Supply Response Analysis of Wheat Growers in District Peshawar: Pakistan.

Raza Ullah, Shahid Ali, Qaisar Shah Safi, Jamal Shah and Kamran Haider Khan

1. Introduction

The importance of estimating valid elasticities of farm output supply and input demand can hardly be overemphasized. Reliable estimates of these elasticities are sine qua non for predicting accurately the farmer responsiveness to changes in input-output prices and government taxes and thereby for formulating successful agricultural incentive programmes consistent with national requirements of feed, development and exports. In fact, robust estimates of the coefficients of such elasticities can serve as a solid basis in determining effective policy relevant interventions for promoting production, equity, efficiency, and finally egalitarian income distribution in the farm sector of the economy (Chaudhary, et al 1998).

Since the introduction of a series of policy reforms in agriculture sector of Pakistan, supply response has become more important and crucial research agenda for agricultural growth in Pakistan. To assess the impact of incentives, adopted agricultural policies and to understand possible adjustments to improve policies in changed scenario, supply response analysis from time to time is essential (Mohammad, et al 2007).

Sidhu and Baanante (1981) argued that the elasticity estimates for input demand and output supply include both the price elasticities and the elasticities with respect to several other variables that are usually considered as constraints on farm production. Thus, policy analyses which evaluate the impact of changes in single price or non-price variables or combinations of them become available. Byerlee et al. (1993) and Ali (1995) suggest that realizing future productivity gains in Pakistan and other parts of South Asia will require significant adjustments in the institutions serving agriculture. Chaudhary et al. (1998) concluded that farmers are price-responsive and prevalence of fair output and input prices is important for preservation of farmer incentive for higher production. Farooq et al. (2001) concluded that a support price policy appears to be inadequate. Supplementary measures aimed at promoting expansion in area and use of quality seeds possibly through extension projects, are also desirable. Rehman and Parkinson (2006) found that changes in market prices of inputs and outputs significantly influenced farmers’ resource use and productivity. The purpose of this paper is to apply the normalized restricted translog profit function and the corresponding system of derived demand equations to the farm-level data for wheat from two villages of district Peshawar, Pakistan in order to generate policy-relevant empirical estimates for wheat supply and input demand function. The study addresses some of the issues that need to be confronted in determining what adjustments might be appropriate. In particular, the study explores the response of wheat producers in district Peshawar of Pakistan, to changes in prices and fixed inputs.

2. Data Collection and Sampling

For this study, the proportional allocation sampling technique was adopted in order to get the required sample size of 100. Two villages of district Peshawar (Regi and Lakarai Kaneza) were randomly selected as the universe of the study. The survey was undertaken between June and August, 2009. The reason for selecting this time was that by June, farmers have finished their wheat harvesting and marketing, hence there is a high probability of meeting the farmer and he can provide sufficient time for interview.

3. Specification of Empirical Model

A generalization of the normalized restricted translog profit function for a single output is given by Diewert (1974); Christensen, et al. (1971),

\[ \ln \Pi' = \alpha_0 + \alpha_1 \sum_{j=1}^n \ln P_j + 1/2 \sum_{j=1}^n \sum_{k=1}^m \gamma_{jk} \ln P_j \ln P_k + \sum_{h=1}^n \sum_{k=1}^m \delta_{hk} \ln P_j \ln z_k + \sum_{i=1}^n \beta_i \ln z_i + 1/2 \sum_{j=1}^n \sum_{k=1}^m \theta_{jk} \ln z_k \ln z_j \]

where

\[ \Pi' = \text{Restricted profit, } \Pi, \text{ normalized by the output price (P_v)} \]
\( P'_{i} \) = Price of ith input \((P_i)\) normalized by the output price \((P_w)\)

\[
P'_{i} = \frac{P_i}{P_w}
\]

\( i=j = 1 \), Labor

\( i=j = 2 \), Fertilizer

\( Z_k \) = Quantity of fixed input, \( k \)

\( k=h = 1 \), Area under wheat crop

\( k=h = 2 \), Average no. of schooling years per male family member above 13 years

\( \alpha_0, \alpha_i, \gamma_{ij}, \delta_{ik}, \beta_k \) and \( \theta_{kh} \) are parameters to be estimated.

The corresponding share equations are expressed as,

\[
S_i = S_w = \frac{X_i}{\Pi} = -\frac{\partial \ln \Pi^*}{\partial \ln P^*_{i}}
\]

\[
S_w = \frac{P_w X_w}{\Pi} = 1 + \frac{\partial \ln \Pi^*}{\partial \ln P^*_{w}}
\]

Where \( S_i \) is the share of ith input, \( S_w \) is the share of output, \( X_i \) denotes the quantity of input \( i \) and \( X_w \) is the level of wheat output. Since the input and output shares come from a singular system of equations, one of the share equations, the output share, was dropped and the profit and factor demand equations were estimated as a simultaneous system (Farooq, et al. 2001).

