SEASONAL VARIATION IN AGRICULTURAL ACTIVITY AND ESTIMATING THE MARGINAL PRODUCT OF LABOUR (1)

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This paper is circulated for discussion purposes only and its contents should be considered preliminary.

INTRODUCTION

There are a number of reasons why we should be interested in estimating the marginal product of labour in agriculture - particularly in the less developed countries. Perhaps the most important of these is the relevance of such estimates to calculating the shadow wage rate for social cost-benefit analysis of public investment.(2) The purpose of this study is to highlight an important aspect of agricultural activity which seems always to be neglected when estimating the marginal product of labour in agriculture: the response of agricultural output to inputs is quite different in different parts of the agricultural year.(3) We think that this aspect of agriculture vitiates the usual methods of estimating the marginal product of labour in agriculture, and that its recognition leads to some unusual policy conclusions.

The first section of this paper explains the consequences of seasonality for the procedures for estimating the marginal product of labour in agriculture, and for a farmer's decisions about the use of labour. The second section presents an analysis of some cross-section data, in the light of the considerations put forward in the first. The third section discusses the implications of our analysis for estimating the social opportunity cost of labour that moves out of agriculture, and the fourth section draws some policy conclusions.

1. Theoretical Considerations

1.1 Seasonal variation in agricultural activity

The act of producing a unit of a commodity takes time; it may be a few minutes, hours, or even years; the length of time depends on the technical characteristics of production and on the level of aggregation at which the commodity is defined. Since we are usually interested in analysing the production of more than just one or two units of a commodity, we add the units produced - and the units of inputs used - over a period of time. This period is conventionally taken to be a calendar year in economic theory. Similarly, in econometric work it is usual to take a calendar year as the period of account for fitting a production function.

For most industrial processes, this seems to be a reasonable procedure. Though a calendar year is made up of fifty-two weeks, there may be no strong reason why the response of output to inputs, as successive weeks are included in the reckoning, should not trace out a smooth and continuous function for the whole year. Hence, if we were to keep the amounts of other inputs constant, and draw a curve to show the response of total output (measured along the vertical axis) to increasing inputs of hours of labour week by week throughout the year (measured along the horizontal axis), we would get the familiar smooth and continuous curve relating total output to labour input.

When it comes to fitting an industrial or an agricultural production function, we seldom have data about the weekly or even monthly inputs and outputs. We are usually provided with the annual totals of outputs and inputs. We then proceed to fit a production function to these annual totals - in a cross-section analysis where the annual totals are for different firms or industries, etc., for the same year; or in a time-series analysis where the annual totals are for different years; or the procedure adopted might be a pooling of the cross-section and time-series data. In any case, the individual observations are annual totals and the assumption is that the production function over a whole calendar year is smooth and continuous.

Needless to say, the procedure of fitting a production function rests on a number of assumptions, some of which are: that factors used and the outputs produced by different members of the sample are homogeneous and that they all have access to the same technical knowledge, etc. If a single equation estimation procedure is used, then it also has to be assumed that there is no joint determination of inputs and outputs, i.e. that the factor amounts used can be genuinely considered exogenous. However it is not our purpose to review these assumptions.(4) We are concerned here with the assumption of a smooth and continuous production function for a whole calendar year - as assumption which may often be innocuous enough for industry, but which could lead to seriously misleading results if applied to agriculture.

In the production of crops there are some stages when there is intense activity - a great deal of work needs to be put in within certain weeks, and the response of output during those particular weeks is such that it is usually worthwhile for most farmers to put in a spurt of work. But then there are some weeks during which output responds sluggishly to activity, and that point is quickly reached where any further work makes little or no difference to output. During such weeks not much work is done in the fields. Thus the weeks of the year fall into two categories which may be called the busy and the slack season. In the production of crops, there would appear to be a contrast between two such seasons even in countries where agriculture is highly mechanized. It is often suggested that this marked seasonal variation in the labour and other input requirements for crop production is one important cause of the development of mixed farming in the more fortunate countries where the farmers have introduced dairy farming, cattle raising and poultry, etc., to even out, to some extent, the peaks and troughs of activity caused by crop production. (Where climate, technology and incentives permit, farmers also adopt cropping schemes which would help to give a less uneven seasonal distribution of labour and other input requirements).

There is another characteristic of crop production. The length of time which must elapse before any complete units of the produced good are ready is much longer than with most other things; this period covers both the busy and slack seasons; and all complete units of the good get ready nearly at the same time. It may therefore be argued that in crop production, no "production" takes place till the weeks when the crop is finally harvested. But if we consider the value of output instead of the physical units of the final good, then there can be no doubt that work done in weeks other than the harvesting weeks also adds to the value of output.

Nevertheless, the relationship between the value of output and the inputs is not smooth and continuous for the year as a whole. Within the two categories of seasons, the response of value of output to the inputs is reasonably smooth, but between them there is a marked kink or a discontinuity. Indeed, there is a different production function for each of the two seasons, and a different marginal product curve for each season for every factor which is used in both the seasons. Hence for the purposes of fitting production functions for crop production, ideally we need data about outputs and inputs differentiated according to whether they pertain to the slack or the busy season. However, what we are usually provided are annual totals for outputs and inputs, exactly as with industrial data. The usual procedure is to fit a smooth and continuous production function to such annual totals (of a cross-section, or time series, or a combination of both), derive from it smooth and continuous marginal product functions for inputs, such as labour, and then estimate their marginal products at their mean values - all these for the whole year. (With labour, for example, this may be an estimate of the marginal product of an hour's labour or of a man-year, for the whole calendar year.) But the coefficients of a production function fitted in this manner, will be seriously biased for all such inputs as are used in both the slack and the busy seasons.(5)

1.2 The economics of the use of labour in peasant agriculture

We now construct a model of how a farmer decides on how much labour to employ in different parts of the calendar year. We must start by assuming some aim for the farmer. We can assume, after Sen (10), that the aim is to maximize the happiness of the household, or we can assume that the aim is to maximize profit. The analysis remains basically the same irrespective of which of the two aims we assume. We shall assume that the aim is profit maximization.

