studies did use the farm level data, the aggregation bias persisted inasmuch as the data for different villages were pooled and studied in terms of averages. Secondly, the procedure for testing the relationship using farm size as a single independent variable has been questioned. It has been pointed out that though farm size is the single most important variable surrogating income, wealth, social status, etc., of the sample households, the complex organisation of farming unit cannot be reduced to a single scale variable. In fact, the studies have shown that if an allowance is made for land quality differences, the inverse relationship loses much of its validity. Thirdly, the assumption of monotonous linear relationship captured by employing linear regression equations is not realistic. It is quite likely that the said relationship holds true in some ranges of farm size, while in others it may not exist. Fourthly, there is as yet not sufficient evidence to resolve the question whether the farm size-relationship has ceased to exist or has got weakened with more thorough spread of new agricultural technology. Fifthly, it has been pointed out that most of the studies have established the inverse relationship between farm size and value productivity per hectare. There is not much evidence to establish whether the relationship also exists between physical yields of individual crops and farm size. The confirmation of this later relationship is considered essential to establish higher efficiency on the small farms. Likewise, it is also argued that while analysing the relationship between farm size and value productivity, all major crops need to be considered. It is against this background that the present study was undertaken to examine the relationship between farm size and productivity of different crops and farm size and inputs use in different crops across different categories of farms in an agriculturally developed region of Himachal Pradesh.

IV

METHODOLOGY

Agricultural development in Himachal Pradesh has come about a long way since the early 1970s. It is evident from the significant increase in the production and productivity of foodgrains and other crops. Over the years, while the temperate zone in the state has acquired the status of 'fruit bowl' in the country, some areas in the sub-tropical zone, especially adjoining Punjab, have emerged as leading foodgrains producers. The Gagret block of Una district, the Indora block of Kangra district, Ponta valley of Sirmaur district, Nalagarh block of Solan district and Bahl valley of Mandi district have emerged as leading foodgrains producing areas in the state. Since the study was proposed to be carried out in an agriculturally developed region, the Indora block of Kangra district, which is one of the agriculturally developed regions, adjoining Punjab, was chosen purposively. Some idea of the agricultural development of the study area can be had from Table 1. The list of villages having more than 75 per cent of irrigated area was obtained from the revenue officials. A two-stage random sampling procedure was followed to select the sample households. At the first stage, ten per cent of the villages were selected randomly. Thereafter, 120 farm households were selected randomly in proportion to the number of households in each selected village. The selected households were stratified into small (less than 1.87 hectares each), medium (1.88-5 ha) and large (above 5 ha) categories on the basis of their land holdings using square root cumulative frequency method. Thus 64 households from the small category, 36 from the medium and 20 from the large category were selected for the purpose of study.

TABLE 1. AGRICULTURAL DEVELOPMENT OF THE STUDY AREA: SOME SELECTED INDICATORS

Indicators (1)	Small (2)	Medium (3)	Large (4)	All (5)
1. Area under HYVs (per cent)				
Wheat	100	100	100	100
Paddy	100	100	100	100.
2. Ratio of hired labour to family labour	0.28	0.87	1.51	0.48
3. Use of chemical fertilisers (kg/ha)				
N	80.38	75.50	72.00	76.82
P	50.03	45.69	39.01	46.89
K	30.00	25.50	22.83	26.21
4. Irrigation (per cent)	86.65	74.06	69.50	80.01
5. Tractor (No./farm)	0.06	0.39	0.75	0.28
6. Threshers (No./farm)	0.08	0.31	0.65	0.24
7. Use of chemicals (Rs./farm)	418	466	478	443
8. Farm assets ('000 Rs./farm)	133.78	207.76	330.00	188.68
9. Cropping intensity (per cent)	223	212	206	217
10. Average yield (qtl./ha)				
Wheat	32.68	31.43	30.25	31.90
Paddy	47.12	43.36	38.11	44.49

Source: Field Survey, 1997-98.

