FARM SIZE AND PRODUCTIVITY RELATIONSHIP (AN EMPIRICAL INVESTIGATION BASED ON COST OF CULTIVATION DATA)

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Introduction:

The debate of farm size and productivity relationship is one of the most important debates in the Indian agricultural economic literature and continues to attract the attention of the scholars even today. The controversy is important for it provides information on the existence of economies of scale in agriculture and on the choice of the optimal farm size. The genesis of the problem can be traced to the chronic food shortages, which India has been facing ever since the separation of Burma. The situation, aggravated by the Second World War set in motion thinking about the need for a policy for agricultural development. Though some programs had been launched even earlier, serious discussions started in the post-independence era only. The discussion relating to the strategy for agricultural development brought into prominence two schools of thought-one based on technological approach and the other on institutional reforms. The latter school addressed itself, among other things, to the question of farm organization. The major objective of this approach was to effect a re-organization of the units of production (i.e., farms) to achieve high level of productivity and efficiency through appropriate land reforms. Since then began the investigations for providing efficient conditions for agricultural production.

There fore, in this study, an attempt is made to examine the nature of the relationship between farm size and productivity using new sets of data, especially the primary data samples collected from Cost of Cultivation studies for the state of Andhra Pradesh.

The data used in this present study is for the normal year, 1994-95 (a post economic reform period). It represented a favorable year in post-liberalization phase- a period of strong recovery

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in agriculture following a run of poor monsoons, which retarded agricultural growth. Compared to the previous years, the country has had excellent rains and as a consequence food grain production had a record output up to the level of 191 million tones (Agricultural Statistics, 1994-95).

Before we proceed with the empirical verification of these relationships with the farm level data, a brief description of the rough theoretical framework is presented and the nature of hypothesis being tested is discussed in the next section[1].

Section II

Farm size and Productivity:

There are three groups on the nature of findings relating to farm size and productivity that can be identified in economic literature.

The first group started with the publication of Sen's (1962) paper in economic weekly. The investigations were mostly based on farm management survey reports and cost of cultivation data, which supported the existence of an inverse farm size–productivity relationship [Sen (1962); Bhagawati and Chakravarthy (1969); Bharadwaj (1974); Reddy (1993), etc]. The second group of the debate (studies done mostly in 1980s) is associated with conflicting results, they used different data sets or analyzed the same Farm Management Survey Reports with different statistical tool by incorporating some new modifications, argued with the new agricultural technology, the inverse relationship either weakened or even has got reversed. They found positive relation of farm size and productivity [Chadha (1978); Rudra and Sen (1980); Bagai and Soni (1983), etc]. Contrary to both the groups, there are few studies (third group) that found no relationship between farm size and productivity [Rao (1967), etc]. Further more, there is not sufficient evidence to resolve the question whether farm size and productivity relationship has ceased to exist or has got weakened with the spread of new agricultural technology and reform/liberalization policies. From the empirical evidences, it is very often observed; controversies arise due to definition of the terms concerned, methodology of data analysis concerned, etc. Several reasons have been put forward for the existing relationships.

[1] This study follows the framework applied by Bharadwaj (1974) to the Farm management survey data from India.

In general, the literature evidences show though it is not a universal phenomenon, output per unit of available land, labour and input intensity in production are inversely related to farm size, even when compensating for factors such as land quality and availability of irrigation, etc. In other words, it is said small farms tend to achieve higher production relative to their available land, and employ relatively more labour and less capital, than large farmers. The economic forces causing this divergence include the intensive use of family labour on small farms in a surplus labour context in which outside wage employment is scarce, and the fact that large landholders often impute a low price to the use of land resources (in part because they hold land as a portfolio asset hedge against inflation). Imperfect capital markets that tend to make the price of capital equipment lower for large farms than for small reinforce these tendencies. Compared with agrarian structures based on large farms sizes, therefore, small-farms structures hold out the promise of greater productivity.

Section III

Hypotheses:

The studies in the literature have shown small farms tend to achieve higher production relative to their available land, and employ relatively more labour and less capital, than large farmers. That is, there is existence of the inverse relationship of farm size and productivity. Therefore, to examine the current status (whether the introduction of economic reforms has weakened or strengthened the inverse relationship), we too have formulated similar hypotheses.

In this study, we shall test following hypothesis using cost of cultivation data.

1. Farm Size and Land Productivity are inversely related. Smaller farms use family labour and opportunity cost of family labour is less in a situation of wide spread unemployment. Probability of getting employment will be less than one and therefore opportunity cost of family labour will be less than prevailing market wage. Higher labour use per unit of land on smaller farms is major factor that causes inverse relationship between farm size and productivity.

2. Farm Size and Labour Use per unit of land are inversely related. As mentioned earlier, opportunity cost of family labour is less than prevailing market wage; smaller farms will apply more labour because they largely depend on family labour for labour supply.

3. Farm Size and Animal Labour per unit of land are inversely related. Human labour and bullock labour are complementary. Since farm size and labour use per unit of land are inversely related, it is also expected that farm size and animal labour per unit of land will also be inversely related.

4. Farm Size and Cropping Intensity are inversely related. Smaller farms cultivate land more intensively through application of cheap family labour and therefore one expects negative relationship between farm size and cropping intensity. It is expected; the Cropping Intensity has a positive relationship with Proportion of Irrigated Area.

5. Large farms are expected to have better command over material inputs and tractor use because of easy accessibility and cheaper credit. Small farms cultivate land more intensively and produce more output per unit of land. It is difficult to predict the nature of the relationship with the farm size. Some of the studies have found negative relationship between material inputs and farm size.

Section IV

Methodology:

The main objective of present study is to examine the effect of farm size on productivity, labour use, cropping intensity, proportion of irrigated area, and other ancilliary inputs. We use cost of cultivation data of Andhra Pradesh to examine these hypotheses. The, information on 600 farm households, distributed among 120 villages from 60 tehsils/clusters, belonging to five zones or regions are collected under cost of cultivation scheme, Hyderabad.

As per Cost of Cultivation studies, 'FARMSIZE' is defined as 'Acreage or Physical Area of the cultivator'. Average farm size in group one is 0 to 1 hectares; farm size group two is 1 to 2 hectares; farm size group three is 2 to 4 hectares; farm size group four is 4 to 6 hectares; and farm size group five is 6 hectares and above.

In the following sections, we proceed with the empirical investigation of the above said hypotheses – 'the relationship between farm size and productivity' with the help of both linear and log-linear equations. The basic forms that have been tried in the literature are linear and log-linear. Here, we tried both linear and log-linear functions, in which log-linear estimations are robust on many aspects in the analysis. As far as proportion of irrigated area and farm size are concerned, we found linear function to be a satisfactory fit (In present sample we find that some farmers do not irrigate land. In order to examine the influence of proportion of irrigated area, were there is 0 value, estimation with log-linear function becomes invalid. Therefore, linear regression function is the most appropriate method for examining this kind of relationship) Estimations are done with and without regional (tehsil and zones) dummies and seasonal dummies for regional and seasonal factors impact on the nature of relationship[2].

