LABOUR REQUIREMENTS MODEL FOR THE WHEAT CROP UNDER MECHANIZED AND TRADITIONAL FARMING SYSTEMS IN THE NWFP: A CASE STUDY OF PESHAWAR DISTRICT

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ABSTRACT
Agriculture is the single largest sector of Pakistan’s economy. More than 50% of the labour force is absorbed by this sector. The manual labour requirements vary from crop to crop. The present study finds the effect of farm machinery on labour requirements for the wheat crop in the NWFP of Pakistan. Wheat is the major cereal food item in Pakistan. In terms of area allocation, wheat is the single largest crop of the country. Wheat also serves as a raw material for many manufacturing units. The study highlights that wheat is grown on large area in the Province. The field data (Rabi, 2004) of the research area (District Peshawar) revealed that for the cultivation of the crop both mechanized and traditional methods of farming were practiced. The Cobb-Douglas production function was used for the parameters’ estimation. The sum of income elasticities of each of the farming system was less than one and so there is a tangible scope for improvement by applying the inputs optimally. The Marginal Physical Product of labour and machinery were higher on mechanized farms. The study explored that labour requirements/ha. of the mechanized farms for the crop were 75.5 man-days as against 357.4 man-days for traditional farms. The mechanized farms used both machinery and labour for the cultivation of the wheat crop whereas the traditional farms mainly depended on labour and animal power and use machinery only for threshing purposes. A unit use of machinery reduced the labour requirements by over 3 times. The prices of inputs showed an inverse relation with labour requirements. Both the output and animal power had a positive effect on labour requirements.

INTRODUCTION
In terms of employment agriculture is the single largest sector of Pakistan’s economy. This sector meets the ever increasing food requirements of the ever increasing population and raw materials for the manufacturing units. In a sector like this the application of agricultural mechanization will adversely affect the labour requirements, which will further aggravate the existing unemployment situation. However, at the same time it is argued that the application of mechanization will boost up productivity which will enhance employment.

Bose and Clark (1969) are of the view that the use of farm machinery reduces the labour requirements. Roy and Balse (1978) have observed that agricultural mechanization helps in increasing yield. Agarwal (1980) has noted that the use of tractor has an adverse effect on labour. Nassem (1981) is of the opinion that farm mechanization has displaced tenants cultivators. Faiz (1984) argued that mechanization has accelerated the adoption of improved agricultural practices which increase yield. Ali (1986) has pointed out that mechanization has increased unemployment in rural area. The study of Jehanzeb (1999) shows that application of farm mechanization has reduced the labour requirements.

Saeed (2000) has shown that the power requirements of the agricultural sector can easily be met by applying farm machinery. Iqbal (2002) analyzed that credit facilities be provided to small farm size holders for the application of farm machinery which increases yield. All these studies provide valuable information about the issue under discussion. However, very little has been said about the situation in the North West Frontier Province (NWFP) Pakistan. The present study addressed this issue for the wheat crop in the Province so as to fill in this gap.

The main objectives of the study were to find out (i) the labour displacement effect of agricultural mechanization (ii) Marginal Physical Product (MPP) of labour, animal power and tractor (iii) elasticities of each input in the case of the wheat crop.

Wheat is a major staple food item in Pakistan and also of the NWFP. Every effort is being made to meet the wheat requirements of the country at a reasonable price (Khan and Iqbal 1981). In terms of area allocated to different crops, wheat is the major crop of Pakistan as well as of the NWFP (Govt. of Pakistan, 2004). Wheat is also being used as a raw
material by many manufacturing units like confectionery and backers, etc.

MATERIALS AND METHODS

Universe
The universe of the study is the NWFP where agriculture is the largest economic sector. Peshawar district in the NWFP was selected as the most suitable area from which to select the sample respondents after considering the physical and financial resources. Moreover, Peshawar Valley is the backbone of the provincial’s economy and it is mainly this area where agriculture has made a visible progress in the last few decades. Also, in term of area allocation to different crops, wheat is the major crop of the District (Hussain 1990; Saeed 1996; Govt. of Pakistan 2003).

