Demand for agricultural mechanization services for smallholder farmers in Malawi

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Abstract
One of the main barriers to adopting smallholder agricultural mechanization in developing countries is the mismatch between the economies of scale of machines and farm size. Private sector-led mechanization services hold a promise to address this challenge, but there is a lack of evidence on demand for smallholder mechanization services. This study estimates the farmers' willingness to pay for mechanization services using the double-bounded contingent valuation method and data from 1,512 households. Results show that farmers are willing to pay, on average, 5, 11, and 33% more than prevailing market rates for land preparation, maize shelling, and transportation services, respectively. The amounts that farmers are willing to pay for the mechanization services vary by sex, age group, size of cultivated land, the value of farmer assets, market access, and agroecology. Men are willing to pay 26, 25, and 11% more than women for land preparation, maize shelling, and transportation services. Moreover, 40% of female and 90% of male farmers are willing to pay more than or equal to the prevailing market rate for land preparation services. The high demand for mechanization services among smallholder farmers points to the need for making the machinery available to rural communities through mechanization service providers or machinery hiring centers run by the private sector. The paper concludes by discussing the contextual factors and policy options for promoting smallholder mechanization in Malawi.

JEL classifications: O33 Q11 Q13 Q16

Keywords: Willingness to pay, hire mechanization service, two-wheel tractor, land preparation, Malawi

1. INTRODUCTION

Human labor is the primary source of agricultural power in sub-Saharan Africa. Bishop-sambrook (2005) states that humans supply 65% of farm labor. However, farm operations are arduous and tedious. They need long working hours; thus, humans lack the energy to perform them in time, desired quality, and quantity, resulting in low agricultural productivity (Sims & Kenzle, 2006; Vemireddy & Choudhary, 2021). Moreover, there is a reduction in the availability of human labor for arduous farm activities due to improved (1) access to social services (e.g., universal education), (2) illnesses such as HIV/AIDS, malaria, and malnutrition, (3) migration of the rural population to urban areas, (4) aging rural populations, and (5) new economic opportunities in regions from where migrant workers originated (Asenso-Okyere et al., 2011; Bignami-Van Assche et al., 2011; Bishop-sambrook, 2005; FAO-AUC, 2018). The reduced availability of human labor for agricultural activities causes serious labor shortages during the peak agricultural season. It contributes to the low productivity of agriculture in sub-Saharan African countries like Malawi, where human labor is the primary source of farm power (Alwang & Siegel, 1999; Baudron et al., 2019; Feder et al., 1985; Leonardo et al., 2015; Mbalule, 2000; Mrema et al., 2008; Wodon & Beegle, 2006).

The alternative agricultural power sources a`re draught animals and tractors. These sources of farm power can improve agriculture productivity and reduce the work and time burden (Olasehinde-Williams et al., 2020). According to Sims and Kienzle (2006), a typical farm family in sub-Saharan Africa (SSA) can cultivate 1.5 ha per year using solely human labor, 4 ha using draught animal power, and over 8 ha using tractor power. Therefore, mechanization using animals such as oxen and donkeys or tractors can increase cultivated land area, increase crop yields through convenient operation, and reduce drudgery levels, helping redeploy family labor. Overall, the mechanization of smallholder agriculture can increase labor productivity, household income, and food security. Governments in SSA, such as in Malawi, where hoe culture is prevalent, recognize the need to stop the use of hand hoes which are rudiment, inefficient and burdensome. (FAO-AUC, 2018). Besides, agricultural mechanization can help increase youth engagement in agricultural production, processing, and provision of services to sustainably transform agriculture and reduce youth unemployment (Daum & Birner, 2020).