The functional form used in the linear analysis is:

1. $Y = \alpha + \beta\ FS$.
2. $Y = \alpha + \beta\ FS + \beta 1\ \Sigma\ DMY$.

The functional form used in the log-linear analysis is:

3. $Log\ Y = Log\ \alpha + \beta\ Log\ FS$.
4. $Log\ Y = Log\ \alpha + \beta\ Log\ FS + \beta 1\ \Sigma\ DMY$.

Where 'Y' is dependent variable; 'FS' is farm size in hectares; and 'DMY' is the dummy variable (regional and seasonal factors). α and β are constant terms.

In present sample we find that there are few farmers who do not adopt HYV, nor use tractors and irrigate land. On that basis, in order to examine the influence of farm size on use of tractors, irrigation, and HYV adoption, the regression analysis using ordinary least square method or correlation method was found to be not useful. It is therefore necessary to use alternate statistical

[2] In examining the relationship between farm size and productivity, from the farm–level data the technique of analysis pose problems due to different sampling procedures adopted for the study. For example, pooling of data from different villages can change the relationship in either direction depending upon characteristics of the villages [Berry and Cline (1979); Chattopadhyay and Rudra (1976); etc]. This would mean that even if we use disaggregated data but pool them from different villages, then the risk of statistical bias is not ruled out. Therefore, in regression analysis this *problem* can be *overcome* by using *dummy variable* methods [Gujarati, Damodar (1988)].

method to examine these relationships. Logistic regression is the most appropriate method for examining these kinds of relationships after converting dependent variable in dichotomous form.

If the dependent variable has only two possible values, for example 0 and 1, methods such as multiple regressions become invalid because predicted values of y would not be constrained to lie between 0 and 1. In logistic regression the dependent variable is the probability that an event will occur, hence y is constrained between 0 and 1. Logistic regression has the additional advantage that all of the predictors can be binary, a mixture of categorical and continuous or just continuous.

The logistic model is written as:

Log(p/1-p) = a +b log x ; where p = 1/[1+e-a x-b]

The left side of the equation is known, as the logit of dependent variable is a transformation of the probability.

The logistic equation can be rearranged into a linear form by converting the probability into a log odds or logit.

Log [Prob(event)/Prob (no event)] = b0+b1x1=b2x2+….bpxp

This produces a relationship similar to that in multiple regression except that now each one-unit change in a predictor is associated with a change in log odds rather than the response directly.

There is a non-linear relationship between p and its logit. In the mid range of p there is a linear relationship, but as p approaches the 0 or 1 extreme the relationship becomes non-linear with increasingly larger changes in logit for the same change in p.

Section V

Empirical Verification:

Land use

The most important of the issues debated in the economic literature was the question of relationship between farm size and productivity per unit of land. A series of studies, based on different data sources in various parts of India claimed to find an inverse relationship between farm size and productivity; the larger the farm size, is the smaller amount produced per unit of land. Although the results varied in comparability and significance, on the whole, the statistical evidence favored the negative relationship hypothesis[3]

Farm size and value of production: We examined the relationship between farm size and value of production (total output is defined as gross value of production) with totally eight equations in the estimation. The first four sets of equations were estimated taking log of value of production per unit of gross cropped area (GCA) as a dependent variable. The other four sets of equations were estimated taking log of value of production per unit of net cropped area (NSA) as a dependent variable. Tehsil, Zonal and seasonal dummies were included in the equations to see the impact of regional and seasonal factors on the nature of the relationship.

The findings of the study are very interesting (Table 1). When productivity (value of production / GCA) is regressed against farm size, we did observe positive relationship. At best there is a mild evidence of positive relationship between productivity and farm size, even when controlled through tehsil dummies (impact of regional factors). The observed coefficient of farm size is 0.131.

This result is in contradiction to the hypothesis formulated in the beginning about the nature of relationship between farm size and productivity. We expected negative relationship and found positive relationship. Some of the studies do find similar results. [Hanumantha Rao (1975); Chadha (1978); Deolikar (1981); Roy (1981) etc].

On this basis, it was too early to consider this result as an evidence against negative relationship between productivity and farm size. When productivity is defined as a ratio of total value of production and gross cropped area, impact of multiple cropping is eliminated. If smaller farms are producing more compared to large farms through cultivating land more intensively, it will not be captured here.

It was therefore necessary to examine what happens to the nature of relationship, when productivity is defined as a ratio of total value of production and net sown area. One would expect a negative relationship between productivity and farm size, if small farms were cultivating their land more intensively by cultivating their land more than once.

Interestingly, we do find an evidence of negative relationship between productivity and farm size, when productivity is defined as value of production per unit of net sown area. The coefficient of farm size is –0.24. The negative relationship survives even after inclusion of regional and seasonal dummies [There is a higher and statistically significant negative coefficient (-0.313) when controlled for seasonal dummies]. Inverse relationship between farm size and productivity survives, even after introduction of economic reforms.

Our results are in conformity with the results of Reddy (1993), as he also used the Cost of Cultivation data for the state of Andhra Pradesh. He found substantial evidence of the existence of an inverse relationship between farm size and output in quantity as well as in value terms for both local and HYV paddy (the study conducted is for 1971-73 and 1976-78). The interesting point is that he found the negative relation for individual crop and we found it for total production.

Higher amount of labour use, cropping intensity, the exogenous land quality factors like soil fertility (superior quality of land under smaller holdings), endogenous land improvement factors - seeds, fertilizers, level of mechanization, irrigation etc, and the institutional factors such as tenancy, share-croppers, etc, appeared to be some of the important factors in determining the inverse relationship of farm size and productivity.

In our analysis, the important explanation concerning differential of the inverse relationship between farm size and productivity is reflected in the use of family labour across different farm size groups (This was identified when ANOVA test was done as a separate study). It is based upon the assumption of the 'low opportunity cost' of family labour and the resultant variations in the amount of family labour used per acre on different size classes of farms. Many research workers empirically found this[3].

[3] Such conclusions can be observed from Sen (1962); Bharadwaj (1974); Bardhan (1973); Mehra (1976); Chattopadhyay and Rudra (1976), etc.

