Small mechanization big benefits: farmers' willingness to pay for the two wheel tractor in the hilly areas of Pakistan

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Abstract

The current study was carried out in the hilly areas of Gilgit-Baltistan and Azad Jammu and Kashmir. In some of the hilly areas, the four wheel tractor are not used due to topography and the farmers still use bullock and hand implements for land preparation. For the current study, data were collected from the farmers by using a comprehensive questionnaire. The farmers willing to pay for the two wheel tractor indicates that farmers having higher education, secured land rights and owns higher household assets are normally willing to pay more for the two wheel tractors. Moreover, the farmers were willing to pay more for the imported tractors as compared to the local manufactured tractors. The farmers were willing to pay more the two wheel tractors if the implements can be drawn with the two wheel tractor and vice versa. For sustainability, the local production of the two wheel tractors can ensure the lower prices as well as initially the subsidy from the government side can help to popularize the two wheel tractors in Pakistan.

Key words: Willingness to Pay, Two Wheel Tractor, Pakistan

Introduction

Mechanization is the powered use of machine to replace or enhance human labor or animals' power. The farm mechanization is necessary to boost agricultural production or productivity through better cultivation of a large area, timely crop establishment, improved efficiency of resource-use, and better water management. It was primarily introduced during Green Revolution era in the developing nations. Use of bulldozers and tractors converted vast barren lands into productive agricultural fields. The introduction of tractors helped to increase the yield, cropping intensity and saved farmers' time. More than that, the farmers got rid of manual monotonous work of cultivating with bullocks (Maamun, 1991).

Difficulty in farm machineries' access to famers' fields predominantly accounts for less cultivated lands in hilly areas. The farm mechanization and farm productivity are as positively correlated in hilly areas as on plain lands. But the need of farm mechanization in hilly areas is even more necessary as the area is prone to unpredictable weather vagaries, with very limited span of cropping seasons as well. Therefore, one can minimize loss or even transform it into profit through timely farm operations with mechanized farming techniques (Singh, 2014).

Generally farmers plow their lands with hand-tools and bullocks at sloppy fragmented lands in most of the hilly areas. A four wheel tractor can work safely on slopes up to 8-10 percent, where plowing with bullocks is quite difficult. But two wheel tractors can work safely up to 13 percent slopes on small area (Esdaile *et al.,* 2012). Moreover, cultivation with two-wheel tractor is done ten times faster than manual hoeing and 2.5 times faster than animal-driven plow (Maamun, 1984).

Commonly, plow pan is formed below the root zone if repeated plowing is practiced with the traditional tines or animal driven plows. It hinders the water infiltration and enhances the erosion of upper most fertile layer of soil. This plow pan can be broken through the use of chisel plow. Furthermore, mechanization can help to utilize inputs in more effective way. It is proved that there exists a long term relationship between production and technological progress (Hye et al., 2007), therefore, mechanization convert resources into profit (Singh, 2014).

In major areas of the world, farmers with small land-holdings are using two wheel tractors. With the introduction of two wheel tractors in Bangladesh, some 30 years ago, a large number of farmers shifted from animal powered tillage system to mechanized farming. In 2009, there were 300'000 two-wheel tractors providing services in Bangladesh alone (Islam, 2009). In south Asia, small fields and affordable prices of two wheel tractors persuaded farmers to get rid of traditional plowing with bullocks and adopt two wheel tractors. Two wheel tractors can provides better weed management, saves time and reduce seed rates as compare to the broadcast method. Mechanized rice planting with direct seeder facilitates inter-rows weed management through hand or hand-operated tools, thereby reduces use of herbicides (Esdaile, 2012).

Two-wheel tractor is recognized as an appropriate pro-poor machine technology (Justice et al, 2004). It can perform diversified operations by using a range of modified implements. In the neighboring countries, like Bangladesh, many farmers use seed drill, strip tiller (effective for minimum and zero tillage), rotary tillage seed drill, the versatile multi-crop planter with two-wheel tractor (Haque et al., 2011). The two-wheel tractors are commonly known as power tillers that has been the part of farming system for many small farmers in developing countries due to small farm and fragmented field size combined with an affordable price (Rabi et al. 2012).