We divide the calendar year into two not necessarily equal parts, the slack season and the busy season. Work done in the field in either of the two seasons adds to the value of output, but the functions describing the response of the value of output to inputs are different for the two periods. A profit maximizing producer would compare the marginal return of using any input with the marginal cost of using that input. Further, between any alternative sources of supply for the same input he would use that source for which the marginal cost is the lowest. We assume that the personal efficiency of an hour's labour is the same irrespective of whether it is supplied by the family, the permanently hired or the casually hired. We assume that in the slack season, since the opportunities for employment are limited, the reserve price of casual labour as well as family and permanent labour is lower than in the busy season. Further, since it is more pleasant to work for oneself than for others, and since casual work being uncertain would require a higher price than permanent work, it also seems reasonable to expect that the reserve price of casual labour will be higher than that of family or permanently hired labour in both seasons.

Since there are different marginal product and marginal cost curves for labour for the two seasons, the profit-maximizing farmer would compare the marginal products with the marginal cost of the permanent and casual labour for each season, in order to decide how much to use of each in the two seasons.

These decisions are illustrated in Figs. 1(a) and 1(b). Considering the slack season first, in Fig. 1(a) P^s curve is the marginal product curve for hours of all permanent labour (including hired and family) and casual labour in the slack season. C^s_p curve is the marginal cost curve of permanent labour in the slack season. Casual labour can be hired at a constant wage-rate as indicated by the height of the horizontal line C^s_c. However, since for the critical region the wage rate for casual labour is higher than the reserve price of permanent labour, no casual labour is hired in the slack season. All the labour that is utilized in the slack season is ON_1 hours of permanent labour. The equilibrium value of the marginal product of permanent labour in the slack season is JN_1.

In the busy season, there is a different, much higher, marginal product curve of labour - curve P^b, in Fig. 1(b). Line C^b_c represents the marginal cost curve for casual labour in the busy season; this too is higher than the corresponding curve in the slack season. Curve C^b_p is the marginal cost curve of permanent labour in the busy season, again higher than the corresponding curve in the slack season. In the busy season,

Fig. 1(a)

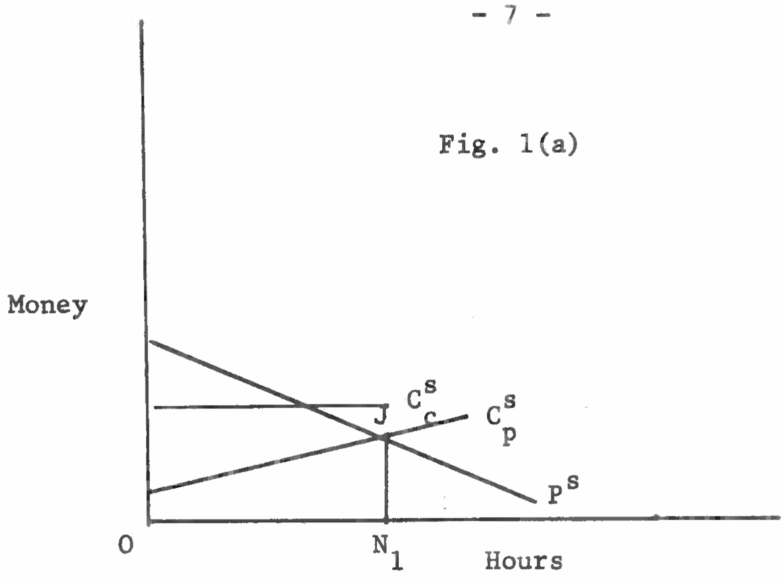
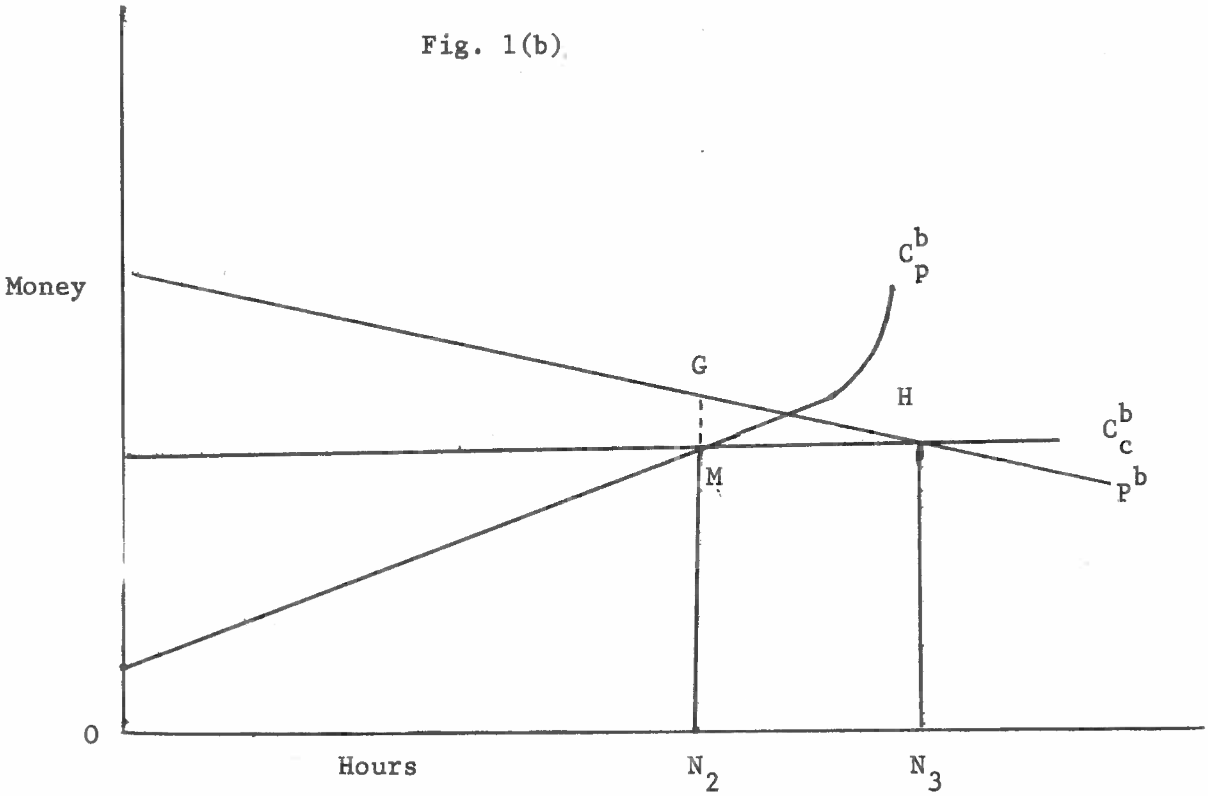