4. Estimation of Elasticities

i. Input Demand Elasticities

The own price elasticity of demand for variable input \( i \) \((\eta_i)\), was estimated as:

\[
\eta_i = - S_i - \gamma_i / S_i - 1
\]

Where \( S_i \) is the ith share equation, at the sample mean.

For the cross-price elasticity of demand for ith variable input with respect to the price of jth variable input \((\eta_{ij})\), the following expression was used.

\[
\eta_{ij} = - S_j - \gamma_{ij} / S_i \quad \text{for} \quad i \neq j
\]

The following equation was used for estimating the elasticity of demand for variable input with respect to output price, \( P_w (\eta_{iw}) \)

\[
\eta_{iw} = S_w + \gamma_{ij} / S_i
\]

The elasticity of demand for variable input with respect to kth fixed factor, \( \eta_{ik} \) was calculated as:

\[
\eta_{ik} = \beta_k + \delta_{ik} \ln P^*_{i} + \theta_{kh} \ln Z_h + \sum_{i=1}^{2} \delta_{ik} S_w
\]

ii. Output Supply Elasticities

To compute the elasticity of output supply with respect to price of ith variable input \((\epsilon_{wi})\) the following equation was used.

\[
\epsilon_{wi} = - S_i - \gamma_i / S_w
\]

The own price elasticity \((\epsilon_{ww})\) was calculated using the following equation

\[
\epsilon_{ww} = \sum_{i=1}^{2} S_i + \gamma_{ij} / S_w
\]

The elasticity of output supply with respect to fixed input \( k \) \((\epsilon_{wk})\) was computed as:

\[
\epsilon_{wk} = \beta_k + \sum_{i=1}^{2} \delta_{ik} \ln P^*_{i} + \theta_{kh} \ln Z_h + \sum_{i=1}^{2} \delta_{ik} S_w
\]

iii. Profit Elasticities

These are defined as:

\[
\frac{\partial \ln \Pi^*}{\partial \ln P^*_{i}}
\]

For the elasticity of profit with respect to changes in input prices and

\[
\frac{\partial \ln \Pi^*}{\partial \ln Z_k}
\]

For the profit elasticity with respect to changes in fixed inputs.

5. Empirical Estimation of the Model
The empirical application is now fairly straightforward. First, the model is specified in actual variables, and the variables are defined, second, the parameters of the model are estimated using Ordinary Least Squares (OLS). Then the estimation results are presented and discussed (Sidhu and Baanante, 1981).

### Model Specification

From the general function, the normalized restricted translog profit function can be specified in actual variables as:

\[
\ln \Pi_w^* = \alpha_0 + \alpha_1 \ln P_L + \alpha_2 \ln P_F + \beta_1 \ln Z_1 + \beta_2 \ln Z_2 + \frac{1}{2} \gamma_{LL}(\ln P_L)^2 + \frac{1}{2} \gamma_{FF}(\ln P_F)^2 + \frac{1}{2} \gamma_{LF}(\ln P_L)(\ln P_F) + \delta_{L1} \ln P_L \ln Z_1 + \delta_{L2} \ln P_L \ln Z_2 + \delta_{F1} \ln P_F \ln Z_1 + \delta_{F2} \ln P_F \ln Z_2 + \theta_{11}(\ln Z_1)^2 + \frac{1}{2} \theta_{22}(\ln Z_2)^2
\]

#### Labor:
Labor input used in the model comprised the family labor and the casually hired labors and was normalized by the output price. It was transformed into monetary expenditure by adding the imputed cost of family labor at the permanently hired labor wage rate in the area concern to the expenditure on the casual and/or regularly hired labor. The weighted average of the daily money wage rate was calculated by dividing the total labor expenditure by the labor days per farm. It is represented by $P_L$ in the model.

#### Fertilizer:
Fertilizer input per farm was measured as money price of fertilizer per kilogram normalized by the output price. It was a weighted price per kilogram of fertilizer worked for all kinds of fertilizers used by the sample farmers. More specifically, it was obtained by dividing the total fertilizer expenditure per farm by the total kilogram of fertilizer used and is represented by $P_F$ in the model.