However, there are several challenges in the use of animals and tractors for agricultural power: (a) the decline in the number of draught animals due to diseases and recurring droughts and the high costs of possession and maintenance of the animals; (b) the high costs of possession and running of tractors; and (c) inadequate supply of implements and spare parts (Sims & Kienzle, 2016). Besides, government-run tractor hire service schemes are failed due to poor management, lack of financial support, poor infrastructure, lack of incentives for tractor operators to work extended hours, and inefficient utilization of tractors (Baudron et al., 2015; Daum & Birner, 2020; Diao et al., 2014a; Sims & Kienzle, 2006).

A recent development in agricultural mechanization in sub-Sahara Africa (SSA) suggests the importance of private sector-led hiring services to provide smallholder farmers with access to tractor hire services in their vicinities from medium and large-scale tractor owners (Diao et al., 2014; FAO-AUC, 2018). Different institutions and private enterprises have also promoted small-size and low-cost tractors to encourage smallholder farmers to own tractors for use and hire out to others (Baudron et al., 2015; FAO-AUC, 2018). However, in Malawi, where human power is the primary source of farm labor, and the landholdings are small (less than 1 ha on average), there is a need to assess the demand for tractor hire services. The assessment results help to advise the government, service providers, and other institutions supporting the promotion of agricultural mechanization. This paper estimates the demand for two-wheel-based mechanization services for land preparation, maize shelling, and transportation of agricultural produce from farm fields to homesteads. Therefore, this study's objectives are to assess labor shortages related to different farm activities, estimate the willingness to pay for mechanization services, and propose policy options that help promote smallholder mechanization services.

Previous studies in SSA reveal that smallholder farmers are willing to pay for tractor hire services for agricultural activities such as land preparation, weeding, harvesting, threshing, and transport (Hodjo et al., 2021; Houssou et al., 2016; Takele & Selassie, 2018). To our knowledge, no study has investigated smallholder farmers' willingness to pay (WTP) for agricultural mechanization services in Malawi. We analyze smallholder farmers' demand for mechanization services using the double-bound dichotomous choice contingent valuation method because the services are not prevalent in Malawi. Our results show that farmers are willing to pay 22,211 MWK/acre for land preparation, 467 MWK per 50 kg shelled maize grain, and 2096 MWK per trip within a range of 6 km. For all the services, farmers are willing to pay amounts within the range of the prevailing market rates. The amounts farmers are willing to pay for the services depend on sex, age, landholding size, market access, agroecology, and asset ownership.

The following is the organization of the rest of the paper. Section 2 outlines the empirical estimation procedures, whereas the third section gives an overview of the survey design and data collection. Section 4 provides variable definitions and discusses the sample households' descriptive statistics; and Section 5 presents and discusses labor shortages and mechanization and results of the econometric analysis. The last section draws conclusions and policy implications.

2. ANALYTICAL FRAMEWORK

To assess smallholder farmers' demand for mechanization services (– land preparation, maize shelling, and transportation), we use the double-bound dichotomous choice (DBDC) contingent valuation method (Lopez Feldman, 2012). The DBDC format was preferred over a single-bound format because of the statistical efficiency of the former over the latter (Hanemann et al., 1991). In the single-bound contingent valuation format, a respondent is asked only one dichotomous question, i.e., if the individual is willing to pay a threshold amount for a good or service under consideration. However, the DBDC format involves a follow-up dichotomous question depending on the response to the first question. If the response to the first question is 'yes,' the individual is asked a follow-up question with a higher bid amount. If the answer to the first question is 'no,' the individual is asked a follow-up question with a lower bid amount.

The DBDC format thus provides individual respondents with more information concerning WTP than the single-bound format and provides an interval within which the actual WTP for an individual lies.