The data from the sample households were collected through personal interview method using suitably designed pre-tested schedule/questionnaire for the agricultural year 1997-98. Appropriate statistical tools were applied to accomplish the objectives of the study. The difference in the means of gross value productivity of different crops and mean inputs use between different categories of households were tested.[1] The effect of farm size on gross value productivity and inputs use was quantified by estimating the following regression equations:

$$\text{Log } y = \log a + b \log x + e \quad \ldots (1)$$

$$\text{Log } l = \log a + b \log x + e \quad \ldots (2)$$

$$\text{Log } f = \log a + b \log x + e \quad \ldots (3)$$

$$\text{Log } tbc = \log a + b \log x + e \quad \ldots (4)$$

where y is gross value productivity of different crops per hectare, x is farm size, l is per hectare labour use and is total of family and hired labour, f is the value of fertiliser per hectare, tbc is the tractor and bullock charges per hectare, b is regression coefficient and e is the error term.[2]

V

FARM SIZE AND PRODUCTIVITY

The yield rates of paddy and wheat and gross value productivities in the case of other crops (which include maize, pulses, oilseeds, berseem, etc.) and all crops are given in Table 2. The table shows that the yield rates of wheat and paddy were significantly higher on the small farms as compared to the medium and large farms. In the case of other crops and all crops taken together, the average gross value productivities were higher on the small farms but the difference between the small farms and higher farm size categories, in some cases, was not statistically significant. To examine the effect of farm size on productivity of different crops, log-linear regression analysis was done. The results of regression analysis (Table 3) confirmed the negative effect of farm size on yield rates of wheat and paddy and on the gross value productivities of other crops and all crops taken together. The regression coefficients in all three cases were negative and statistically significant. In the case of other crops, the effect of farm size was positive though insignificant. Thus the results of the study did not support the view that the spread of new agricultural technology has weakened or even reversed the inverse farm size-productivity relationship.

TABLE 2. FARM SIZE AND VALUE PRODUCTIVITY OF DIFFERENT CROPS

(Rs./ha)

Farms/ Crops	Small		Medium		Large		't' value for difference		
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Small and Medium	Small and Large	Medium and Large
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Wheat	19,594	1,318.4	18,790	1,740.9	18,058	929.0	2.62*	4.87*	1.76***
Paddy	31,873	1,681.9	30,173	3,432.2	26,010	4,433.7	3.34*	8.88*	3.06*
Others	10,074	3,810.6	11,179	2,252.7	10,664	974.7	1.82*	1.13	1.19
All	61,179	4,983.6	60,197	5,312.6	54,736	4,749.5	0.93	0.57	3.86*

Source: Field Survey, 1997-98.
* and *** Significant at 1 and 10 per cent level respectively.

TABLE 3. FARM SIZE AND PRODUCTIVITY RELATIONSHIP· RESULTS OF REGRESSION ANALYSIS

Crops (1)	b_0 (2)	b_1 (3)	r^2 (4)
Wheat	4.29	-0.048* (7.00)	0.29
Paddy	4.49	-0.091* (8.03)	0.35
Other crops	4.05	0.007 (0.75)	0.005
All crops	4.79	-0.041* (4.42)	0.14

* Significant at 1 per cent.

VI

FARM SIZE AND INPUT USE

As mentioned above, the higher productivity on the small farms has, *inter alia*, been attributed to more intensive use of inputs, particularly human labour. This section, therefore, analyses the intensity of use of three major inputs on different categories of farms. To begin with, the average use of three inputs in value terms, namely, fertilisers, human labour, and bullock and tractor on different categories of farms is given in Table 4. The table revealed that in wheat, paddy and all crops taken

TABLE 4. INPUTS USE ON DIFFERENT CATEGORIES OF FARMS

Inputs	Small		Medium		Large		't' value for difference between		
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Small and Medium	Small and Large	Medium and Large
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Inputs use in wheat				
Human labour (days/ha)	43.5	16.9	29.9	3.2	29.3	1.7	6.197*	6.575*	0.785
Fertilisers (Rs./ha)	1,203.8	213.1	1,001.6	285.5	1,031.0	147.7	0.342	3.397*	0.507
Bullock and tractor charges (Rs./ha)	2,267.6	7.6	2,249.7	30.3	2,233.8	57.9	4.536*	4.631*	0.132
					Inputs use in paddy				
Human labour (days/ha)	78.8	25.8	54.8	10.9	51.5	6.1	6.460*	7.774*	1.250
Fertilisers (Rs./ha)	1,153.5	155.7	1,142.2	433.6	939.8	242.7	0.187	4.672*	1.939***
Bullock and tractor charges (Rs./ha)	2,597.8	172.6	2,604.1	95.4	2,529.8	62.2	0.234	2.646*	0.577
					Inputs use in other crops				
Human labour (days/ha)	44.7	32.9	32.2	19.9	23.9	11.1	0.210	2.784*	1.726***
Fertilisers (Rs./ha)	699.2	260.1	770.1	157.0	720.9	66.6	1.495	0.371	1.630
Bullock and tractor charges (Rs./ha)	1,642.2	583.7	1,756.0	309.0	1,733.3	75.9	1.274	1.215	0.419
					Inputs use in all crops				
Human labour (days/ha)	131.41	61.38	114.5	21.2	107.8	20.1	16.84*	13.24*	0.160
Fertilisers (Rs./ha)	3,045.8	377.1	2,914.1	649.9	2,691.8	236.7	1.12	4.99*	1.840***
Bullock and tractor charges (Rs./ha)	6,479.3	651.7	6,607.0	324.8	6,496.7	120.9	1.30	0.20	1.822***

Source: Field Survey, 1997-98.