### Parameter Estimates of the Translog Profit Function

<table>
<thead>
<tr>
<th></th>
<th>Intercept</th>
<th>$\ln P_L$</th>
<th>$\ln P_F$</th>
<th>$\ln Z_1$</th>
<th>$\ln Z_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Profit</strong></td>
<td>7.258</td>
<td>-0.844</td>
<td>-0.183</td>
<td>1.078</td>
<td></td>
</tr>
<tr>
<td><strong>Function</strong></td>
<td>-6.339</td>
<td>-4.181</td>
<td>-1.706</td>
<td>-1.037</td>
<td>0.276</td>
</tr>
<tr>
<td><strong>Share equation</strong></td>
<td>-0.844</td>
<td>-0.151</td>
<td>-0.066</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td><strong>Of labor</strong></td>
<td>-4.181</td>
<td>-1.407</td>
<td>-0.592</td>
<td>-0.348</td>
<td>-0.297</td>
</tr>
<tr>
<td><strong>Share equation</strong></td>
<td>-0.183</td>
<td>-0.066</td>
<td>-0.728</td>
<td>-0.177</td>
<td></td>
</tr>
<tr>
<td><strong>Of fertilizer</strong></td>
<td>-1.706</td>
<td>-0.592</td>
<td>-0.68</td>
<td>-0.188</td>
<td>0.005</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$(\ln P_L)^2$</th>
<th>$(\ln P_F)^2$</th>
<th>$nP_L \ln P_F$</th>
<th>$nP_L \ln Z_1$</th>
<th>$\ln P_L \ln Z_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.151</td>
<td>0.728</td>
<td>0.066</td>
<td>.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.407</td>
<td>0.68</td>
<td>0.592</td>
<td>0.348</td>
<td>0.297</td>
</tr>
<tr>
<td></td>
<td>$nP_L \ln Z_1$</td>
<td>$nP_L \ln Z_2$</td>
<td>$\ln Z_1^2$</td>
<td>$\ln Z_2^2$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.177</td>
<td>.005</td>
<td>0.072</td>
<td>0.228</td>
<td>.063</td>
</tr>
<tr>
<td></td>
<td>0.188</td>
<td>0.134</td>
<td>0.066</td>
<td>0.134</td>
<td>0.095</td>
</tr>
</tbody>
</table>
Land: Land input was measured as the cultivated land acres operated by sample households. It is represented by $Z_1$ in the model.

Education: It was measured as the average number of years of schooling per male family member above 13 years of age. It is represented by $Z_2$ in the model.

Fertilizer and labor in addition with animal power, are the three major inputs that are essential in producing any crop and contribute significantly to total cost of production (Rahman, 1999). Total cultivated land devoted to modern rice is expected to have significant positive association with quantities of input demanded (Rehman and Parkinson, 2006). Studies found land to be the most important input in crop production with a very high level of output elasticity (Wadud and White, 2000).

6. Empirical Results and their Implication

Restricted parameter estimates of the normalized restricted translog profit function and the demand equations for labor and fertilizer are presented in table 1.

Table 2: Estimated Elasticities Of Output Supply And Inputs Demand

<table>
<thead>
<tr>
<th></th>
<th>Output Price</th>
<th>Wage Rate</th>
<th>Fertilizer</th>
<th>Land</th>
<th>Education Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>1.66</td>
<td>-0.894</td>
<td>-0.741</td>
<td>1.932</td>
<td>0.053</td>
</tr>
<tr>
<td>Labor</td>
<td>2.613</td>
<td>-1.755</td>
<td>-0.694</td>
<td>1.644</td>
<td>0.123</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>2.599</td>
<td>-0.832</td>
<td>-0.816</td>
<td>1.258</td>
<td>0.270</td>
</tr>
<tr>
<td>Profit</td>
<td>2.685</td>
<td>-0.919</td>
<td>-0.766</td>
<td>1.549</td>
<td>0.036</td>
</tr>
</tbody>
</table>

Source: (Derived from Survey Data, 2008-09)

The co-efficient of determination ($R^2 = 0.966$) shows that the explanatory variables explained 96% variation in the dependent variable. The F value show that the model is good to fit and the DW value (1.969) indicates that there is no autocorrelation problem in the model. The parameter estimates of the normalized restricted translog profit function are used to derive the output supply, input demand and profit elasticities with respect to output price, wage rate, fertilizer price, land and education. The derived elasticities are presented in the following table.

The output response of farmers in the region to increase in the wheat price is found to be positive and elastic; a one percent rise in the price of wheat would expand the supply of wheat by 1.660 percent. Increase in the wheat price would also encourage direct and significant expansion in demand for variable inputs. In quantitative terms, the percent increase in demand for labor associated with one percent rise in wheat price was 2.613 percent and for fertilizer it was 2.599 percent. Rise in the price of wheat will also increase the profit of farmers in the study area, one percent increase in the price of wheat will increase the profit by 2.685 percent.