Some economists like Prannoy Roy, try to explain this inverse relation between farm size and productivity by saying that this extra labour on small farms is used for increasing the *cropping intensity* of the small farms. That is, more of the area of small farms is used for multiple cropping than that of large farms due to availability of more labour. Prannoy Roy, in fact, points out that if we look only at *the yield per acre* of a given crop on small and large farm, we find *no difference* in it on these farms. But when we look at the *gross value of output of an acre* of small farm as well as that on a large farm, we find that an acre of small farm gives greater value of output because of higher cropping intensity (due to multiple cropping). Berry and Cline fully support Prannoy Roy in this regard.

There fore, it is our interest to investigate the nature of the relationship of cropping intensity with farm size. It will throw more light on the negative relationship between farm size and productivity.

Farm size and cropping intensity: Cropping Intensity' is defined/measured as a 'ratio of gross cropped area to land holding in percentages'.

One would expect a negative relationship between farm size and cropping intensity. This has also been found by many scholars (the empirical evidence showed a tendency of cropping intensity to vary inversely with the farm size, irrespective of level of irrigation and fragmentation of land holdings. That is, small farmers cultivate more number of crops compared to large farmers in various parts of India).[4]

As such, we tried to estimate the relationship between farm size and cropping intensity with different sets of equations in the estimation - taking log of cropping intensity as a dependent variable (Table 2).

The first equation reports the nature of relationship without dummies, where as tehsil, zonal and seasonal dummies were included in the equations to check the nature of relationship when controlled for regional and seasonal factors.

As expected we find the inverse relationship between the intensity of cropping and the size of holding or farm size. The coefficient observed is –0.205 (when the estimation is done without controlling for regional and seasonal factors). Even after inclusion of regional and seasonal dummies in the equation, the negative relationship between farm size and cropping intensity survives.

The explanations put forward by us for the inverse relationship between cropping intensity and farm size, is due to the labour intensity differences (that is, more intensive use of family labour and total labour used). These findings are statistically significant and robust.[5] This implies that the opportunity cost of family labour is less than the market wage rate due to prevalence of mass

[4] The possible explanations given for such findings in the literature are: small farms tend to use more family labour compared to large farms, soil characteristics, more intensive use of inputs (HYV innovations), higher proportion of irrigated area, and the cropping pattern which is of short duration varieties, etc. [Sen (1962); Bardhan (1973); Dasgupta (1977); Reddy (1993), etc]

[5] It has to be noted here, our finding coincides the arguments suggested by Sen (1962); Bhagawati and Chakravarthy (1964) and Bharadwaj (1974).

unemployment and surplus labour in agriculture, as a consequence small farms will employ family labour more profusely.

Cropping intensity and proportion of irrigated area: Irrigation plays an important role in crop cultivation. Given the limited opportunities for bringing additional acreage of fallow lands under cultivation, it is generally observed, irrigation is capable of playing a useful 'land-augmenting' role. The availability of water all the year round through irrigation networks, in addition to reducing dependence on vagaries of nature, facilitates the increase of labour input via an increase in cropping intensity. It improves the relative economic position of the farming community and generates dynamism of growth and productivity (this however, depends on the type or source of irrigation). At an out set, the proportion of irrigated area has the potential for higher cropping intensity and an increase in total value of production [Vaidyanathan (1987); Rao, S.K. (1979); etc]. There fore, there is a close association of farm size (a principal production unit), cropping intensity, and the proportion of irrigated area in increasing the crop output.

As observed from the findings, the intensity of cropping is negatively related to proportion of irrigated area, which is statistically significant (Table 3). The coefficient observed is –0.545 when the estimation is done without controlling for regional and seasonal factors. A similar observation (a negative relationship) survives even after inclusion of regional and seasonal dummies in the estimation. The coefficients are statistically significant. This implies cropping intensity is low and proportion of irrigated area is higher on larger farms, compared to smaller farms and vice versa. This tendency (strong evidence) shows that proportion of irrigated area has nothing to do with the intensity of cropping.

Few studies relate the effect of irrigation on cropping intensity to be essentially depending on the crop-mix, apart from other factors. [Dasgupta (1977); Pandya (1996), etc]

Most of the empirical studies in the literature reveal a similar observation of significant negative relationship of cropping intensity and proportion of irrigated area, and attributed such findings is due partly because of the changing cropping pattern and partly due to the type of irrigation (statistical defects) treated on raising the output. For example, the area irrigated by Wells has higher cropping intensity and higher yields than the tank-fed irrigated areas. Farmers with higher cropping intensity has better control over well irrigation [Bharadwaj (1974); Vaidyanathan (1987); Nadkarni, et.al (1979); Sawant (1975)[6] etc].

Another possible explanations put forwarded are: that the big farmer (supplying a sizeable part of the local market) exercises his monopoly power to restrict output, that is, he may limit the production of certain crops (may be in favour of long-duration crops) in the hope of a better price; or some times, the big farmers may not find multiple cropping profitable even though it is highly irrigated land in view of their high reliance on the use of hired labour. Where as, on the other hand, small farmer cultivates land solely or mainly with his own family labour whose wage rate is practically zero. Small farmer has the possibility of raising two to three crops on his land, while the big farmer would leave his land idle after the first crop. This is contended that the big farmer has a multiplicity of channels of profit making. [Ranjit Sau (1976);Ahmed (1981), etc].

Labor use

The analysis of factors influencing labour use is very important for formulating appropriate policy for employment generation in agriculture. Farm size is considered to be important determinant of employment in agriculture. In fact, the existence of negative relationship between productivity and farm size is attributed to negative relationship between labour use per unit of land area and farm size. Scholars have provided different explanations of why smaller farms use more labour compared to large farms[7]. Over a period of time, due to institutional, technological and policy changes some scholars have raised the doubts about the survival of the negative relationship between productivity and farm size in post green revolution period [Chadha (1978); Papola (1979); Vaidyanathan (1986); Bhalla (1993); etc].

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6 On the aspect of defects in the compilation of irrigation statistics, Sawant (1975) argued that '..the calculation of cropping intensities separately for the irrigated and un-irrigated area on the basis of presently available land utilization statistics is likely to give misleading conclusions which may vitally differ from reality. The extent of bias depend upon the extent of mixed category of land such as rain fed-irrigated or irrigated-rain fed' (p.51).

7 There are mainly four factors in the literature to which the observe differences of inverse relationship in labour use by size can be attributed. First, small farms use mainly family labour whose opportunity cost is less than the prevailing market wage; therefore smaller farms tend to use labour more intensively. [Sen (1962); Khusro (1964); Bharadwaj (1974); Mehra (1976); etc]. Second, smaller farm size groups are said to have better quality of land and the proportion of irrigated area is higher among smaller holdings; therefore it is possible to cultivate land more intensively with more labour use [Bardhan, (1973)]. However, few studies had a conflicting result and had differences of opinion on this factor. [Ahmed (1981); Bhalla (1979), etc]. Third, the proportion of area under labour intensive crops is higher among smaller holdings and therefore the amount of labour use per unit of land is higher [Ahmed (1981); Booth and Sundrum (1985)]. Fourth, the institutional factor- that is, tenancy acts as disincentive to the use of more labour along with other factors and as the proportion of area leased increases with the size of holding, it results in an inverse relationship between labour use and farm size. [Khusro, (1969)].