Sampling Procedure
All the irrigated farm households in Peshawar district constituted the sample frame for the study. For this study the mechanized farms were those where the farmers generally used agricultural machinery and did not use the traditional methods of cultivation or used it but very rarely. Traditional farms in the present case were those who did not use agricultural machinery or used it but very sparsely. For the cultivation of the wheat crop the mechanized farms used machinery (i.e. tractor with appliances) for land preparation (i.e ploughing, planking, leveling, and ridges), sowing and harvesting. The traditional farms carry out these activities by using animal power, and labour. Thresher (operated by tractor) was used by both mechanized and traditional farms. For this study Union Council (UC) Gulbela was randomly selected. The number of households related to agricultural activities in the UC was over one thousand which was 70 % of the total population. The sample size arrived at about 200 \( n = \frac{K^2 S^2}{N(\bar{e}^2 + K^2 S^2)} \) \cite{Parel1973}. It is assumed that \( S = 3 \) and error is 0.4 where as \( K=2 \). Jehanzeb (1999) has also taken a sample size of 200 for his study. Of the total population engaged in agriculture, 65 % were using mechanized method and the rest were applying traditional method of cultivations. The sample size was, therefore, proportionately distributed in the mechanized and traditional farms. As such 130 respondents were randomly selected from the mechanized category and the rest from the traditional.

Data Collection
This study is primarily based on farm level data collected through the sample survey. The data were collected from the farmers through a structural performa. Regarding information on mechanization, the ideal method would be to use data on the input of tractor power (tractor-hours) per farm \cite{Rao1974}. Thus, information on the use of tractor was gathered in the form of tractor-hours used per farm. Both animal power and labour were also measured in animal hours and labour hours at a farm level. Thus, prediction regarding the employment or displacement of labour in this case was strictly limited to farm only. It did not capture the indirect employment generated or displaced in the process of manufacturing, distribution and servicing of tractor with related equipments, fertilizers, other non-agricultural inputs, and marketing and distribution of additional output.

The cost incurred on inputs was measured in terms of the prices paid by respondents for each input. However, for some of the family provided resources like labour, animal power and farm yard manure, the local market prices were used to impute a cost to these inputs. The unit of measurement of land in the study area was “Jareeb” (1 Jareeb=0.5 acre=0.2 hectar), so the data were collected in Jareeb. However, it were converted and presented in the study in hectare.

Description of the Variables
The list of the variables included labour, animal power, use of tractor along with accompanied equipments, seed, farmyard manure (FYM), chemical fertilizers, irrigation, and other costs (i.e. rent of land, expenditure on Pest/Inst. measurements and refreshment served to labour). The outputs included main product and by-product.

Basic Tests
As said earlier, we collected data from mechanized and traditional farms. However, before going to analysis it is necessary to test whether there is any difference between the mentioned groups or not. For this purpose our hypothesis that there was no difference between the two groups i.e. mechanized
and traditional farms, was tested for its validity on the assumption of normal population. The original hypothesis was equivalent to two separate hypotheses:

a. No differences between the means; and
b. No differences between the variances.

A t-test was used for (a) and Chow test was used for (b) (Gujrati 1987) and both the tests are summarized below:

**Test for Difference Between the two Means**

As there were two unpaired, independent samples, so the following t-test was used:

\[
t = \frac{\bar{X}_1 - \bar{X}_2}{\delta \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}
\]

where as \(\delta\) is unknown and

\[
= \sqrt{\frac{n_1 S_1^2 + n_2 S_2^2}{n_1 + n_2 - 2}}
\]

\(\bar{X}_1, \bar{X}_2\) are the sample means of mechanized and traditional farms respectively and \(S_1^2\) and \(S_2^2\) are the respective sample variances. The null hypothesis to be tested is that the two population means are identical i.e. \(H_0: \mu_1 = \mu_2\).