* and *** Significant at 1 and 10 per cent level respectively.

together, the small farms used significantly higher amount of human labour as compared to their large counterparts. Not only that, they also spent higher amount on fertilisers and tractor and bullock labour, though the difference between the use of fertiliser on the small and high farm size categories was not significant in some cases, particularly in the case of other crops. The difference in the inputs use on different categories of farms in the case of other crops was not significant in most of the cases. The inverse relationship between farm size and inputs use was also supported by the results of regression analysis. Table 5 showed significant negative effect of farm size on the use of inputs, particularly human labour and fertiliser; the regression coefficients were negative and statistically significant. The effect of farm size on the use of bullocks and tractor was negative and significant in the case of wheat and other crops. In the remaining two cases, the effect of farm size on the use of bullocks and tractor was negative but insignificant in paddy production and positive though again insignificant in all crops taken together.

TABLE 5. FARM SIZE AND INPUTS USE: RESULTS OF REGRESSION ANALYSIS

Inputs/ crops	Wheat			Paddy			Other crops			All crops		
	b_0	b_1	r^2	b_0	b_1	r^2	b_0	b_1	r^2	b_0	b_1	r^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Human labour	1.59	-0.25* (10.78)	0.50	1.83	-0.26* (13.02)	0.59	1.50	-0.27* (6.12)	0.25	2.27	-0.25* (10.81)	0.49
Fertiliser	3.05	-0.12* (5.70)	0.21	3.04	-0.11* (3.73)	0.10	2.88	-0.009 (1.03)	0.009	3.50	-0.06* (3.68)	0.10
Bullock and tractor	3.35	-0.006* (4.81)	0.16	3.41	-0.008 (1.13)	0.01	3.25	-0.02* (6.29)	0.26	3.80	0.02 (1.76)	0.03

* Significant at 1per cent level.

VII

CONCLUSIONS

In sum, micro evidence from an agriculturally developed region, where new agricultural technology had permeated quite thoroughly, showed the existence of inverse farm size-productivity relationship in the production of wheat, paddy and also when all the crops were taken together. In the case of other crops, which include maize, oilseeds, pulses, berseem, etc., the negative relationship was not so robust and, in some cases, it was even positive though statistically insignificant. The results further showed that the small farms used higher amount of human labour and fertiliser as compared to higher farm size categories. The regression results also confirmed the inverse relationship between farm size and inputs use; the regression coefficients in most of the cases, except in the case of other crops, were negative and statistically significant. In broader terms, the results of the study do not support the view that the inverse farm size-productivity relationship has disappeared with the spread of new agricultural technology. On the contrary, negative relationship appeared to have become stronger. The results assume significance as these have been obtained after controlling the effect of irrigation facilities, and, to some extent, soil quality, which have been traditionally held responsible for higher efficiency on small farms.

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NOTES

1. To test the difference in the mean value productivity and inputs use of different crops and between households belonging to different categories, the following procedure was adopted.

To begin with, $H_0 = \sigma_1^2 = \sigma_2^2$ was tested by applying 'F' test.

$$F\ cal = \frac{s_1^2}{s_2^2} \quad (S_1^2 > S_2^2) \sim (n_1-1, n_2-1)$$ degrees of freedom. Further in those cases where H_0 is rejected, Cochran and Cox test

$$|t_{cal}| = \frac{|x_1 - x_2|}{\sqrt{s_1^2/n_1 + s_2^2/n_2}}$$

was applied. In the remaining cases, Fisher's 't' test

$$|t_{cal}| = \frac{|x_1 - x_2|}{\sqrt{s^2(1/n_1 + 1/n_2)}} \sim (n_1 + n_2 - 1)$$ degrees of freedom was applied.

$$s^2 = \frac{(n_1-1)\, s_1^2 + (n_2-1)\, s_2^2}{n_1 + n_2 - 1}$$

where s_1^2 = variance of the first group; s_2^2 = variance of the second group; s^2 = combined variance and n = number of observations.

2. In the case of wheat and paddy, the yield rates, labour use, fertiliser use and tractor and bullock charges were computed on the basis of per hectare of net sown area. In the case of other crops and all crops these were computed on the basis of per hectare of gross operated area.

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