In this section we examine the relationship between farm size and total labour hours with different sets of equations in the estimation. We expect a negative relationship between farm size and total labour hours [8]. The equations were first estimated taking log of total labour hours per unit of gross cropped area (GCA) as a dependent variable, and separate equations were estimated taking log of total labour hours per unit of net cropped area (NSA) as a dependent variable. Tehsil, Zonal and seasonal dummies were included in the equations to see the impact of regional and seasonal factors on the nature of the relationship (Table 4).

The results based on regression analysis suggest that irrespective of how labour intensity, is defined (per unit of net sown area or per unit of gross cropped area) we find negative relationship between farm size and labour use, which is as expected in the hypothesis. The coefficient is –9.45 and –0.226 for total labour hours/GCA and total labour hours/NSA respectively. Inclusion of regional and seasonal dummies reduces the size of the coefficient of farm size (land holding) but not the change in the direction of the relationship. The coefficients remain statistically significant with improved R^{-2}. This means that farm size plays a dominant role in determining the total labour hours.

It is important to note, from the analysis, we observe the negative relationship is much stronger and clear when labour intensity is defined as total labour used per unit of net sown area (a higher *R bar square*). The relationship becomes weaker when the labour intensity is defined as the total labour use per unit of gross cropped area.

There is nothing surprising in these findings, particularly when cropping intensity is also found to have inverse relation with farm size. In case where smaller farms have higher cropping intensity compared to large farms and using more labour, it is quite natural that labour intensity when defined as total labour used per unit of gross cropped area, effect of cropping intensity on labour use will be eliminated. There are other points that should be carefully noted here. Negative relationship between farm size and labour intensity is associated with negative relationship between farm size and land productivity (only with value of production/net sown area). But the relationship disappears and positive relationship emerges when land productivity is defined as the total value of production per unit of gross cropped area. This means that productivity on large farms is higher compared to smaller farms.

8 Total labour hours is calculated as the total of family labour hours, casual labour hours, attached labour hours and exchange labour hours irrespective of labourer's age and sex in consideration.

On the whole, our analysis supports the inverse relationship hypothesis of labour use with size of holding.

In most of the studies, proportion of irrigated area, intensive use of fertilizers, tractor power in preparatory tillage, differences in plot size, and cropping pattern which are of labour-intensive are identified as some of the important factors influencing the labour use of cultivated area. [Sen (1962); Bharadwaj (1974); Chadha and Sharma (1982); Reddy (1993), Ninan (1984), Pandya (1996) etc].

Our data analysis as far as irrigation is concerned, reveals a significant inverse association of proportion of irrigated area and total labour hours[9]. This implies may be the large farmers who possess higher proportion of irrigated area prefer for long-duration cropping pattern, which is of labour-saving technique.

Another explanation put forward by us for the inverse relation between proportion of irrigated area and labour use is the mode of labour hour used. That is to say, less irrigated farms employ exclusively family labour (will use their own family labour hour more intensively) than farms based exclusively on hired labour[10.]

Labour Productivity**:** **'**Labour productivity' is defined in the analysis as 'the ratio of total value of production (yield) to total labour hours'. The study on labour productivity helps us to understand the economic condition of the agricultural labour, that is, poor condition of agricultural labour can partly be attributed to low productivity of labour (the reason being wages are lower in agricultural sector when compared to other sectors).

We found a positive relationship of farm size and value of production of gross cropped area. Therefore, one would expect a positive relationship between farm size and labour productivity.

We tried the relationship between farm size and labour productivity with totally different sets of equations with and without regional and seasonal factors in the estimation - taking log of labour producitivity as a dependent variable (Table 5).

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9 For example, we find total labour use per net sown area is on the average 2080 hours in small farm size and 1265 hours in large farm size groups. Whereas, the proportion of irrigated area on small size group and large size group is 0.69 and 0.94 respectively.(This exercise was tried with parametric and non-parametric test separately)

10 .For example, as per parametric and non-parametric analysis, we find in small farm size groups the proportion of irrigated area is 69 percent and the corresponding family labour hours spent is 41 percent. Whereas, in large farm size group, only 18 percent of family labour hours is spent in 94 percent of proportion of irrigated area.

The labour productivity is found to be positive with size of holding or farm size. The coefficient observed is 0.170. When controlled for regional and seasonal factors, the positive relationship between farm size and labour productivity survives. It implies that regional or seasonal factors also influence the variation in labour productivity.

Animal use

In the economy of crop production animal labour plays an important role. Use of animal labour permits a farm operator to increase production to a higher level (for example, task operations such as hauling, ploughing, threshing, etc require a traditionally furnished draft power and as such animal/bullocks labour). In fact, animal labour is a multipurpose good for a farmer. Apart from crop production activity alone, it is also useful for transport operations, supply of manure to the farm and when used in breeding, it is a reproductive capital asset too[11]. Therefore, animal labour is expected to be positively associated with quantity of human labour to increase crop production.

In our analysis, since quantity of human labour is inversely related with farm size, one may also expect a negative relationship between farm size and animal labour use. We examine the relationship between farm size and animal labour hours with different sets of equations in the estimation (Table 6). The equations were estimated taking log of animal labour hours per unit of gross cropped area (GCA) as a dependent variable, as well as a separate sets of equations were estimated taking log of animal labour hours per unit of net cropped area (NSA) as a dependent variable. Tehsil, Zonal and seasonal dummies were included in the equations to see the impact of regional and seasonal factors on the nature of the relationship with animal use.

The findings of the study show irrespective of how animal labour intensity, is defined (per unit of net sown area or per unit of gross cropped area) we find negative relationship between farm size and animal labour use. The coefficients of animal hours per unit of net sown area are higher when compared with gross cropped area measurement. It is –0.511 and –0.628 (without regional and seasonal factors) for animal labour hours/GCA and animal labour hours/NSA respectively.

11 It is important to note, when cost issue is taken into consideration, as far as possible the cultivator would like to economize on animal labour, based on the seasonality of employment and higher maintenance cost (in supplying fodder and providing medication, etc).

Inclusion of regional and seasonal dummies reduced the size of the coefficient of farm size (land holding) but not the change in the direction of the relationship. All the coefficients are statistically significant. This implies that farm size plays an important role in determining the animal labour hours.