As per 2010 statistics, 700'000 four-wheel tractors are operating at farmers' fields and are also being used for transportation, earth-work and other related tasks in Pakistan. But tractor-land (in hectare) ratio of 1:31 in the country is still below the international standard of 1:25 that is because of slow pace of farm mechanization in hilly areas and non-existence of two wheel-tractor for agricultural purposes. However, fewer number of locally made two-wheel machinery, resembling with two-wheel tractor, can be seen on roads. Most of these are being used for transportation, oil extraction, stone crushing etc.

With less tractor-land ratio in the country, the farmers (though small in proportion) still depend on traditional plowing techniques (bullocks) in hilly areas of the country. As per agricultural census 2010 (Table 1), the overall

farmers in the country either use tractor (77 percent) or bullocks (4 percent) or both (20 percent) to cultivate their lands. The predominant use of draught animals by the farmers appeared in Khyber Pakhtunkhaw (13 percent) followed by Balochistan (5 percent), Sindh (4 percent) and Punjab (1 percent). Important to note here is that a significant proportion of the farms (20 percent) in the country also use both tractor and draught animals. Whereas one third farmers in Balochistan, less than one third (28 percent) in Khyber Pakhtunkhaw, one fifth in Sindh and little less than one fifth (17 percent) in Punjab are using both tractor and draught animals for different agricultural activities. The pattern of area under tractor, bullocks and both looks same as that of adopting farmers almost across the provinces and the country as a whole.

Gilgit-Baltistan (GB), formally known as Northern Areas of Pakistan, predominantly comprise of highly mountainous landscape with rivers and natural water channels running aside ravines and valleys. GB is recently awarded status of province by Govt. of Pakistan. The province comprises of seven districts like Astor, Gilgit, Diamir, Hunza-Nagar, Ghizer, Skardu and Ghanche. It covers an area of 72,971 km² in north-eastern part of Pakistan and ranges between 35.4 longitudes and 74.1 latitude. The region encompasses majestic cites with world renowned mountains, long glaciers, beautiful rivers and fabulous valleys. This region is dominated by worlds' highest peaks, over 8,000 meters and also situates convergence site of three gigantic mountain ranges namely Karakorum, Himalayas and Hindu Kush. Rocky peaks, steep and over hanged slopes chiefly feature the region. Minimum altitude of most of the area is 1500 meters above sea level, with more than half of the area lies even above 4500 meters (World Bank, 1997). Unique forests and dry fruits' plants naturally grown on these higher altitudes, yield precious wood and dry fruits that significantly contribute in economic activity of the area. Additionally, these uplands are watersheds for rivers, tributaries and valleys, where agricultural farming is being done.

The state of Azad Jamu & Kashmir (AJ&K) comes under Himalayan belt with highly mountainous topography featured primarily by deep gullies, crags and undulating territory. The state is located in north-eastern part of Pakistan, having total area of 13,297 km^2 stretching between 34.56 longitudes and 43.45 latitudes. Its average elevation is 1300 m above sea level. Topographic variations exists within the state as northern districts namely Sudhnoti, Poonch, Haveli, Bagh, Hattian, Muaffarabad and Neelum are mainly mountainous whereas Bhimber, Mirpur and Kotli are comparatively plain. The southern parts of AJ&K including Bhimber, Mirpur and Kotli districts are extremely hot in summers and moderate cold in winters. It receives rains mostly in monsoon season. In the central and northern parts of state, weather remains moderate hot in summers, and very cold with snowfall in winter. The average annual rainfall exceeds 1400 mm.

Due to topography few farmers have access to four wheel tractors and other mechanization implements both in AJK and GB. The main purpose of the current paper is to estimate the farmer's willingness to pay for the two wheel tractor in the hilly areas of Pakistan. For that

the rest of the paper is organized as follows; in section 2 empirical framework is presented; in section 3 methodology is discussed; in section 4 data and description of variables is discussed in section 5 empirical results are presented in section 6 conclusion with some policy recommendations are presented.