Fig. 1(b)



casual labour is taken on once the marginal cost of another hour of permanent labour rises above the marginal cost of hiring an hour of casual labour. In Fig. 1(b), this is assumed to happen at point M. A bit beyond that point, the marginal cost of permanent labour is assumed to start rising steeply because something like a physical maximum number of hours per permanent worker (per day) begins to be approached. In the busy season then ON_2 hours of permanent labour and $N_2 N_3$ hours of casual labour are utilized, i.e. the total number of hours used is ON_3. If in the busy season only permanent labour was used, its marginal product would be GN_2. The marginal product of casual labour in the busy season is HN_3; and that of all labour is again HN_3.

2. Empirical Analysis

2.1 Data

Our data come from the first year, 1967-8, of the three-year study in the Economics of Farm Management in the Ferozepur district of the Punjab. This study is directed by Professor A. S. Kahlon of the Punjab Agricultural University, Ludhiana. The data are collected through the cost accounting method for 150 holdings - 10 each from a sample of 15 villages. The average size of a holding is 12.5 hectares, with a standard deviation of 8.4. The holdings are divided into five size groups, below 6, 6-9, 9-14, 14-24, and 24 and above, hectares. The 150 holdings covered about 11% of the total cultivated area of the villages.

Of the total cropped area in the district, 32.3% was under wheat; and 50.6% under cereals as a group (including wheat). The other major crop of the area is cotton. The percentage for American cotton was 10.3; and for Desi Cotton, 4.5. Fodders accounted for 15.0%. Ferozepur contributed 21.4% of the total wheat production of the Punjab and 15.6%

of the state's cotton production. Punjab in its turn is a major growing area in India for these two crops. The percentage of net irrigated area to area sown was 62 in the district in 1967-8. Most of the irrigation was by canal water, but this was an uncertain source of supply compared to old-style wells and tube wells.

In 67-68, 89.7% of the cultivated area of the 150 holdings was self-cultivated, 2.7% cash rented, 0.5% was fixed kind rented and 7.1% was share rented. There was a marked similarity in the tenurial system in the different size-classes of farms. Of the total cultivated area, 98.3 was sown area, and only 1.5% currently fallow. The average intensity of cropping for all holdings together was 130%. There was some but not a strong tendency for the larger farms to have lower intensity.

2.2 Variables and Specification

Our dependent variable in each regression equation is the money value of only all crops which include Mexican wheat, Desi (or traditional) wheat, paddy, sugar-cane, cotton, fodder and by-products, etc. All the output, as well as the input, figures are annual totals.

Turning to the independent variables, we consider first area sown. This equals total area under cultivation minus current fallow land. We tried to make this variable homogeneous over the different farms. Data provide figures for actual rent paid and imputed rent for each farm. We consider rent per hectare to be perhaps the best single measure of the quality of land that the data provide. In order to make units of area homogeneous between farms, we worked out district-level rent per hectare, and individual farm rent per hectare: by dividing the latter figure for each farm by the district-level rent per hectare we obtained a set of weights for all farms. These weights were then used to adjust the figures for area sown.

Every holding in this sample has some irrigation. Irrigation may be by old-style wells, tube wells or canals. Separate information is not available about the amount of each different kind of irrigation used by a farm. But we are provided with figures for irrigation expenses which include irrigation charges (actually paid or imputed) <u>and</u> depreciation on irrigation equipment. Like irrigation expenses, the figures for other inputs, except labour, are in terms of money value.

In studies of agricultural production functions, inputs are often grouped into a small number of categories. We tried various groupings, but the relevant correlation matrices revealed much higher correlations among broad groups of inputs than exist among the individual inputs; the latter were quite small except for area sown. This was also reflected in the high standard errors for the regression coefficients for grouped inputs. Moreover, since some inputs are used rather exclusively in the busy weeks, while others are used in both the busy and the slack weeks, it made good sense to use individual inputs in the main regressions. For regression equations (9) to (12), we grouped inputs, other than labour and land, into two categories: those used mainly or only in the busy season, and those used in both the busy and slack seasons. The correlations were quire modest among these groups. The Two groups were: "Seeds, etc.", which includes seeds, manure, fertilizer, and insecticides and pesticides; and "Total Capital Services" which includes value of bullock labour, interest on working capital, interest on fixed capiral, irrigation expenses, depreciation on buildings and miscellaneous expenses. Where these inputs enter the equation in their logarithms, their logarithms were added together to form the groups.

We now consider the data about labour. We are provided with hours and money value per year for family labour, permanently hired labour, and casually hired labour. Money value of family labour was apparently imputed on the basis of the market wage rate for like labour. Permanently hired labour and family labour are available for work throughout the year. Casual labour is hired on a day to day basis as there is need to supplement the permanently available workers. Of the 150 farms, 49 did not use any permanently hired labour, but each of the 150 farms used some casual labour. The mean value, for the sample, of the ratio of the casual labour to total labour hours was .26, with a standard deviation of .13.