The possible explanation that shows, given the higher availability of animal labour, small farm size groups try to utilize them as fully as possible. There is nothing surprising in these findings, when cropping intensity and the number of parcels (we observe this when we refer for plot size area in hectares) is also found to have a systematic inverse pattern with farm size[12.]

There fore, it is our interest to investigate the nature of the relationship of complementary between animal labour hours and human labour hours with farm size. It will throw more light on the negative relationship between farm size and animal labour hours.

We tried to examine the nature of relationship between ratio between animal and human labour hours and farm size with different sets of equations in the estimation - taking log of ratio of animal and human labour hours as a dependent variable. We expected a negative relationship of the ratio of animals to human labour with farm size.

As per the findings, the coefficients of the relationship of farm size with ratio of animal labour hours to human labour hours were statistically insignificant to give any meaningful inferences. However, there appears to be some complementary (in a weak form) between animal and human labour (Table 7). Both are used more on smaller farm size groups as compared to the larger ones. The explanation for the relatively greater use of animal labour hours may perhaps be related to the fact that smaller farm size groups have higher intensity of cropping involving both animal labour power and human labour hours in preparatory tillage till harvesting and transport operations etc.

Our results support the analysis of Bharadwaj (1974), who estimated with farm management level data. As per her argument, "It is because of higher cropping intensity and complimentarily between human labour, the use of animal labour hours is found higher among smaller farms".

12 To cite, as per parametric test (which is done as additional test) the mean results show farms in the smallest size group use 49 hours of animal labour, while farms in the largest group use only 10 hours of animal labour when measured per unit of net sown area. Large farmers because, of lower croppig intensity, and seasonality in specific crop operations use very less of animal labour hours.

Material Inputs use

(Seeds and Fertilizers)

In the study on farm size – productivity relationship, the basic and critical factor affecting the productivity of land along with the farm size is seeds and fertilizers. The better quality seeds and fertilizers with the help of timely irrigational facilities not only increases the crop output, but also favors for multiple cropping and brings in new area under cultivation.

Generally, large farms are expected to have better command over material inputs because of easy accessibility and cheaper credit. Small farms cultivate land more intensively and produce more output per unit of land. It is difficult to predict the nature of the relationship with the farm size. In fact, some of the studies have found negative relationship between material inputs and farm size [Hanumantha Rao, (1975); Ahmed (1981); Chinna Rao (1989); Reddy (1993); Singh (1999); etc]. The existence of negative relationship between productivity and farm size is attributed to negative relationship between input use per unit of land area and farm size. With the introduction of High Yield Variety innovations the farming communities are said to have responded the maximum benefit from the material inputs (such as seeds and fertilizers, etc) in raising the value of production[13].

We expect a negative relationship between farm size and with material inputs because of the negative relationship observed between farm size and cropping intensity as well as farm size and labour intensity.

The methodology undertaken for studying quantitative/material inputs like seeds and fertilizers (NPK-Nitrogen, Phosphate, Potassium) are the value measurement rather than the quantity measurement. Regression Analysis was carried out separately with and without regional and seasonal factors for between total value of seeds and farms size as well as between NPK value and farm size (Table 8).

The observations of the study relating material input use is carried out in two sub-sections:

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13 Such evidence we find in Raymond (1974); Hanumantha Rao (1975); Parikh and Trivedi (1982); Ganesh (1986); Reddy (1993); etc.
In fact, few studies also find the negative shades of extensive material input use (especially improper use of fertilizers) on the relationship with productivity of land. Such studies relate poor management, inappropriate seed variety, lack of plant protection measures, low response of agricultural extension work, etc as the hindrance factors in increasing the fertilizer efficiency use [Parikh and Mosley (1982); Srivastava (1983); Vidyasagar (1995); etc]. Considering the limitations and scope of our study we have not given importance to this aspect.

Farm size and value of seeds: The findings of the study show, when value of seeds/GCA is regressed against farm size, we do observe a significant positive relationship. The coefficient of farm size is 0.339. Even after inclusion of regional and seasonal dummies in the equation, the negative relationship between farm size and value of seeds survives. The coefficient of farm size is positive and statistically significant. It implies that regional or geographical factors also influence the variation in value of seeds.

This result is in contradiction to the hypothesis formulated in the beginning about the nature of relationship between farm size and value of seeds. We expected negative relationship and found positive relationship. Most of the farms cultivate land more intensively using more seeds and as well as cultivate land more than once (the multiple cropping). If this factor were considered, one would expect a negative relationship between farm size and seeds value measured per unit of net sown area (seeds value/NSA)[14]. The observed coefficients as per the estimations do not show negative relationship of farm size and seeds value; in fact it has a positive coefficient and is statistically insignificant. Our samples show, the values of seeds are invariant to farm size groups. Therefore, in the last section of this study we have attempted to find the nature of relationship of HYV adoption and farm size.

Farm size and Value of NPK (chemical fertilizer): The findings of the study are very interesting. When chemical fertilizer (value of NPK / GCA) is regressed against farm size, we do observe positive relationship (coefficient of farm size is 0.125). There is a mild evidence of positive relationship between value of NPK and farm size. When impact of regional factors is controlled through tehsil dummies, the relationship becomes clearer. The observed coefficient of farm size is 0.202.

At this point, it is too early to consider this result as an evidence against negative relationship between value of NPK and farm size. When value of NPK per net sown area, the impact of cropping intensity shows a change in the relationship.

As per the findings, when value of NPK per net sown area (value of NPK / NSA) is regressed against farm size, we do observe negative relationship. The coefficient of farm size is -0.162 and -0.282, when controlled for regional and seasonal factors respectively.

14 This is expected because; in the previous sections we have shown inverse relation of farm size and cropping intensity.

As far as our analysis is concerned, we find mixed results. The plausible explanations put forward by us for the positive relationship between value of seeds as well as value of NPK (fertilizers) per gross cropped area and farm size are due to the positive relation of land productivity, that is, value of production per unit of gross cropped area, and proportion of irrigated area. It is therefore said; large farmers concentrated more on high value seeds, which require adequate water facilities to increase the land productivity. On the other end, value of NPK use (per net sown area) increases in favour of small farm size groups. This is as expected and is in conformity when there is an inverse relationship of cropping intensity and farm size associated with the labour intensity.

On the whole, it is difficult to predict the nature of relationship of material inputs (both seeds and fertilizers) with farm size.

Expenditure per hectare

In the study of farm size – productivity relationship as well as production conditions or production relations in crop activity, there are many more factors, which involves in the discussion, such as irrigation charges, depreciation and interest charges, profitability, etc. As per the data samples, we have concentrated only the selected variables as a part of production relations.

Therefore, on that basis, it is of our interest to investigate the nature of the relationship of overall total expenditure per hectare with size of holding[15]. It is assumed the negative relationship of cropping intensity and farm size will have its reflection on total expenditure per hectare, and as such it is expected total expenditure per hectare to also have a systematic negative relationship with farm size. It will throw more light on the negative relationship between farm size and productivity.