**Test for Differences Between Variances**

The hypothesis of “no differences between the two variances” was tested here by using Chow-test.

The null hypothesis \(H_0 : \delta_1 = \delta_2^2\) was tested against the alternative hypothesis \(H_1 : \delta_1^2 \neq \delta_2^2\). The Chow-test, was used to test the hypothesis of similarity. The Chow - test is as:

\[
F = \frac{S_a/k}{S_b/n_1+n_2-2k}
\]

Where as F is distributed with \((k, n_1+n_2-2k)\) degree of freedom

\(S\) : stands for Residual Sum of Square (RSS);
\(n_1\) = sample size of 1st population;
\(n_2\) = sample size of 2nd population;
\(k\) = number of parameters estimated;
\(S_b = S_1 + S_2\) [Residual Sum of Square (RSS) of the respective population];
\(S_a = S_c - S_b\) [where as \(S_c\) is the RSS of the combined Regressors];

**Application of the Tests**

Before going to the “Results and Discussion” section the above test were applied on the data so as to check significant differences in the two farming communities. In the following paragraphs detail of the above tests for both the mechanized and traditional farms is given.

The results in Table I are for difference in means and in Table II are for the difference in variances.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measured Values</th>
<th>t-Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat Area (hectare)</td>
<td>2.08</td>
<td>1.42</td>
</tr>
<tr>
<td>Seed (Kg.)</td>
<td>106</td>
<td>108</td>
</tr>
<tr>
<td>Farm Yard Manure (trolley)</td>
<td>2.6</td>
<td>3.65</td>
</tr>
<tr>
<td>Fertilizer (bag)</td>
<td>6.2</td>
<td>5.3</td>
</tr>
<tr>
<td>Water (Rs.)</td>
<td>225.1</td>
<td>450.45</td>
</tr>
<tr>
<td>other (Rs.)</td>
<td>10674.5</td>
<td>10132</td>
</tr>
<tr>
<td>Labour (Hrs)</td>
<td>75.65</td>
<td>357.4</td>
</tr>
<tr>
<td>Animal power(Hrs)</td>
<td>0.0</td>
<td>18.75</td>
</tr>
<tr>
<td>Tractor use (Hrs)</td>
<td>10.05</td>
<td>4.45</td>
</tr>
<tr>
<td>Output (Rs.)</td>
<td>49783</td>
<td>44643</td>
</tr>
<tr>
<td>No. of observations</td>
<td>130</td>
<td>70</td>
</tr>
</tbody>
</table>

Source: Based on Tables III & IV

* Significant at 5 %; ** Significant at 10 %
### Table II

**Test of equality between variances of mechanized and traditional farms**

<table>
<thead>
<tr>
<th>Farming System</th>
<th>RSS</th>
<th>DF</th>
<th>Chow value (F calculated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanized</td>
<td>0.106</td>
<td>123</td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td>0.020</td>
<td>63</td>
<td>31.11*</td>
</tr>
<tr>
<td>Combined</td>
<td>0.285</td>
<td>193</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Based on Tables III & IV

*Significant at 5%*

The general impression of the results (Table I) supports the differences between the means of mechanized and traditional farms. The test shows significance difference in variances (Table II) in mechanized and traditional farms. The calculated value of Chow-F-ratio for the crop is 31.11 against the tabulated value of 1.98, thus the hypothesis of equality between the variances is rejected.