The quality of labour in each of these categories may vary from farm to farm. In order to make the hours of labour more homogeneous within these categories, we weighted the hours of each kind of labour on a farm with the ratio of the estimated wage rate on that farm of a certain kind of labour to the estimated district-level wage rate. We assume that these adjusted hours of each of the three categories of labour are homogeneous over the three categories; i.e. that the personal efficiency of the typical family worker is the same as the personal efficiency of the typical permanently hired worker or that of the typical casually hired worker. Since both family workers and permanently hired workers are available for work throughout the year, we see no point in distinguishing between them. Hence - depending on the equation - we added together the weighted hours of family and the permanently hired workers, or their logarithms. We refer to these as hours (or logarithms of hours) of "permanent labour". (For regressions where total labour is an independent variable, we added together the weighted hours of the three kinds of labour, or their logarithms).

If we assume that casual labour is employed only during the busy season we can then use the data on casual labour to represent the hours of casual labour used in the busy season. But we do not have data on the output which results from the work done in the busy season. We have only the totals for annual outputs of different farms. However ,since casual labour is assumed to be used only in the busy season; its contribution to total annual output occurs only in the busy season; hence the contribution to total annual output of casual labour can be interpreted as its contribution to the output during the busy season. And since we assume that the personal efficiency of an hour's labour is the same for different kinds of labour, the marginal product of casual labour in the busy season can be taken to be the marginal product of all labour in the busy season. Hence our data permit us to estimate the marginal product of all labour for the busy season.(6)

In the slack season only permanent labour is used. But permanent labour is also used in the busy season. Our data provide annual totals of hours of permanent labour as well as annual totals of output. From these data, there seems to be no practical way of estimating the marginal product of permanent labour in the slack or the busy season. Indeed the estimates of the marginal product of an hour's permanent labour which we obtain by following the standard procedure in our odd numbered regressions are peculiar mixtures with no meaningful relationship to the marginal product of an hour's permanent labour in the slack season or the busy season, Similarly, the estimates of the marginal product of an hour of undifferentiated labour which we obtain again by following the standard procedure in our even numbered regressions are also peculiar mixtures with no meaningful relationship to the marginal product of undifferentiated labour in either season, or the marginal product of permanent or casual labour in either season..

It is worth noting that if our analysis of the seasonality aspect of crop production is correct, then the regression coefficients estimated from annual totals will be biased not only for labour but also for all other <u>such</u> inputs as are used <u>both</u> in the busy and the slack season and have markedly different marginal product curves for the two seasons. Thus the regression coefficients estimated from the annual totals for bullock labour, fixed and working capital, and depreciation on buildings will be biased for this reason; but not so the coefficients for seeds, fertilizers, insecticides and irrigation expenses, because, though again we are provided with only annual totals for these inputs, it is safe to assume that they are used only in one of the two categories of agricultural seasons.

We tried linear, Cobb-Douglas type and transcendental specifications of the production function. The notation used, and the equations are given below.

<u>NOTATION</u>

Y = value of the total yield of crops

C = constant

L_p = permanent labour hours

L_c = casual labour hours

L_t = total labour hours

A = area sown in hectares

B = value of bullock labour

S = value of seeds

M = value of manure

F = value of fertilizer

I = value of insecticides and pesticides

K_w = interest on working capital

K_f = interest on fixed capital

D = depreciation on buildings

R = irrigation expenses

E = miscellaneous expenses

S^* = value of seeds, manure, fertilizer, insecticides and pesticides

K^* = value of bullock labour, interest on working capital, interest on fixed capital, irrigation expenses, depreciation on buildings and miscellaneous expenses

REGRESSION EQUATIONS

(1) $$Y = C_1 + a_{1,1} L_p + a_{1,2} L_c + a_{1,4} A + a_{1,5} B + a_{1,6} S + a_{1,7} M + a_{1,8} F + a_{1,9} I + a_{1,10} K_w + a_{1,11} K_f + a_{1,12} D + a_{1,13} R + a_{1,14} E + \varepsilon_1$$

(2) $$Y = C_2 + a_{2,3} L_t + a_{2,4} A + a_{2,5} B + \dots + a_{1,14} E + \varepsilon_2$$

(3) $$\frac{Y}{A} = \frac{C_3}{A} + a_{3,1} \frac{L_p}{A} + a_{3,2} \frac{L_c}{A} + a_{3,4} + a_{3,5} \frac{B}{A} \dots a_{3,14} \frac{E}{A} + \frac{\varepsilon_3}{A}$$

(4) $$\frac{Y}{A} = \frac{C_4}{A} + a_{4,3} \frac{L_t}{A} + a_{4,4} + a_{4,5} \frac{B}{A} \dots a_{4,14} \frac{E}{A} + \frac{\varepsilon_4}{A}$$

(5) $$\text{Log } Y = C_5 + a_{5,1} \text{ Log } L_p + a_{5,2} \text{ Log } L_c + a_{5,4} \text{ Log } A \dots a_{5,14} \text{ Log } E + \varepsilon_5$$

(6) $$\text{Log } Y = C_6 + a_{6,3} \text{ Log } L_t + a_{6,4} \text{ Log } A \dots a_{6,14} \text{ Log } E + \varepsilon_6$$

(7) $$\text{Log } \left(\frac{Y}{A}\right) = C_7 + a_{7,1} \text{ Log } \left(\frac{L_p}{A}\right) + a_{7,2} \text{ Log } \left(\frac{L_c}{A}\right) + a_{7,5} \text{ Log } \left(\frac{B}{A}\right) + \dots + a_{7,14} \text{ Log } \left(\frac{E}{A}\right) + \varepsilon_7$$

(8) $$\text{Log }(\frac{Y}{A}) = C_8 + a_{8,3}\text{ Log }(\frac{L_t}{A}) + a_{8,5}\text{ Log }(\frac{B}{A}) + \ldots a_{8,14}\text{ Log }(\frac{E}{A}) + \varepsilon_8$$