As such, we tried the relationship between farm size and total expenditure per hectare with different sets of equations with and without regional and seasonal dummies in the estimation - taking log of total expenditure per hectare as a dependent variable (Table 9).

15 . In the analysis, total expenditure is calculated as: The summation of total land rent paid + payments given to attached farm servants, casual labour hours, animal labour hours, machine hours and total inputs (material inputs) value. It is to be noted, we have not included the imputed cost of owned input (family labour) because it distorts the cost calculation.

As expected we found the inverse relationship between the total expenditure per hectare and the size of holding or farm size. The coefficient observed is –0.161 (when the estimation is done without controlling for regional and seasonal factors. Even after inclusion of regional and seasonal dummies in the equation, the negative relationship between farm size and total expenditure per hectare survives.

The possible explanations put forward by us for the inverse relationship between total expenditure per hectare and farm size is due to the inverse pattern of plot size (that is, based on parametric and non-parametric test done as per the statistics available to confirm, we found more number of fragments in the smaller farm size groups), cropping intensity and labour intensity (both human and animal labour) with farm size groups. Further, we also observe an inverse relationship of total value of seeds and fertilizer use per net sown area with farm size.

Farm size and other factors

In this section we examine the nature of relationship of man - made improvements with farm size. They are tractors use, irrigation (we have considered proportion of irrigated area in the analysis in order to avoid statistical problems with different types of irrigational process), and High Yield Variety adoption.

It is common experience in India that all the farmers do not use tractors or adopt High Yield Varieties. Similarly all the farmers do not irrigate land. In present sample also we find some farmers do not use tractors and irrigate land. In order to examine the influence of farm size on use of tractors and irrigation, the regression analysis using ordinary least square method or correlation method will not be very useful. It is therefore necessary to use alternate statistical method to examine these relationships. Logistic regression was carried out as an appropriate method for examining these kinds of relationships after converting dependent variable in dichotomous form.

Farm size and Tractor use: Tractors play a pivotal role in crop production activity. They are also called as fixed capital assets. To have a better yield at the proper time agricultural operations are to be speeded up and it is possible only if mechanization (tractors) is adopted. Tractors unlike men and bullocks, do not get easily fatigued and work faster than men and animals. Tractors help us in keeping to the time schedule of sowing and harvesting, and therefore to have a better yield (land productivity), to rise multiple cropping pattern and also in raising the employment level[16.]

As observed from the economic literature, the general experience in India is, both the factors – tractorization (mechanization) and introduction of the new varieties- have been influenced by a third factor, the existence of large, resourceful farmers who have been both willing and able to modernize agriculture. It is observed, tractor farms are usually larger, better irrigated and have more highly valued land than bullock farms [Desai (1973); Dasgupta (1980), etc].

Considering these points in view, we expect a positive relationship between farm size and tractor use.

We estimated the logistic regression using maximum likely hood method. The findings of the relationship between use of tractors and farm size is given below:

Log (odds) = -0.087 + .138FS Exp (B) = 1.035

The coefficient of farm size is positive and statistically significant. It means that if we increase farm size by one unit, the odds that the farmers use tractors increase by 1.035 times. In other words large farmers are more likely to use tractors than small farmers.

The Value of Exp(B) = 1.035 implies that with increase in farm size the odds of the use of the tractor increase by 3.5% (1.035-1)*100.

Thus, the present analysis reveals that there is positive relationship between use of tractors and farm size. Large farms tend to use more tractors.

The plausible explanation put forward by us are: Large farmers may be cultivating long duration crops which is of labour saving technique or the result may be because of the specific cropping pattern. Even there is a possibility of large farmers to hire out tractors to small farmers[17.] That is, small farmers because of costly machinery like a tractor cannot be purchased might have resorted

16 .Reclamation of land and multiple cropping (both made possible) through the use of machinery and the labour using nature of high yielding variety of crops have, on the balance, created additional demand for labour [Bergmann (1978); Ghosh (1978) etc]

17. In our samples, we have not differentiated tractors, viz., owned or hired. Irrespective of such consideration, tractor use is taken into analysis.

to the practices of hiring its services either from the large farmers or from some other institutions. This procedure not only reduces for the small farmers, the cost of mechanizing their farms but also gives more flexibility to their cost structure-something quite useful for facing uncertainty in agriculture[18].

Farm Size and Irrigation: Large farms are considered to have greater command over resources and therefore we expect large farmers to have more area under irrigation. Large farmers can take risk and moreover they can obtain credit at lower rate. Credit market is considered to work in favour of large farms. Considering these factors we expect a positive relationship between farm size and irrigation.

In order to examine the relationship between farm size and irrigation, we categorized farmers into two categories, viz. irrigated farms and non-irrigated farms. Irrigated farms are coded as 1 and non-irrigated farms are coded as 0. Since dependent variable is dichotomous, we have used logistic regression to examine the relationship between farm size and irrigation.

The important part of the finding for our purpose is given below:

$$\text{Log (odds)} = 1.973 + \underset{(.273)}{0.057}FS \qquad \text{Exp (B)} = 1.059$$

Figure in the bracket shows significant value. If the value is less than .05, the coefficient is considered to be significant.

The sign of the coefficient of Farm Size is positive but it is not statistically significant. It implies that farm size and irrigated area under cultivation does not have any statistically significant relationship. It is possible that over a period of time the advantage of large farmers in credit market might have diminished.

Farm Size and HYV adoption: It is by now fairly well established that the rate of HYV adoption is usually higher among large farmers. A number of explanations are advanced for the lower adoption rates found among the smaller farms. The most important reason is the risk

18 Soni (1998) finds such strong reasons for the observed positive relationship of farm size and tractor use in the study of Punjab agriculture.

bearing capacity of smaller farms. The returns from HYV is considered be higher but uncertain because of complexity of cultural practices.

Risk and uncertainty attached to HYV cultivation exists for all sizes, the degree of uncertainty is higher for the smaller farms. It is partly because asymmetric information. Smaller farmers are also confronted with market uncertainty arising from variation in the price of output and inputs. Given the high cost of HYV cultivation and the market orientation of its production, it is natural that the decision to adopt new seeds is sensitive to market prices.

Given the limited resources of small farmers, they are forced to operate with a short time horizon, which restricts the scope for adopting HYVs. Large farmers are capable of planning over a long period and they have capacity to withstand occasional losses.

We expect a positive relationship between farm size and HYV adoption. In order to examine the relationship between farm size and HYV adoption, we categorized farmers into two categories, viz. HYV using farms and non-HYV farms. HYV using farms are coded as 1 and non-HYV farms are coded as 0. Since dependent variable is dichotomous, we have used logistic regression to examine the relationship between farm size and HYV adoption.