### Specification of Econometric Model

The most generally applied Cobb-Douglas (CD) production function was applied. For the estimation SPSS and Excel were used. A cost function rather than a production function was used (Binswanger 1974). The general form of the CD function is expressed by \( \theta = AL^\alpha K^\beta e^\varepsilon \), where as \( \theta \) is output, L and K are inputs and \( \varepsilon \) is residual. However, the appropriate form of the function in agricultural related activities is its non-linear form. The corresponding coefficients of the regressor variables are the respective elasticities which give clear picture regarding the return to scale, whether constant, increasing or decreasing (Lau, and Yotopoulos 1978; Bernum and Squire 1979; Kuroda and Yotopoulos 1980; Adulavidhya 1984; Shah, H.N. (1993) ; Jehanjeb (1999) ). The general form of the function is as:

\[
Y = b_0 X_1^{b_1} X_2^{b_2} \ldots X_n^{b_n} e^\varepsilon
\]

In logarithmic form it can be written as:

\[
\ln Y = \ln[b_0 X_1^{b_1} X_2^{b_2} \ldots X_n^{b_n} e^\varepsilon]
\]

which can be expressed as:

\[
\ln Y = \ln b_0 + b_1 \ln X_1 + b_2 \ln X_2 + \ldots + b_n \ln X_n + \varepsilon
\]

where as:

\[
\ln \text{stands for natural logarithm.}
\]

\[
Y = \text{Income (output values)}
\]

\[
X_s = \text{various variables (Repressors explained above), and}
\]

\[
\varepsilon = \text{Error term}
\]

The analyses were based on cross sectional data where the auto-correlation problem is generally not considered. The Durban Watson (d) test, as pointed out by Gujarati (1987), is applied to the time series data for detecting auto-correlation. As explained by Loomis and Walsh (1997) that there is no problem of multi-colinearity if the correlation coefficient \( \rho < 0.80 \). We have calculated the correlation coefficients of all the variables used in the model, which are in the range of \( |0.5| \) i.e. lower than 0.8 so there is no problem of multi-colinearity. John (1984) has observed that if \( R^2 \) is less than 99 % then there is no problem of multi-colinearity. Kvalseth (1985) has pointed out that \( R^2 \) (Adjusted) is to be used instead of \( R^2 \).

### RESULTS AND DISCUSSION

The total area devoted to the wheat crop in the sample area accounted for 338.34 hectares. Of the total area, 72.38 % was covered by the mechanized farms and the remaining by traditional farms. It is worth mentioning to say at the outset that we estimated elasticities of all inputs and Marginal Physical Product (MPP) for labour, animal power and tractor, as we were interested in finding the contribution of these inputs. To get these measures the Cobb-Douglas (CD) function, as described above, was applied.

As mentioned earlier, there were significant differences in mechanized and traditional farms so they were treated separately. First we take mechanized farms to be followed by traditional farms. The labour used by the mechanized and
traditional farms has been presented which is
followed by a labour requirements model.

Mechanized Farms
The mechanized farms devoted a total area of
244.89 hectares to the wheat crop. The detailed
information regarding inputs and output of the crop
of the mechanized farms is presented in Table III
below:

<table>
<thead>
<tr>
<th>Inputs/output</th>
<th>Unit</th>
<th>Quantity</th>
<th>Price (Rs./Unit)</th>
<th>Value (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>Hrs</td>
<td>75.5</td>
<td>10.33</td>
<td>780</td>
</tr>
<tr>
<td>Tractor</td>
<td>Hrs</td>
<td>10.05</td>
<td>412.44</td>
<td>4145</td>
</tr>
<tr>
<td>Seed</td>
<td>Kg.</td>
<td>106</td>
<td>12.45</td>
<td>1320</td>
</tr>
<tr>
<td>FYM</td>
<td>Trolley(50 Mnd)</td>
<td>2.6</td>
<td>390.38</td>
<td>1015</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>Bag(50 Kg)</td>
<td>6.2</td>
<td>592.74</td>
<td>3675</td>
</tr>
<tr>
<td>Other costs</td>
<td>Rs.</td>
<td></td>
<td></td>
<td>10675</td>
</tr>
<tr>
<td>Water</td>
<td>Rs.</td>
<td></td>
<td></td>
<td>225</td>
</tr>
<tr>
<td>Total Costs</td>
<td>Rs.</td>
<td></td>
<td></td>
<td>21835</td>
</tr>
<tr>
<td>Grain Yield</td>
<td>Mound</td>
<td>94.2</td>
<td>450.11</td>
<td>42400</td>
</tr>
<tr>
<td>Straw yield</td>
<td>Bosara</td>
<td>5.25</td>
<td>1405.71</td>
<td>7380</td>
</tr>
<tr>
<td>Total revenue</td>
<td>Rs.</td>
<td></td>
<td></td>
<td>49785</td>
</tr>
<tr>
<td>Net income</td>
<td>Rs.</td>
<td></td>
<td></td>
<td>27950</td>
</tr>
</tbody>
</table>