Denoting that b^I is the initial bid amount and b^F is a follow-up bid amount, an individual's WTP can be expressed as (1) $b^I \leq WTP < b^F$ if the individual's responses are 'yes' for b^I and 'no' for b^F; (2) $b^F \leq WTP < \infty$ if the individual's responses are 'yes' for both bid amounts; (3) $b^F \leq WTP < \mathrm{b}^I$ if the individual's responses are 'no' for b^I and 'yes' for b^F; and (4) $0 \leq WTP < \mathrm{b}^F$ if the individual's responses are 'no' for both bid amounts. Following (Lopez-Feldman, 2012) and assuming that r_i^1 is a response of for the initial bid amount and r_i^2 is a response for the follow-up bid amount, the probability that the individual's response is 'yes' to the initial bid amount and 'no' to the follow-up bid amount can be expressed as $P(r_i^1 = 1, r_i^2 = 0|x_i)$ where x_i is a vector of explanatory variables. If we omit the fact that the probability is conditional on the values of the explanatory variables, we can rewrite the probability as $P(y, n)$. Following (Lopez-Feldman, 2012) and further assuming that $WTP_i(z_{i,}u_i) = x_i'\beta + u_i$ where β is a vector of parameters, u_i is an error term ($u_i \sim N(0, \sigma^2)$), and $\phi(.)$ is the standard cumulative normal distribution, the probability for each of the four response categories can be given as follows.

a. $r_i^1 = 1 \; and \; r_i^2 = 0$

$$P(y, n) = P(b^I \leq WPT < b^F)$$

$$= P(b^I \leq x_i'\beta + u_i < b^F)$$
$$= P\left(\frac{b^I - x_i'\beta}{\sigma} \leq \frac{u_i}{\sigma} < \frac{b^F - x_i'\beta}{\sigma}\right)$$
$$= \phi\left(\frac{b^F - x_i'\beta}{\sigma}\right) - \phi\left(\frac{b^I - x_i'\beta}{\sigma}\right)$$

Using the symmetry of the normal distribution, we can rewrite the last expression as

$$P(y, n) = \phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^I}{\sigma}\right) - \phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^F}{\sigma}\right) \quad 1.$$

b. $r_i^1 = 1 \; and \; r_i^2 = 1$

$$P(y, y) = P(WTP > b^I, WPT \geq b^F)$$
$$= P(x_i'\beta + u_i > b^I, x_i'\beta + u_i \geq b^F)$$

Using Bayes rule $P(y, y) = P(x_i'\beta + u_i > b^I | x_i'\beta + u_i \geq b^F) * P(x_i'\beta + u_i \geq b^F)$.

As $b^F > b^I$ and therefore $P(x_i'\beta + u_i > b^I | x_i'\beta + u_i \geq b^F) = 1$, which also implies

$P(y, y) = P(u_i \geq b^F - x_i'\beta) = 1 - \phi\left(\frac{b^F - x_i'\beta}{\sigma}\right)$ which by symmetry is

$$P(y,y) = \phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^F}{\sigma}\right) \quad 2.$$

c. $r_i^1 = 0\ and\ r_i^2 = 1$

$$P(n,y) = P(b^F \leq WPT < b^I)$$
$$= P(b^F \leq x_i'\beta + u_i < b^I)$$
$$= P\left(\frac{b^I - x_i'\beta}{\sigma} \leq \frac{u_i}{\sigma} < \frac{b^F - x_i'\beta}{\sigma}\right)$$
$$= \phi\left(\frac{b^I - x_i'\beta}{\sigma}\right) - \phi\left(\frac{b^F - x_i'\beta}{\sigma}\right)$$

$$P(y,n) = \phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^F}{\sigma}\right) - \phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^I}{\sigma}\right) \quad 3.$$

d. $r_i^1 = 1\ and\ r_i^2 = 0$

$$P(n,n) = P(WTP < b^I, WPT < b^F)$$
$$= P(x_i'\beta + u_i < b^I, x_i'\beta + u_i < b^F)$$
$$= P(x_i'\beta + u_i < b^F)$$
$$= \phi\left(\frac{b^F - x_i'\beta}{\sigma}\right)$$

$$P(n,n) = 1 - \phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^F}{\sigma}\right) \quad 4.$$