Methodology

Purposely potential northern hilly areas of the country were selected for conducting survey. An effort was made to cover valleys situated at different altitudes with different cropping patterns. A comprehensive questionnaire was designed to glean information from the farmers through one-to-one interviews. In total 53 percent farmers were interviewed from AJ&K and 47 percent from GB, were interviewed. The data thus obtained was then analyzed using SPSS and STATA statistical softwares. The data was collected from all the 7 districts of Azad Jamu & Kashmir and 3 districts of Gilgit Baltistan (Figure 1). This study looked into socio-economic features of the farmers, prevailing cropping patterns, adopted production technologies, area type, slope of land, fragmentation and field size, use of four wheel tractor, state of 2-wheel tractor awareness and usage, famers' cost estimation and willingness to use 2-wheel tractor, existing potential and constraints in adoption of two wheel tractor etc.

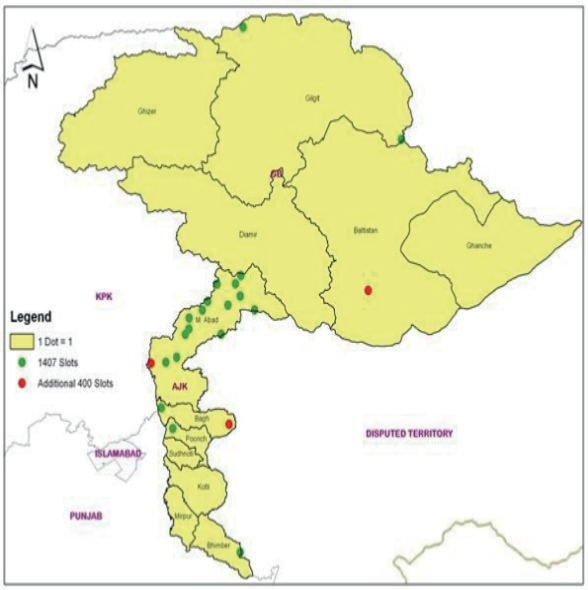

Figure 1: Map of Gilgit-Baltistan and AJK

Data and Description of Variables

The farmers' awareness regarding two wheel tractors are presented in Table 2. Majority of the farmers (more than 80 percent) have no awareness regarding two wheel tractors while only 20 percent have awareness about two wheel tractors. For the farmers having awareness about the two wheel tractor, majority of them have from the fellow farmers and friends and the rest from the agricultural department.

Majority of the farmers like (more than 70 percent) have shown interest in the willingness to purchase two wheel tractor and a similar number was interested to purchase the two wheel tractor if the implements can be drawn with the two wheel tractor. About 80 percent of the respondents were willing to have two wheel tractors on rent.

The description of the variables is presented in Table 3. The mean age of the farmers was 48 years. The mean education level was 7 years of schooling. The mean family size was

11 persons in the household. The average land holding was very small and it was only 0.23 hectares per household. About half of the farmers about 49 percent were participating in the non-farm activities. The per annum household income levels was rupees[i] 143,000. About 83 percent of the household have cultivated wheat and 100 percent of the households have cultivated maize and 21 percent of the households have cultivated vegetables and 38 percent of the households have cultivated rice. Only 30 percent of the households have four wheel tractors. None of the households have two wheel tractors. About 26 percent of the households have trolley ownership and none of the household have zero tillage ownership, only 5 percent of the households have MB plough ownership, about 21 percent of the households have combine harvester ownership; 4 percent of the household have rotavator ownership and 2 percent have ridges ownership and 34 percent have spray machine ownership. The mean level of the farmers experience was 33 years. The majority of the farmers i.e. 82 percent were the owner of the land. About 46 percent of the farmers have some organization's membership. The mean number of cattle owned by the household are 6 cattle per household. Only 13 percent of the households have access to metalled road. The mean numbers of adult male and female are almost the same. About 41 percent of the households have TV ownership and 86 percent of the households have fan ownership. About 18 percent of the households have access to credit facility. About 22 percent of the households have access to agricultural extension services.

The difference in key characteristics of the farmers willing to pay for the two wheel tractor and not willing to pay for the two wheel tractor is presented in Table 4. The difference in age is negative and significant at 5 percent level of significance indicating that the farmers willing to pay are young in age and vice versa. The difference in education is positive and highly significant at 1 percent level of significance indicating that educated farmers are more willing to pay for the two wheel tractor. The difference in experience is negative and significant. The difference in family size is negative and significant at 5 percent level of significance. The difference in farmer's ownership status is positive and significant indicating that owners are more willing to pay for the two wheel tractor. The difference in land holding is positive and significant at 10 percent level of significance. The difference in nonfarm participation and household income levels are also positive and significant indicating that household having higher income levels are more willing to have two wheel tractor and vice versa. The difference in wheat, maize, vegetables and rice cultivation is non-significant. The difference in implements ownership like four wheel tractor, trolley, MB plough, combine harvester, ridges etc. is positive and significant.