(9) $$\text{Log } Y = C_9 + b_{9,1}\text{ Log } L_p + b_{9,2} L_p + b_{9,3}\text{ Log } L_c + b_{9,4} L_c + b_{9,4} L_c + b_{9,7}\text{ Log } A + b_{9,8} A + b_{9,9}\text{ Log } S^* + b_{9,10} S^* + b_{9,11}\text{ Log } K^* + b_{9,12} K + \varepsilon_9$$

(10) $$\text{Log } Y = C_{10} + b_{10,5}\text{ Log } L_t + b_{10,6} L_t + b_{10,7}\text{ Log } A + b_{10,8} A + \ldots b_{10,12} K^* + \varepsilon_{10}$$

(11) $$\text{Log }(\frac{Y}{A}) = C_{11} + b_{11,1}\text{ Log }(\frac{L_p}{A}) + b_{11,2}(\frac{L_p}{A}) + b_{11,3}\text{ Log }(\frac{L_c}{A}) + b_{11,4}(\frac{L_c}{A}) + b_{11,9}\text{ Log }(\frac{S^*}{A}) + \ldots b_{11,12}(\frac{K^*}{A}) + \varepsilon_{11}$$

(12) $$\text{Log }(\frac{Y}{A}) = C_{12} + b_{12,5}\text{ Log }(\frac{L_t}{A}) + b_{12,6}(\frac{L_t}{A}) + b_{12,9}\text{ Log }(\frac{S^*}{A}) + \ldots b_{12,12}(\frac{K^*}{A}) + \varepsilon_{12}$$

In each of the odd numbered equations, permanent labour and casual labour are included as separate independent variables; but in each of the even numbered equations all labour hours added together are included as one undifferentiated labour input. Equations (1) and (2) are linear. However, area sown is fairly highly correlated with a number of other variables, and the residuals of these two regressions also suggested that the variance of the disturbance is roughly proportional to area sown. Therefore, we modified our specification to get the two linear equations (3) and (4). Once we have obtained the regression coefficients for equations (3) and (4), we can multiply each side of the equations by A, so that the coefficient of 1/A becomes the new constant, and the constant becomes the coefficient of A.

The results included in Table 1 for equations (3) and (4) were obtained in this way.

Equations (5) and (6) are in double logs. There seemed no strong reason to suspect problems of multicollinearity or heteroscedasticity in the regression results of these rwo equations. Nevertheless we decided to normalize the variables for area sown in the double-log equations (7) and (8), In these two equations, the specification chosen implies that we have restricted the sum of the elasticity with respect to all inputs (including are aown) to be equal to one. There seems good justification for this procedure because the sum of the estimates of elasticities obtained from regressions (5) and (6) was in each case not significantly different from one.

Equations (9) to (12) are the transcendental production functions. In these equations some of the inputs have been aggregated into broad groups as mentioned earlier. All variables have been normalized for area sown for equations (11) and (12). Whereas the Cobb-Douglas type production function assumes that elasticity of output with respect to an input is constant, the transcendental production function allows that elasticity to vary. This is obviously an advantage.

2.3 Results

Table 1 gives the regression results for the first eight equations, and Table 2 for the last four, Looking at Table 1 first, we note that the coefficient for casual labour is significant each time it is included, but the coefficient of permanent labour is significant in only two regressions out of four. In each of the four regressions where both permanent and casual labour are included, their coefficients are highly significantly different from each other. As for undifferentiated total labour, its coefficient is again significant in only two out of the four regressions in which it was tried.

Turning to the logarithmic specifications, we note that the coefficient of casual labour is highly significant in both regressions (5) and (7); but that of permanent labour is insignificant in both, indeed in regression (7) it has the wrong sign. The coefficient of total (undifferentiated) labour is insignificant in both regressions (6) and (8). The sums of the input elasticities are .93 and 1.13 in regressions (5) and (6); neither sum was found to be significantly different from one. As mentioned earlier, in regressions (7) and (8), the sums of input elasticities have been constrained to add up to one. By subtracting from one the sums of elasticities for inputs other than area sown, elasticity for that input is estimated to be .35 and .38 according to regressions (7) and (8) respectively.

Looking at the regression results from the transcendental production function in Table 2, of the four coefficients for casual labour or its logarithms, three are significant, and each has a positive sign. But of the four coefficients for permanent labour, only one is signficant, and of the three insignificant ones, one has a negative sign. Of the four coefficients for total undifferentiated labour only one is significant.

It is also interesting to note that the coefficients of seeds, fertilizers, insecticides and pesticides, and interest on working capital are positive and significant in each of the four regressions, (3) and (4), (5) and (6). The regression coefficients for fertilizer, and insecticides and pesticides both bear out what one expects of them - a very high marginal product. (Recall that these inputs, as well as the output, are measured in

Table 1 : Regression Results for Total Crops : Ferozepur District, Punjab 1967-68