Source: Survey

The production function (CD) for the crop in log linear form estimated for the mechanized farms is given in Table VII. However, a brief of the same is as:

\[
\ln Y = 7.20 + 0.03 \ln X_1 + 0.24 \ln X_2 + 0.15 \ln X_3 + 0.009 \ln X_4 + 0.05 \ln X_5 + 0.03 \ln X_6 - 0.13 \ln X_7
\]

\[
(10.029)^* (0.78) (4.154)^* (2.863)^* (1.271) (3.904)^* (0.855) (0.264)
\]

where as:

\[
Y = \text{Income (value of the produce)}
\]

\[
X_1 = \text{Labour cost}
\]

\[
X_2 = \text{Tractor cost}
\]

\[
X_3 = \text{Seed cost}
\]

\[
X_4 = \text{Farm Yard Manure Cost}
\]

\[
X_5 = \text{Fertilizers cost}
\]

\[
X_6 = \text{Water Cost}
\]

\[
X_7 = \text{Other costs}
\]

While in CD form the above equation can be produced as:

\[
Y = 1339.43 \; X_1^{0.03} \; X_2^{0.24} \; X_3^{0.15} \; X_4^{0.09} \; X_5^{0.05} \; X_6^{0.03} \; X_7^{-0.13} \; .... \; (1)
\]

\[
R^2_{(Adj)} = 0.475, \quad F^* = 10.65
\]

* Significant at 5 %

(Figures in parentheses are t-value)

The F-value shows significance of the model. The
\[
R^2_{(Adj)}
\]
value shows that over 47 % of the variations have been captured by the exogenous variables. The value of \[
R^2_{(Adj)}
\] is low; however, it is very common in cross sectional data (Salam, 1981). The powers (coefficients) are the
elasticities of the respective variables. The sum of the coefficients Table VII) arrived at 0.38 which is
less than one and so there is a decreasing return to scale.

Taking derivative of the above equation –1 with respect to (w.r.t) \( X_1 \) and \( X_2 \) and substituting the average values from \( X_1 \) to \( X_7 \) we get

\[
\text{MPP}_{\text{lab}} = 4.62, \quad \text{MPP}_{\text{tractor}} = 6.49
\]

Both the values suggest that there is high return to scale in the case of mechanized farms. Moreover, the tractor return is higher than that of the labour. This means that any additional investment in mechanization will yield better results as compared to labour.

**Traditional Farms**

The traditional farms devoted 93.45 hectares of land to the wheat crop. The detail of the inputs and output of the crop in the case of traditional farm can be seen in Table IV below:

<table>
<thead>
<tr>
<th>Inputs/output</th>
<th>Unit</th>
<th>Quantity</th>
<th>Price (Rs.)/Unit</th>
<th>Value (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>Hrs</td>
<td>357.4</td>
<td>10.28</td>
<td>3675</td>
</tr>
<tr>
<td>Animal power</td>
<td>Hrs</td>
<td>18.75</td>
<td>34.93</td>
<td>655</td>
</tr>
<tr>
<td>Tractor</td>
<td>Hrs</td>
<td>4.45</td>
<td>174.15</td>
<td>5225</td>
</tr>
<tr>
<td>Seed</td>
<td>Kg</td>
<td>107.8</td>
<td>17.02</td>
<td>1835</td>
</tr>
<tr>
<td>FYM</td>
<td>Trolley (50 Mnd)</td>
<td>3.65</td>
<td>472.6</td>
<td>1725</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>Bag (50 Kg)</td>
<td>5.3</td>
<td>484.91</td>
<td>2570</td>
</tr>
<tr>
<td>Other costs</td>
<td>Rs.</td>
<td></td>
<td></td>
<td>10130</td>
</tr>
<tr>
<td>Water cost</td>
<td>Rs.</td>
<td></td>
<td></td>
<td>450</td>
</tr>
<tr>
<td>Total Costs</td>
<td>Rs.</td>
<td></td>
<td></td>
<td>26355</td>
</tr>
<tr>
<td>Grain Yield</td>
<td>Mound</td>
<td>82.9</td>
<td>449.88</td>
<td>37295</td>
</tr>
<tr>
<td>Straw yield</td>
<td>Bosara</td>
<td>4.7</td>
<td>1562.77</td>
<td>7345</td>
</tr>
<tr>
<td>Total revenue</td>
<td>Rs.</td>
<td></td>
<td></td>
<td>44640</td>
</tr>
<tr>
<td>Net income</td>
<td>Rs.</td>
<td></td>
<td></td>
<td>18285</td>
</tr>
</tbody>
</table>

Source: Survey

The detail of the production function (CD) is given in Table VIII. However, a brief summary in log linear form is presented below:

\[
\ln Y = 5.8 + 0.09\ln X_1 + 0.04\ln X_2 + 0.3\ln X_3 + 0.09\ln X_4 + 0.03\ln X_5 + 0.03\ln X_6 + 0.03\ln X_7 - 0.15\ln X_8
\]

\[ (5.53)^* (2.11)^* (0.518) (3.321)^* (1.125) (3.511)^* (1.348) (0.694) (1.767) \]

Where as:

- \( Y \) = Income (Production Value)
- \( X_1 \) = Labour (Rs)
- \( X_2 \) = Animal power (Rs)
- \( X_3 \) = Tractor (Rs)
- \( X_4 \) = Seed Cost
- \( X_5 \) = Farm Yard Manure Cost
- \( X_6 \) = Fertilizer Cost
- \( X_7 \) = Water Cost
- \( X_8 \) = Other Costs

The results of the production function show that over 48% of the variations have been explained by the exogenous variables. The F-value gives significance of the model. The powers (coefficients) are the elasticities of the respective variables. The sum of the elasticities (as given in Table VIII) stood at 0.45 (i.e. less than one) which means that traditional farms are operating in decreasing return to scale.

Differentiating the above equation – 2 w.r.t \( X_1, X_3 \) and \( X_5 \) and substituting the average value of all the
variables from $X_1$ to $X_8$, we get the MPP of labour, animal power and tractor as:

\[
\begin{align*}
\text{MPP (Labour)} & = 0.602 \\
\text{MPP (Animal)} & = 1.521 \\
\text{MPP (Tractor)} & = 1.426 \\
\end{align*}
\]

The results of the MPPs show that labour is increasing with a decreasing return to scale. This may be due to excessive use of labour by traditional farms. As can be seen that in the case of mechanized farms the labour is giving increasing return to scale, which means that machinery is complimenting the labour. The MPP of tractor is giving increasing return to scale but it is much lower than that of the mechanized farms. The reason is that the traditional farms apply machinery only for threshing purposes.

**Labour Requirements of the Wheat Crop by Mechanized and Traditional Farms**

Labour is one of the basic inputs of production. The amount of this input varies with a change in production process. In the case of wheat production, for example in our case, generally there were two production methods namely mechanized and traditional. Both the farming communities used labour. However, the amount of labour requirements of mechanized and traditional farming is significantly different. As can be seen in Table-III and Table-IV that per hectare labour requirements of the mechanized farm is 75.5 man hours against 357.4 for the traditional farms. Similarly the animal power input has been limited to traditional farms. These observations show that tractor has been substituted for labour and animal power. McInerney and Donaldson (1975) have observed that mechanization has reduced the labour requirements by nearly 40 per cent. Lawrence (1970) has also observed that the overall use of labour/acre of wheat was higher on bullock farms than on tractor farm. A similar view has also been given by Singh (1968); Beg (1971); Harry (1972); and Ali (1992).