The difference in organization membership, cattle, road access and TV ownership is non-significant. The difference in refrigerator ownership is positive and significant. The difference in access to credit is positive and significant at 10 percent level of significance. Similarly the difference in agricultural extension service is positive and significant at 5 percent level of significance.

Empirical Framework

The farmer's willingness to pay for the two wheel tractor is dichotomous choice i.e. either farmers are willing to pay or they are not willing to pay. The farmer's choice can be written as latent variable as follows;

$$WTP^{*} = Z^{/}\beta + \varepsilon \qquad (1)$$

In equation 1, *WTP** is the farmer's latent (or unobserved) willingness to pay, $Z^{/}$ is vector of variables that influence the farmer's willingness to pay for the two wheel tractor, β *is a vector of parameters indicating the* relationship between willingness to pay and variables in $Z^{/}$ and ε is an independently and identically distributed error term with mean zero and variance 1.

If a farmers *WTP** falls within a certain range, their WTP is assigned a numerical value that reflects the category in which their unobserved willingness to pay lies.

In particular, if $\gamma_{j-1} < WTP^{*} \leq \gamma$, then, *WTP=j-1 for all j=1,……, J*

where j is the WTP category selected by the respondent and γ_k are the category threshold parameters. Threshold parameters represent points at which the change in utility is sufficiently high to merit a consumer being willing to pay more for the two wheel tractor. While threshold parameters are unobserved but they can be estimated statistically.

Furthermore, $-\infty = \gamma_0 < \gamma_1 < ..... < \gamma_j = \infty$ with γ_1 being set equal to zero during estimation. The probability of a WTP being in one of the *J* finite categories can now be written as;

$$\Pr(WTP = j-1) = \Phi(\ _j - \gamma Z^{/}\beta) - \Phi(\gamma_{j-1} - Z^{/}\beta) \forall j \in j \qquad (2)$$

Where $\Phi(.)$ is a cumulative density function (CDF), which measures the probability of WTP being less than the respective threshold level. The Logit model is estimated for the farmer's willingness to pay for the two wheel tractor i.e. 1 if the farmers are willing to pay for the two wheel tractor and 0 otherwise. In the empirical model a set of models are employed like CLAD model is estimated for the price the farmers are willing to pay for the two wheel tractor, while Tobit model is estimated for the price of the two wheel tractor and also the Poisson regression model is estimated for the number of implements to be drawn with the two wheel tractor.

Empirical Results

The farmers' willingness to pay for the two wheel tractor is presented in Table 5.The farmers choice was estimated as dichotomous choice i.e. 1 if the farmers are willing to pay for the two wheel tractor and 0 if they are not willing to pay for the two wheel tractor, hence for that Logit model is estimated. A set of independent variables is included in the model. The farmers' age coefficient is negative and significant indicating that young farmers were more willing to pay for the two wheel tractor. The education level is positive and highly significant at 1 percent level of significance indicating that educated farmers are more willing to pay for the two wheel tractor and vice versa. The farming involvement coefficient is positive and significant. The family size is negative and significant. The family type coefficient is positive and highly significant at 1 percent level of significance. The tenancy status was

included as dummy variable and the coefficient is positive and highly significant at 1 percent level of significance. The own land holding coefficient is positive and highly significant at 1 percent level of significance. The road access is negative and highly significant at 1 percent level of significance. The extension contact is positive and highly significant at 1 percent level of significance. The Kasola ownership is negative and significant at 10 percent level of significance. The trolley ownership is positive and highly significant at 1 percent level of significance. The value of R-square is also quite high indicating the robustness of the variables included in the model.

The farmer's willingness to pay in monetary terms is estimated through CLAD model and the results are presented in Table 6. The censored least absolute deviation model (CLAD) model has been estimated because the estimates are consistent. The dependent variable is the farmer's willingness to pay in cash for the purchase of the two wheel tractor and a set of independent variables is included in the model.