		Eqn. 1	Eqn. 2	Eqn. 3	Eqn. 4
		Linear	Linear	Linear derived from Per-hectare specification	Linear derived from Per-hectare specification
C	(Constant)	1541.52 (1766.53)	847.33 (1921.34)	1081.00 (936.08)	2302.30* (1077.41)
L_p	(Permanent Labour Hours)	.92* (.32)		.64* (.27)	
L_c	(Casual Labour Hours)	5.22* (.74)		2.78* (.76)	
L_t	(Total Labour Hours)		1.67* (.31)		.045 (.018)
A	(Area Sown in Hectares	-7.40 (5.80)	2.60 (6.29)	281.3 (140.8)	170.40 (189.82)
B	(Value of Bullock Labour)	.46 (.56)	.35 (.61)	.077 (.043)	.706 (.37)
S	(Value of Seeds)	4.40* (1.80)	5.15* (1.95)	5.51* (1.61)	6.90* (1.63)
M	(Value of Manure)	5.68 (3.16)	8.39* (3.40)	3.48 (3.19)	4.58 (3.28)
F	(Value of Fertilizer)	3.54* (1.19)	3.87* (1.3)	3.43* (1.18)	3.90* (1.21)
I	(Value of Insecticides & Pesticides)	1.48 (5.35)	15.56* (5.03)	14.98* (6.13)	17.02* (6.22)
K_w	(Interest on Working Capital)	-83.32 (53.66)	-84.31 (58.52)	4.44* (1.06)	4.62* (1.07)
K_f	(Interest on Fixed Capital)	-1.12 (7.012)	.376 (7.64)	-16.56 (27.91)	-5.16 (28.51)
D	(Depreciation on Buildings)	4.22* (1.14)	6.24* (1.16)	-3.63 (4.42)	-4.67 (4.58)
R	(Irrigation Expenses)	-.95 (2.11)	-.38 (2.30)	.80 (1.57)	1.19 (1.62)
E	(Miscellaneous Expenses)	-.13 (1.15)	-.38 (1.26)	-.069 (1.27)	.43 (1.30)
	F test	61.06	53.72	25.47	24.90
	$\bar{R}^2$	.84	.81	.68	.66

continued on next page ...

Table 1 - continued

		Eqn. 5 Double Logs	Eqn. 6 Double Logs	Eqn. 7 Double Logs per hectare data	Eqn. 8 Double Logs per hectare data
C	(Constant)	5.27* (.33)	4.95* (.31)	5.09* (.24)	5.30* (.25)
L_p	(Permanent Labour Hours)	.000034 (.0096)		-.0033 (.0086)	
L_c	(Casual Labour Hours)	.11* (.0034)		.10* (.032)	
L_t	(Total Labour Hours)		.016 (.0095)		.011 (.0086)
A	(Area Sown in Hectares)	.32* (.055)	.40 (.005)		
B	(Value of Bullock Labour)	.050* (.021)	.057* (.022)	.053* (.020)	.048* (.021)
S	(Value of Seeds)	.20* (.063)	.28* (.064)	.21* (.061)	.27* (.064)
M	(Value of Manure)	.0015 (.011)	.0013 (.017)	.00018 (.011)	.0044 (.012)
F	(Value of Fertilizer)	.059* (.019)	.0043* (.0021)	.050* (.016)	.0046* (.0022)
I	(Value of Insecticides & Pesticides)	.029* (.012)	.037* (.013)	.029* (.012)	.0407* (.013)
K_w	(Interest on Working Capital)	.061* (.021)	.073* (.022)	.064* (.021)	.068* (.022)
K_f	(Interest on Fixed Capital)	-.015 (.077)	.14* (.069)	.028 (.054)	.065 (.057)
D	(Depreciation on Buildings)	-.018 (.035)	-.0051 (.038)	-.0096 (.034)	-.025 (.037)
R	(Irrigation Expenses)	.14* (.031)	.15* (.033)	.14* (.031)	.15* (.033)
E	(Miscellaneous Expenses)	-.0072 (.012)	-.013 (.012)	-.0099 (.011)	-.0075 (.012)
	F test	63.45	61.25	26.10	23.12
	$\bar{R}^2$	.85	.83	.67	.62

Notes:
(1) The numbers in parentheses are the calculated standard errors of the respective coefficients.

(2) An asterisk on a coefficient indicates that the coefficient is significant at at least the 5% level.

(3) The dependent variable, total crops, is measured in money value.

(4) The sums of the input elasticities in regressions (5) and (6) are .93 and 1.13 respectively; neither sum was found to be significantly different from one.

Table 2 : Regression Results for Total Crops: Ferozepur District, Punjab, 1967-68

(Transcendental Specifications)

	Eqn. 9	Eqn.10	Eqn.11	Eqn.12
C (Constant)	7.19* (.260)	7.51* (.24)	6.20* (.19)	6.49* (.13)
Log L_p (Log Permanent Labour Hours)	.0034 (.0081)		-.0050 (.0085)	
L_p (Permanent Labour Hours)	.000022* (.000011)		.00023 (.00012)	
Log L_c (Log Casual Labour Hours)	.11* (.033)		.093* (.046)	
L_c (Casual Labour Hours)	.000052* (.000024)		.00081 (.00050)	
Log L_t (Log Total Labour Hours)		.011 (.0079)		.0035 (.0088)
L_t (Total Labour Hours)		.000032* (.000011)		.000013 (.0000070)
Log A (Log Area Sown in Hectares)	.43* (.072)	.51* (.073)		
A (Area Sown in Hectares)	-.102*	-.011*		
Log S* (Log value of Seeds etc.)	.0036* (.0018)	.0038* (.0019)	.0021 (.0021)	.0026 (.0022)
S* (Value of Seeds etc.)	.000087* (.000024)	.000099* (.000025)	.0015* (.0037)	.0018* (.00038)
Log K* (Log Value of Total Capital Services)	.011 (.0082)	,015 (.0085)	.026* (.0080)	.030* (.0084)
K* (Value of Total Capital Services)	.000038 (.000021)	.000037 (.000022)	-.026* (.0079)	.00022 (.00016)
F test	85.59	95.07	30.33	33.61
$\bar{R}^2$	.85	.83	.61	.57

Notes:

(1) The numbers in parentheses are the calculated standard errors of the respective coefficients.

(2) An asterisk on a coefficient indicates that the coefficient is significant at at least the 5% level.

(3) S* = The sum of the values of seeds, manure, fertilizer and insecticides and pesticides. Log S* equals the sum of the logarithms of the foregoing inputs.

(4) K* = The sum of the vakue of bullock labour, interest on working and fixed capital, irrigation expenses, depreciation on buildings and miscellaneous expenses. Log K* equals the sum of the logarithms of the foregoing inputs.