The findings of the relationship between HYV adoption and farm size is given below:

$$\text{Log (odds)} = 1.319 + \underset{(0.094)}{0.071}FS \qquad \text{Exp(B)} = 1.073$$

Figure in the bracket shows significant value. If the value is less than .05, the coefficient is considered to be significant. Here the value is 0.094, so it is mildly significant.

The findings based on logistic analysis suggest that there are no strong evidence of statistical significant relationship between farm size and adoption of HYVs. The relationship between these two variables is found to be positive.

Section VI

Summary and Conclusions:

The main objective of this study is to examine the nature of the relationship between farm size and productivity using new sets of data (cost of cultivation data). The studies in the literature have shown small farms tend to achieve higher production relative to their available land, and employ relatively more labour and less capital, than large farmers. That is, there is existence of the inverse relationship of farm size and productivity. Therefore, we tried to examine the current status of the nature of farm size –productivity relationship (whether the introduction of economic reforms has any changes in the nature of relationship).

The methodology undertaken is both linear and log-linear functions, in which log-linear estimations are robust on different issues in the analysis. We have even tried logistic regression for some of the statistical information, which is of dichotomous nature.

As per the findings, there is existence of negative relationship between farm size and productivity relationship. Smaller farms used higher amount of human labour, animal labour, material inputs (both seeds and chemical fertilizers-NPK), etc as compared to higher farm size groups. The results assume significance because of higher cropping intensity on smaller farm size groups. The relationship is confirmed even when controlled for regional and seasonal factors. However, the analysis does not show any strong evidence of inverse relationship with farm size and value of production. The elasticity coefficients are insignificant to explain the variations between value of production and farm size.

Another important finding, which we observe, is there is a negative and significant relationship between cropping intensity and proportion of irrigated area, which is contradictory to expectations. It shows cropping intensity is low and proportion of irrigated area is higher on larger farms, compared to smaller farms, On the other hand, smaller farms have a higher cropping intensity and lower proportion of irrigated area. This tendency is therefore presumed that may be larger farms opt for long-duration crops and smaller farms adopting diversified cropping pattern that can minimize risk of crop failure.

The total expenditure per hectare has a negative relationship with farm size. The estimations when controlled for regional and seasonal factors increase the size of the coefficient of farm size (land holding) but do not change the direction of the relationship. The negative relationship is much stronger and significant. This is as expected when the cropping intensity is negative with farm size groups. Simultaneously, the other possible explanation, one can assume for is diversified cropping pattern, financial assistance provided by the government/credit markets, etc, may have given an impetus for the small farm cultivators to use more of factor inputs in comparison to large farm cultivators.

Labour productivity (yield per day) has a consistent and significant positive relation on different size of holdings. This is a direct result of tractors which we found to be having a positive relationship with farm size.

The findings based on logistic analysis show strong evidence of positive relationship between farm size and tractor use, where as, this (a significant relationship) is not to be found in farm size and irrigation, as well as farm size and adoption of HYVs. There is a possibility that over a period of time the advantage of large farmers in credit market might have diminished.

Therefore, from the study, it appears there is existence of the inverse relation of farm size–productivity relationship (in a weak form) for the production of all the crops taken together. The introduction of economic reforms has not brought any drastic changes in the nature of relationship.

TABLE 1.

Farm Size (land holding) and Value of Production

EQ. No.	Dependent Variable	α (constant)	β_1 (farm size)	R^2	R^{-2}
1.	Log. Value of Production/GCA	9.444 (208.23)	8.706 (2.392)	.009	.008
2.	Log. Value of Production/ GCA^t	9.832 (50.984)	.131* (4.485)	.449	.387
3.	Log. Value of Production/ GCA^z	9.671 (147.53)	.101 * (2.890)	.099	.092
4.	Log. Value of Production/ GCA^s	9.635 (80.440)	8.523 (2.333)	.042	.032
5.	Log. Value of Production/NSA	9.508 (78.749)	-.243 (-2.511)	.010	.009
6.	Log. Value of Production/NSA^t	9.055 (16.303)	-.198 (-2.356)	.355	.283
7.	Log. Value of Production/NSA^z	9.805 (54.752)	-.224 (-2.341)	.052	.044
8.	Log. Value of Production/NSA^s	10.956 (34.990)	-.313* (-3.279)	.077	.067

Note:
a) Figures in parentheses are t-values.
b) (*) -Statistically significant at 5% level.
c) Equations with superscript 't, z, and s' refers to estimations done with tehsils, zones and seasonal dummies respectively.

TABLE 2.

Farm size and Cropping Intensity

EQ. No.	Dependent Variable	α (constant)	β_1 (farm size)	R^2	R^{-2}
1.	Log. Cropping Intensity	4.790 (125.850)	-.205* (-6.694)	.070	.068
2.	Log. Cropping $Intensity^t$	4.404 (26.872)	-.201* (-8.112)	.468	.409
3.	Log. Cropping $Intensity^z$	5.111 (94.391)	-.196* (-6.779)	.180	.173
4.	Log. Cropping $Intensity^s$	5.603 (66.048)	-.257* (-9.950)	.359	.353

Note:
a) Figures in parentheses are t-values.
b) (*) -Statistically significant at 5% level.
c) Equations with superscript 't, z, and s' refers to estimations done with tehsils, zones and seasonal dummies respectively.

TABLE 3.
Linear Regression

Cropping Intensity and Proportion of Irrigated Area

EQ. No.	Dependent Variable	α (constant)	β_1 (PIA)	R^2	R^{-2}
1.	Log Cropping Intensity	4.427 (180.840)	-.545* (-17.101)	.328	.327
2.	Log Cropping Intensity^t	5.061 (37.018)	-.580* (-18.753)	.639	.599
3.	Log Cropping Intensity^z	4.719 (112.523)	-.532* (-17.534)	.418	.413
4.	Log Cropping Intensity^s	4.949 (61.189)	-.430* (-13.498)	.428	.422

Note: a) Figures in parentheses are t-values.
b) (*) -Statistically significant at 5% level.
c) Equations with superscript 't, z, and s' refers to estimations done with tehsils, zones and seasonal dummies respectively.

TABLE 4.