**Labour Requirements Model for the Wheat Crop**

The labour requirements are related to the amount of time allocated to agricultural machinery and animal power and to inputs and outputs. The inputs and outputs can not be taken quantitatively because they are measured in different units, so we have taken these in money terms (Salam 1981). The detail of the model is given in Table-IX and a brief description is presented below:

\[
\begin{align*}
\text{Labour (time)} & = 60.464 - 3.064 X_1 + 0.002 X_2 - 0.005 X_3 + 0.839 X_4 - 44.909 \\
\end{align*}
\]

\[
\begin{align*}
(1.201) & \quad (0.956) \quad (2.02) * \quad (2.503) * \quad (2.046) * \quad (9.546) *
\end{align*}
\]

$R^2$ (Adj) = 0.493, $F^*$ = 18.01

*Significant at 5 %

where as:

\[
\begin{align*}
Y & = \text{Labour time} \\
X_1 & = \text{Tractor time} \\
X_2 & = \text{Output (Rs)} \\
X_3 & = \text{Input (Rs)} \\
X_4 & = \text{Animal time} \\
X_5 & = \text{Dummy} \quad [1 \text{ for mechanized}, 0 \text{ other-wise (i.e. for animal etc.)}] \\
\end{align*}
\]

The results show that over 49 % of the variations have been covered by the induction of the exogenous variables. The value of $F$ is significant.

The results are consistent, because all the signs of the estimated coefficients are in conformity with the expected ones (Subhan, 2002). As the Dummy variable is significant so the mechanized and traditional farms labour model will be:

\[
\begin{align*}
Y & = 15.555 - 3.064 X_1 + 0.002 X_2 - 0.005 X_3 \quad \text{(Mechanized Farms)} \\
Y & = 60.464 - 3.064 X_1 + 0.002 X_2 - 0.005 X_3 + 0.83X_4 \quad \text{(Traditional Farms)} \\
\end{align*}
\]

The results reveal that, holding all other factors as constant, the animal power and output encourage the labour requirements. It is also observed that input costs and tractor have adverse effect on the labour requirements. It is understood that with the increase in the cost of inputs their consumption
quantity will be reduced resulting a decrease in labour requirements. Increase in the output will need more labour to manage it. The application of animal power also needs labour and so its application increases labour requirements.

The tractor has negative but insignificance effect on labour. This shows that tractor is a substitute for labour. All factors remaining the same (ceteris paribus) a unit use of agricultural machinery reduces the labour requirements, in case of wheat crop, by over 3 times.

**CONCLUSION**
Agriculture is the single largest sector of the NWFP’s economy. Wheat is the major crop of the Province as well as of its Peshawar District. For the cultivation of the wheat crop both mechanized and traditional farming methods were used in the study area. The sum of income elasticities of each of the farming system (mechanized and traditional) was less than one. Both the categories can improve their income if the inputs are optimally utilized. The MPPs of labour and agricultural machinery of the mechanized farms were higher than that of the traditional farms. The mechanized farms used machinery and labour for the cultivation of the crop where as traditional farms mainly applied labour and animal power. The results of the study showed that labour requirements of the mechanized farms were nearly 20% of that of the traditional farms. A unit application of agricultural machinery reduces labour requirements by over 3 times. The input prices and labour have inverse relation. The output and animal power encourage labour requirements.