(5) The dependent variable in these regressions is the logarithm of the money value of the total crops.

money value.) It would seem that at their existing prices farmers could profitably use much more of them and also of seeds and working capital. The coefficient for irrigation expenses is positive and significant in each of the four logarithmic specifications; and all the four estimates are very close to one another. As we mentioned earlier, area sown is rather highly correlated with a number of other variables and there was also some evidence of heteroscedasticity in regressions (1) and (2); therefore we need not take seriously the coefficients which are estimated from those two regressions.

The coefficients of interest on fixed capital, depreciation on buildings, manure and miscellaneous expenses are seldom, if ever, significant. None of these variables is highly correlated with any other; so multicollinearity cannot be the explanation. With some of them, e.g. manure and miscellaneous expenses, there may be rather strong measurement errors. But we think that the most plausible explanation is that fixed capital, buildings and land, etc., are inputs which are used in both the slack and the busy seasons, and that their contributions to output are markedly different in the two seasons. Hence regressing annual totals of outputs on annual totals of inputs, we get particularly biased estimates of the coefficients for these inputs. In contrast, inputs like seeds, fertilizers, insecticides and pesticides (and working capital?) are used only or mainly in the busy weeks. Hence we get more meaningful estimates of their coefficients.

In Table 3, we give the estimates of the marginal products of casual labour, permanent labour and undifferentiated labour, calculated for their mean values: for a specification in double logs, we used the geometric mean values. We have no confidence in the estimates we obtain from annual data of the marginal products of permanent labour or undifferentiated labour, for reasons explained in Section 1. Looking at these estimates, we might conclude that the marginal product of undifferentiated labour in the Punjab agriculture in 1967-68 was rather low, perhaps negligible, whereas the truth perhaps is that the marginal product of labour is low in the slack season, and much higher in the busy season. If our assumption that casual labour is used only or mainly in the busy weeks is right, then the estimates obtained of the marginal product of casual labour can be taken to be the estimates of the marginal product of casual labour in the busy season. Further, as we argued in Section 1, on some apparently reasonable assumptions an estimate of the marginal product of casual labour in the busy season can be taken to be an estimate of the marginal product of permanent labour in the busy season.

Table 3. Estimates of Marginal Product of Labour : Ferozepur District, Punjab, 1967-68.

Type of Labour	Estimated Marginal Product in Rupees	Obtained from Regression Equation
1. An hour of Casual Labour	2.8	3
2. " " " " "	1.6	5
3. " " " " "	2.6	9
4. An hour of Permanent Labour	.64	3
5. " " " " "	.000136	5
6. " " " " "	.53	9
7. An hour of Undifferentiated Labour	.045	4
8. " " " " "	.0048	6
9. " " " " "	.80	10

3. Relevance to estimating the social opportunity cost of labour moving out of agriculture

If our analysis in Section 1 is correct, it follows that the estimate of the marginal product of an hour's undifferentiated labour during the year - obtained from any of the even numbered equations - is quite useless for the purposes of calculating the social opportunity cost of an hour's work by the worker who emigrates from agriculture. Unless he has been a casual worker in agriculture, an hour's work by him had a different marginal product according to whether that hour was put in during the slack or the busy season. For the permanent (hired or family) workers, what we need to know are their separate marginal products for the two seasons, and the proportions of the annual total of hours worked which are devoted to the two seasons. If we had such information, then we could estimate the marginal product of a permanent worker for the whole year as the sum of the marginal product of an hour of permanent worker's labour in the slack season, multiplied by the number of hours worked in the slack season , and the marginal product of an hour of the same kind of labour in the busy season multiplied by the number of hours worked in the busy season. Unfortunately even the rather unusually detailed data such as we have do not enable us to estimate the separate marginal products for the two seasons of the permanent workers; nor do the data give any information on the proportions of total annual hours which go into the two seasons.

Similarly, for estimating the forgone marginal product for a whole year when a hitherto casually hired agricultural worker emigrates to a town we need the sum of his marginal products in the two seasons - each multiplied by the number of hours worked in that season. We have argued above that our data enable us to estimate the marginal product of an hour of casual labour in the busy season. Since we assume that casual labour is hired only in the busy season, our data also provide us with the total number of hours worked by casual workers at each farm. However, since we have no information on how many casual workers were employed by each farm - or by all farms together - we have no way of calculating the number of hours worked during the busy season by a casual worker.

What does casual labour do in the slack season? Our guess is that casual workers in the slack agricultural season pursue such occupations as cottage industries, and other non-agricultural but related activities; perhaps some of them even migrate to towns to work as domestic servants or in factories where the seasonal peak demand for labour happens to coincide with the agricultural slack season. Obviously it is important to gather more information on this in order to be able to estimate the marginal product of an hour's work by a casual worker in the agricultural slack season; we also need to know the average number of hours worked in the slack season by a casual worker.

We have so far discussed the marginal product for the calendar year either of permanent labour (be it family or hired) or of casual labour. It is quite likely that the group that leaves agriculture to go into town for the whole year consists of workers from both these categories. If our foregoing assumptions and analysis are correct, it is important then to know the proportions of the two kinds of workers in the migrating group. If we knew these, and had also been able to work out the separate marginal products for the whole year of the two kinds of workers in their previous occupations, then the displaced marginal product for a whole year of an undifferentiated member of the group could be taken to be the weighted sum of the displaced marginal products for the whole year of a permanent worker and of a casual worker - the weights being the proportions of the two kinds of workers in the migrating group. Needless to say, such an estimate of the marginal product of undifferentiated labour is likely to be quite different from that obtained by regressing annual totals of outputs on annual totals of undifferentiated labour (and other inputs).