The age coefficient is negative and significant at 10 percent level of significance. The education coefficient is positive and significant at 1 percent level of significance. The family size coefficient is negative and significant at 1 percent level of significance. The farmer ownership status was included as dummy variable and the coefficient is positive and significant at 1 percent level of significance. The land holding is positive and significant. The land holding is positive and significant at 1 percent level of significance. The non-farm is positive and significant at 5 percent level of significance. The households' assets like rotavator, ridger, spray machine etc. are non-significant. The organization membership is positive and highly significant at 1 percent level of significance. The cattle ownership is also positive although non-significance. The road access and TV ownership are also positive and significant. The refrigerator and fan ownership are positive and non-significant. The access to credit is positive and significant at 1 percent level of significance. The agricultural extension is also positive and highly significant at 1 percent level of significance.

The farmer's willingness for the number of implements to be drawn with the two wheel tractors are presented in Table 7. As the dependent variable is the number of implements, hence for that Poisson regression model has been estimated. A set of independent variables is included in the model. The age coefficient is positive and significant indicating that more experienced farmers are more interested to draw more implements with the two wheel tractor. The education coefficient is positive and highly significant at 1 percent level of significance indicating that educated farmers are more interested to draw more implements with the two wheel tractor. The family size is negative and significant at 10 percent level of significance indicating that larger households are not interested to draw more implements with the two wheel tractor as compared to small households. The famer ownership status was included as dummy variable i.e. 1 for the owner and 0 for the tenant and the coefficient is negative and significant. The land holding and non-farm participation are positive and non-significant. The household income levels are positive and highly significant at 1 percent

level of significance. A set of implements like combine harvester, rotavator, ridger, spray machine are positive and significant indicating that households having ownership of the more implements are interested to have two wheel tractor and vice versa.

The organization membership was included as dummy variable i.e. 1 for the owner and 0 for the tenant indicating that farmers having membership of any organization are interested to draw more implements with the two wheel tractor and vice versa. The cattle ownership is negative and significant and road access is also negative and significant. The TV ownership is positive and significant at 1 percent level of significance. The refrigerator ownership is negative and significant at 10 percent level of significance. The credit ownership is positive and significant while the agricultural extension services are also positive and significant at 1 percent level of significance. The R-square value is 0.34 while the LR Chi square is also positive and highly significant at 1 percent level of significance indicating the robustness of the variables included in the model.

Conclusion

The mountain ecosystems are relatively unstable and have low inherent productivity. Within this fragile environment, however, there is a great variety of ecological slots upon which people base their livelihood. Small fragmented land holdings, smaller field size and difficulty in operation with 4-wheel tractors, the farmers from both regions of AJ&K and GB have eagerness to try small 2-wheel walking tractors for farm operations and transportation. The introduction of small farm machniery could also help to mechnize tillage and planting operations in these hilly regions.

Considering smaller earnings, particularly in GB, reasonably-priced machinery preferably locally made or imported from China could be a better option for prospective buyers. Linking local manufacturers and/or suppliers with Chinese companies either to import machinery or technology to manufacture and/or supply locally could be economical and easily accessible for prospective buyers. Realizing strong eagerness amongst the farmers to try 2-wheel tractor, provision of such machinery on rent either by government Research/extension department or local big progressive landlords could benefit more farmers.

Complete technological package including 2-wheel tractor operated tool/implements and farmers' trainings regarding operation and maintenance of such machinery could properly disseminate the technology in target areas. Being more illiterate farming community in GB, the training should preferably be conducted in local language. Complete demonstration of such machinery at significant number of sites (research stations and farmers' fields), ensuring participation from all relevant stakeholders, would support speedy adoption of technology among the farming community. As maize, wheat and potato are principle crops of both regions, therefore, availability of necessary farm machinery for tillage operation, sowing; harvesting, threshing and transportation of such crops could support complete mechanized farming in the target regions.

To popularize such innovative machinery, tax exemption to local importer and/or

manufacturer for initial few years would help make such machinery affordable to more farmers and ultimately improve crops' productivity and livelihood of small farmers in hilly areas of the country.

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