### Table VII
**Parameters estimates of mechanized farms**

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Variable</th>
<th>Co-efficient</th>
<th>Standard Error</th>
<th>T-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>7.20</td>
<td>0.718</td>
<td>10.029*</td>
</tr>
<tr>
<td>2</td>
<td>Labor</td>
<td>0.032</td>
<td>0.041</td>
<td>0.780</td>
</tr>
<tr>
<td>3</td>
<td>Tractor</td>
<td>0.239</td>
<td>0.057</td>
<td>4.154*</td>
</tr>
<tr>
<td>4</td>
<td>Seed</td>
<td>0.149</td>
<td>0.052</td>
<td>2.863*</td>
</tr>
<tr>
<td>5</td>
<td>FYM</td>
<td>0.0089</td>
<td>0.007</td>
<td>1.271</td>
</tr>
<tr>
<td>6</td>
<td>Fertilizer</td>
<td>0.053</td>
<td>0.014</td>
<td>3.904*</td>
</tr>
<tr>
<td>7</td>
<td>Water</td>
<td>0.028</td>
<td>0.033</td>
<td>0.855</td>
</tr>
<tr>
<td>8</td>
<td>Other costs</td>
<td>-0.126</td>
<td>0.026</td>
<td>0.264</td>
</tr>
</tbody>
</table>

Source: Based on Tables III & IV

R² (Adj) = 0.75,  F* = 10.65

* Significant at 5 % (t(0.025,222), F(7,222))

### Table VIII
**Parameter estimates of traditional farms**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Variable</th>
<th>Co-efficient</th>
<th>Standard Error</th>
<th>T-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>5.81</td>
<td>1.051</td>
<td>5.530*</td>
</tr>
<tr>
<td>2</td>
<td>Labour</td>
<td>0.093</td>
<td>0.044</td>
<td>2.110*</td>
</tr>
<tr>
<td>3</td>
<td>Animal power</td>
<td>0.041</td>
<td>0.027</td>
<td>0.518</td>
</tr>
<tr>
<td>4</td>
<td>Tractor</td>
<td>0.306</td>
<td>0.092</td>
<td>3.321*</td>
</tr>
<tr>
<td>5</td>
<td>Seed</td>
<td>0.090</td>
<td>0.080</td>
<td>1.125</td>
</tr>
<tr>
<td>6</td>
<td>FYM</td>
<td>0.003</td>
<td>0.001</td>
<td>3.511*</td>
</tr>
<tr>
<td>7</td>
<td>Chemical fertilizer</td>
<td>0.031</td>
<td>0.023</td>
<td>1.348</td>
</tr>
<tr>
<td>8</td>
<td>Water</td>
<td>0.034</td>
<td>0.049</td>
<td>0.694</td>
</tr>
<tr>
<td>9</td>
<td>Other costs</td>
<td>-0.152</td>
<td>0.086</td>
<td>1.767**</td>
</tr>
</tbody>
</table>

Source: Based on Tables III & IV

R² (Adj) = 0.48,  F* = 22.79

* Significant at 5 % (t(0.025,61), F(8,61))

** Significant at 10% (t(0.025,61), F(8,61))
Table IX  
Labour requirements of wheat crop: regression estimates

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Variable</th>
<th>Co-efficient</th>
<th>Standard Error</th>
<th>T-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>60.464</td>
<td>49.958</td>
<td>1.201</td>
</tr>
<tr>
<td>2</td>
<td>Tractor time</td>
<td>-3.064</td>
<td>3.20</td>
<td>0.956</td>
</tr>
<tr>
<td>3</td>
<td>Output (Rs)</td>
<td>0.002</td>
<td>0.001</td>
<td>2.023*</td>
</tr>
<tr>
<td>4</td>
<td>Input (Rs)</td>
<td>-0.005</td>
<td>0.002</td>
<td>2.503*</td>
</tr>
<tr>
<td>5</td>
<td>Animal time</td>
<td>0.839</td>
<td>0.410</td>
<td>2.046*</td>
</tr>
<tr>
<td>6</td>
<td>Dummy</td>
<td>-44.909</td>
<td>4.704</td>
<td>9.546*</td>
</tr>
</tbody>
</table>

Source: Based on Tables III & IV
$R^2_{(Adj)} = 0.493, \quad F^* = 18.01$
* Significant at 5% ($t_{0.025,194}, \quad F_{(5,194)}$)

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