Policy implications and concluding remarks

Our analysis highlights the need to gather agricultural data differentiated according to the agricultural seasons. Regarding the inputs, it should raise no great problem; in a farm management survey it should not be difficult to keep separate records of the different months - if not weeks - regarding inputs and the kind of agricultural activity performed, e.g. ploughing, sowing, weeding, spreading fertilizer, irrigating, harvesting and threshing etc.[7] Regarding the output, there is a bigger problem. In a sense, the value of output is not known till it has been harvested. However, even a few days old crop has a value. Therefore, it should not be impossible to put a value on the crop in different months of the year as more work is done on it. For example, a hectare of land with a few days old crop will have a higher market value than a hectare of similar land with no crop on it.

Some policy conclusions are also suggested by our analysis. If the marginal product of an hour's work is much higher in the busy season than in slack season, and if even the smallest farms in our sample hire some casual labour in the busy season, then if some labour is withdrawn from such agriculture for the whole year (including the busy season), total agricultural output is bound to suffer unless labour substituting methods and machinery are simultaneously introduced for the busy season, e.g. such things as mechanical harvesters and threshers, etc.[8] A related implication is that it may be socially more advantageous if - at least for the next decade or so - agricultural labour migrated into other jobs only during the busy season.[9] Further, the analysis also suggests that there may be significant social advantage in encouraging certain kinds of mixed farming, cropping schemes and cottage industries which would help provide more employment mainly in the hitherto slack weeks. It is worth recalling that according to Mahatma Gandhi this was one of the strongest arguments for protecting and encouraging cottage industries in India.

Finally we should recognise that though every farm in our sample employed some casual labour, not every farm throughout India does so - though it would seem that in a number of regions the majority do.[10] However, if at all there are important seasonal differences between the levels of activity (and between the response of output), then - irrespective of whether any casual labour is hired or not - there is a need to think in terms of a different marginal product of labour in each of the two major agricultural seasons. To the extent that there is marked seasonality in the agricultural activity in other countries, our analysis may have some relevance for them also.

Footnotes:

(1) I am indebted to the Ministry of Food & Agriculture, Government of India and Professor A. S. Kahlon of the Punjab Agricultural College at Ludhiana for making available the data on which this study is based. Part of the research expenses were financed by the Leverhulme Trust through Nuffield College, Oxford. For this, and for many useful discussions, I am grateful to Ian Little and Maurice Scott. I would also like to thank Farouk El-Sheikh and members of the Applied Econometrics Seminar at Warwick University for helpful comments and suggestions. Earlier stages of research were assisted by Jeremy Corbett.

(2) It may be argued that for this purpose it should be sufficient to know wage rates in the sectors from which labour is likely to be attracted. But there may be reasons (such as "tradition - determined" wages rates, etc.) to suspect that those wage rates are not equal to the relevant marginal products.

(3) That there is a seasonal variation in agricultural activity has often been noted and commented upon in the literature. Some examples are: Clark and Haswell (3), Hansen and Mona El Tomy (5), Mazumdar (6), Wellisz (11), and Nakajima (8). However, it does not seem to have been recognised that this seasonality implies that the usual methods of estimating the marginal product of labour for the year as a whole are bound to give highly biased results, see, for example, Desai and Mazumdar (7), Raj Krishna (9) and Wellisz (12).

(4) For an excellent discussion, See Griliches (4).

(5) However, if there are some inputs which are used in only one of the two agricultural seasons, then it may be possible to estimate the marginal product of such inputs from the data about annual totals. (This is further explained in Section 2.2.) Of course, such a procedure makes sense only if the inputs used in the two seasons are not perfectly complementary. But "perfect complementarity" is an unrealistic assumption.

(6) As mentioned in the last footnore, this procedure rests on the assumption that the use of labour in the two seasons is not perfectly complementary.

(7) Our analysis also indicates the importance of gathering information on agricultural wage rates for different regions for finely differentiated parts of the year.

(8) Already tractors and mechanical threshers are beginning to be quite common in the Punjab, the combine "is still a machine which is years in the future"; see Billings and Singh (2).

(9) It would seem that this already happens to some extent. See Agarwal and Varshney (1). Some of the examples of seasonal industries they give are: production of sugar, coffee, tobacco products; processing of cotton, jute and wool; making bricks, tiles and salt; and manufacturing ice, aerated and mineral water, and umbrellas.

(10) See Mazumdar (6).

References:

(1) B. L. Agarwal and R. G. Varshney, "Seasonal Variations in Employment in India", Economic and Political Weekly, Bombay, 29 November, 1969, pp. 1845 - 1849.

(2) Martin H. Billings and Arjan Singh, "Labour and The Green Revolution - The Experience in Punjab", Economic and Political Weekly, Review of Agriculture, Bombay, December, 1969, pp. A.221 - A.224.

(3) C. Clark and M. Haswell, The Economics of Subsistence Agriculture, Ch. 6, 4th ed., London, 1970.

(4) Z. Griliches, "Specification Bias in Estimates of Production Functions", Journal of Farm Economics, 1957.

(5) B. Hansen and Mona El Tomy, "The Seasonal Employment Profile in Egyptian Agriculture", Journal of Development Studies, July 1965.

(6) D. Mazumdar, "Size of Farm and Productivity: A Problem of Indian Peasant Agriculture", Economica, 1965.

(7) M. Desai and D. Mazumdar, "A Test of the Hypothesis of Disguised Unemployment", Economica, 1970.

(8) C. Nakajima, "Subsistence and Family Farms : Some Theoretical Models of Subjective Equilibrium", in C.R. Wharton, Jr. (ed.), Subsistence Agriculture and Economic Development, London, 1970.

(9) Raj Krishna, "Some Production Functions for the Punjab", Indian Journal of Agricultural Economics, Silver Jubilee Issue, 1964.

(10) A. K. Sen, Peasants and Dualism with or without Surplus Labour", Journal of Political Economy, 1966.

(11) S. Wellisz, "Dual Economies, Disguised Unemployment and the Unlimited Supply of Labour", Economica, 1968, esp. pp. 46 - 47.

(12) S. Wellisz, B. Munk and C. Hummer, "Resource Allocation in Traditional Agriculture: A Study of Andhra Pradesh", Journal of Political Economy.