The own-price elasticities of demand for variable inputs are negative, as expected, and price elastic. In case of labor the own-price elasticity is -1.755, a one percent rise in the wage rate will decrease the demand for labor by 1.755 percent. In case of fertilizer the own-price elasticity is -0.816, one percent rise in fertilizer price will discourage its application by 0.816 percent. Increasing the price of variable inputs would also have a depressing impact on the supply of wheat, one percent rise in wage rate will decrease wheat supply by 0.894 percent and the similar kind of rise in fertilizer price will adversely effect the supply of wheat by 0.741 percent. Rise in the variable input prices also affected profit, as the elasticities of profit with respect to labor and fertilizer are negative. One percent rise in wage rate will decrease the profit of the farming household by 0.919 percent and in case of fertilizer, one percent rise in fertilizer prices will decrease the profit by 0.766 percent.
On the whole, changes in market price, whether input or output prices, significantly affected resource use. Wheat supply and farmer’s profit, the farmer’s response to changing prices, input or output prices, was significant in the study area.

The elasticity of the labor demand with respect to fertilizer price is -0.694, one percent increase in the price of fertilizer will decrease the demand for labor by 0.694 percent. The elasticity of fertilizer with respect to wage rate is also negative -0.832, one percent rise in wage rate will discourage fertilizer application by 0.832 percent. The negative elasticity indicates that fertilizer and labor are complementary inputs. The complementarity in the relationship of labor and fertilizer has important implications. Their combined application increase farm production synergistically. Further, additional labor out of the unemployed workforce could be employed in agriculture by increasing its level of fertilizer application.

Elasticity of labor with respect to fixed input land is positive 1.644, it indicates a fair degree of farm sector responsiveness to labor absorption. One percent increase in land under wheat will increase the demand for labor by 1.644 percent. Fertilizer elasticity with respect to land is 1.258, one percent increase in wheat area would expand the demand for fertilizer by 1.258 percent. The elasticity of profit with respect to land is also positive and elastic, one percent increase in the wheat area will increase the profit of the farmer by 1.549 percent. The elasticities of labor and fertilizer with respect to education are 0.123 and 0.270 respectively, indicates that substantial rise in education level of the household will increase the demand for the variable inputs. The elasticity of profit with respect to education is 0.036, one percent rise in the education level of the farming household will increase their profit by 0.036.

The elasticities of wheat supply with respect to fixed inputs, land and education, are positive. Wheat supply elasticities with respect to land and education are 1.932 and 0.053 respectively. Land has significant effect on wheat supply, and expansion in fixed input land will raise the supply of wheat and the profit of farmers significantly. The effect of education on wheat supply and profit is also positive but inelastic in the study area.

**7. Conclusion and Recommendations**

The analysis revealed that farmers are price-responsive and assured prevalence of fair output and input prices is essential for preservation of farmer incentive for higher production of wheat. Further, increased fertilizer application affected on-farm employment positively. Increase in the area under wheat crop significantly increases the wheat supply, profit and influence the demand for the variable inputs. On the other hand education level of the farming household has also a positive but inelastic effect on the supply of wheat, profit of the farmer and demand for variable inputs. The results of the study suggest that the government should subsidize fertilizer prices to encourage its application. Increasing fertilizer application will not only increase output but will also encourage on-farm employment. Similarly, bringing more area under wheat cultivation will increase production and on farm employment.

**References**


Table 1 Area, Production & Yield of Wheat in Pakistan

<table>
<thead>
<tr>
<th>Year</th>
<th>Area '000' hectares</th>
<th>Production '000' tones</th>
<th>Yield per hectare in Kgs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-04</td>
<td>8216</td>
<td>19500</td>
<td>2375</td>
</tr>
<tr>
<td>2004-05</td>
<td>8358</td>
<td>21612</td>
<td>2568</td>
</tr>
<tr>
<td>2005-06</td>
<td>8448</td>
<td>21277</td>
<td>2519</td>
</tr>
<tr>
<td>2006-07</td>
<td>8494</td>
<td>23520</td>
<td>2769</td>
</tr>
<tr>
<td>2007-08</td>
<td>8414</td>
<td>21749</td>
<td>2585</td>
</tr>
</tbody>
</table>

Source: (GoP, 2008).

Table 2 Area, Production & Yield of Wheat in NWFP

<table>
<thead>
<tr>
<th>Year</th>
<th>Area '000' hectares</th>
<th>Production '000' tones</th>
<th>Yield per hectare in Kgs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-04</td>
<td>741.60</td>
<td>1025.20</td>
<td>1382.41</td>
</tr>
<tr>
<td>2004-05</td>
<td>748.60</td>
<td>1091.10</td>
<td>1457.52</td>
</tr>
<tr>
<td>2005-06</td>
<td>721.31</td>
<td>1100.6</td>
<td>1525.83</td>
</tr>
<tr>
<td>2006-07</td>
<td>754.24</td>
<td>1160.44</td>
<td>1538.55</td>
</tr>
<tr>
<td>2007-08</td>
<td>747.36</td>
<td>1071.82</td>
<td>1434.14</td>
</tr>
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</table>

Source: (Govt. of NWFP, 2008)