Farm Size (land holding) and Total labour Hours

EQ. No.	Dependent Variable	α (constant)	β_1 (farm size)	R^2	R^{-2}
1.	Log Total labour hours/GCA	7.178 (206.555)	-9.45* (-3.393)	.019	.017
2.	Log Total labour hours/GCA^t	7.263 (62.982)	-5.32* (-3.051)	.666	.629
3.	Log Total labour hours/GCA^z	6.987 (140.415)	-8.52* (-3.206)	.121	.114
4.	Log Total labour hours/GCA^s	7.198 (81.872)	-8.87* (-3.313)	.129	.120
5.	Log Total labour hours/NSA	7.412 (176.549)	-.226* (-6.653)	.071	.070
6.	Log Total labour hours/NSA^t	6.580 (45.693)	-.182* (-8.202)	.658	.619
7.	Log Total labour hours/NSA^z	7.553 (129.017)	-.203* (-6.533)	.231	.224

8.	Log Total labour hours/NSA[s]	8.191 (85.108)	-.274* (-9.252)	.320	.313

Note:
a) Figures in parentheses are t-values.
b) (*) -Statistically significant at 5% level.
c) Equations with superscript ‘t, z, and s’ refers to estimations done with tehsils, zones and seasonal dummies respectively.

TABLE 5.

Farm Size (land holding) and Labour Productivity

EQ. No.	Dependent Variable	α (constant)	β_1 (farm size)	R^2	R^{-2}
1.	Log Labour Productivity	2.289 (67.835)	.170* (6.271)	.062	.060
2.	Log Labour Productivity[t]	2.575 (22.671)	.174* (10.124)	.672	.636
3.	Log Labour Productivity[z]	2.692 (59.007)	.177* (7.273)	.253	.247
4.	Log Labour Productivity[s]	2.384 (26.863)	.169* (6.258)	.100	.091

Note:
a) Figures in parentheses are t-values.
b) (*) -Statistically significant at 5% level.
c) Equations with superscript ‘t, z, and s’ refers to estimations done with tehsils, zones and seasonal dummies respectively.

TABLE 6.

Farm Size (land holding) and Total Animal labour Hours

EQ. No.	Dependent Variable	α (constant)	β_1 (farm size)	R^2	R^{-2}
1.	Log Animal labour hours/GCA	2.205 (20.020)	-.511* (-5.784)	.053	.051
2.	Log Animal labour hours/GCA ^{t}	2.306 (5.198)	-.486* (-7.238)	.526	.474
3.	Log Animal labour hours/GCA ^{z}	2.085 (13.717)	-.543* (-6.690)	.215	.208
4.	Log Animal labour hours/GCA ^{s}	1.805 (6.229)	-.460* (-5.203)	.091	.082
5.	Log Animal labour hours/NSA	2.298 (21.235)	-.628* (-7.234)	.080	.079
6.	Log Animal labour hours/NSA ^{t}	2.047 (4.617)	-.612* (-9.131)	.524	.471
7.	Log Animal labour hours/NSA ^{z}	2.397 (15.754)	-.658* (-8.106)	.209	.202
8.	Log Animal labour hours/NSA ^{s}	2.589 (8.986)	-.617* (-7.023)	.096	.087

Note:
a) Figures in parentheses are t-values.
b) (*) -Statistically significant at 5% level.
c) Equations with superscript 't, z, and s' refers to estimations done with tehsils, zones and seasonal dummies respectively.

TABLE 7.

Farm size and Ratio of Animal to Human Labour Hours

EQ. No.	Dependent Variable	α (constant)	β_1 (farm size)	R^2	R^{-2}
1.	Log (animal labourhours/human labour hours)	-2.276 (-16.972)	-1.17 (-.011)	.000	-.002
2.	Log (animal labourhours/human labour hours) ^{t}	-2.663 (-4.955)	-2.17 (-.267)	.505	.450
3.	Log (animal labourhours/human labour hours) ^{z}	-3.920 (-21.939)	.1.15 (0.121)	.227	.220
4.	Log (animal labourhours/human labour hours) ^{s}	-4.140 (-11.970)	3.63 (0.344)	.077	.068

Note:
a) Figures in parentheses are t-values.
b) Equations with superscript 't, z, and s' refers to estimations done with tehsils,

zones and seasonal dummies respectively.

TABLE 8.

Farm Size, Total Seeds and Total NPK

EQ. No.	Dependent Variable	α (constant)	β_1 (farm size)	R^2	$\bar{R}^2$
1.	Log seeds value/GCA	5.480 (46.613)	.339* (3.592)	.021	.019
2.	Log seeds value/GCA^t	6.486 (14.857)	.284* (4.218)	.568	.520
3.	Log seeds value/GCA^z	4.887 (28.401)	.353* (3.842)	.086	.079
4.	Log seeds value/GCA^s	5.952 (19.591)	.308* (3.324)	.093	.084
5.	Log seeds value/NSA	5.649 (41.255)	7.80 (.710)	.001	-.001
6.	Log seeds value/NSA^t	6.004 (10.964)	3.605 (.435)	.508	.453
7.	Log seeds value/NSA^z	5.201 (25.829)	.104 (.971)	.059	.051
8.	Log seeds value/NSA^s	7.113 (20.551)	3.58 (.034)	.115	.106
9.	Log NPK value/GCA	6.588 (70.009)	.125 (1.658)	.005	.003
10.	Log NPK value/GCA^t	6.594 (17.524)	.202* (3.371)	.454	.394
11.	Log NPK value/GCA^z	7.102 (53.204)	.162 (2.275)	.128	.120
12.	Log NPK value/GCA^s	7.382 (30.443)	6.389 (.863)	.082	.073
13.	Log NPK value/NSA	6.723 (53.825)	-.162 (-1.616)	.004	.003
14.	Log NPK value/NSA^t	6.347 (11.695)	-8.54 (-1.041)	.421	.356
15.	Log NPK value/NSA^z	7.335 (41.193)	-.119 (-1.248)	.119	.111
16.	Log NPK value/NSA^s	8.559 (27.532)	-.282* (-2.971)	.144	.136

Note:
a) Figures in parentheses are t-values.
b) (*) -Statistically significant at 5% level.
c) Equations with superscript 't, z, and s' refers to estimations done with tehsils, zones and seasonal dummies respectively.

TABLE 9.

Farm Size and Total Expenditure per Hectare

EQ. No.	Dependent Variable	α (constant)	β_1 (farm size)	R^2	R^{-2}
1.	Log Total Expenditure per hectare	8.936 (178.266)	-.161* (-4.000)	.026	.024
2.	Log Total Expenditure per hectare^t	8.603 (45.921)	-.116* (-4.084)	.581	.534
3.	Log Total Expenditure per hectare^z	9.506 (146.856)	-.137* (-3.970)	.293	.287
4.	Log Total Expenditure per hectare^s	9.998 (84.668)	-.198* (-5.497)	.250	.242

Note:
a) Figures in parentheses are t-values.
b) (*) -Statistically significant at 5% level.
c) Equations with superscript 't, z, and s' refers to estimations done with tehsils, zones and seasonal dummies respectively.

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