The distribution probability of the four responses is expressed as

$$\ln L = \sum_i^N \left[g_i^{yn} ln\left(\phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^I}{\sigma}\right) - \phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^F}{\sigma}\right)\right) + g_i^{yy} ln\left(\phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^F}{\sigma}\right)\right) + g_i^{ny} ln\left(\phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^F}{\sigma}\right) - \phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^I}{\sigma}\right)\right) + g_i^{nn} ln\left(1 - \phi\left(x_i'\frac{\beta}{\sigma} - \frac{b^F}{\sigma}\right)\right)\right] \quad 5.$$

Where g_i^{yn}, g_i^{yy}, g_i^{ny} and g_i^{nn} are variables that take on the value of 1 if an individual respondent contributes to the logarithm of the likelihood function and 0 otherwise. We can directly obtain estimates of β and σ from the maximum likelihood function (Lopez-Feldman, 2012). We use the 'double' command (Lopez-Feldman, 2012) to estimate WTP for the mechanization services. The 'doubleb' command incorporates the first bid, second bid, first response, and second response as dependent variable in a model for each mechanization service.

3. STUDY DESIGN AND DATA

This study uses survey data collected from over 1,500 households in seven districts of Malawi (Appendix Table 1) under the project 'Understanding and Enhancing the Adoption of Conservation Agriculture in Smallholder Farming Systems of Southern Africa' (ACASA). We use a multistage sampling technique to select the households. In the first stage, the seven districts were chosen to represent a high prevalence of CA promotion. The districts also represent two agroecologies, lowland and mid-elevation, and two market-accesses groups, low and high. Balaka, Nsanje, and Nkhotakota districts were selected from the lowland[1] agroecology, whereas Chitipa, Dowa, Rumphi, and Zomba districts were chosen from the mid-elevation[2] agroecology.

Regarding market access, Balaka, Chitipa, Nkhotakota, and Nsanje represent low market access areas, whereas Dowa, Rumphi, and Zomba represent high market access. We used two hours of cut-off travel time from the district center to the nearest cities or large regional markets (Mzuzu, Lilongwe, Zomba, and Blantyre) to categorize districts into low market access and high market access (Benson et al., 2016). We selected three extension planning areas (EPAs) per district and three sections per EPA, respectively, based on a high prevalence of CA promotion in the second and third stages. Three villages per section and eight households per village were selected randomly in the fourth and fifth stages. The data comprise demographic, socioeconomic, and biophysical agricultural production constraints, institutional, social capital and networks, labor constraints and mechanization, and WTP for mechanization services. The mechanization services include land preparation, maize shelling, and transportation of farm produce from the farm to homesteads.

We use the double-bound dichotomous choice contingent valuation data collection format to collect data on WTP for the mechanization services. Initial and follow-up bids were developed using the current market prices for each mechanization service. The initial and follow-up bids for the land preparation services were developed based on the average tractor service hire rate for plowing and ridging. For maize shelling, the bids were developed using the prevailing average cost of shelling 50 kg maize grain as a middle value and subsequently decreasing and increasing by 50 MWK (10% of the median value). The bids for the transportation of produce from the farm to homesteads were estimated based on the average cost of hiring an oxcart per trip as a middle value and decreasing or increasing the subsequent bids by 100 MWK. Based on our assessment, oxen-pulled carts and two-wheel tractors (2WT)[3] carry a similar load[4]. Bid structures for all the mechanization services are in Appendix Tables 2a – 2d. There are 12 initial bid values for all mechanization services and roughly equal questionnaires per bid for all classes. The data were collected using a structured questionnaire programmed in the World Bank's Survey Solutions platform and administered face-to-face by trained enumerators. The

[1] The lowland agroecology includes the lower shire valley (<250 m asl) and the lakeshore, mid and upper shire (200 – 760 m asl).
[2] The mid-elevation category includes the mid-elevation upland plateau (760 – 1300 m asl) and the highlands (>1300 m asl).
[3] Two-wheel tractor (2-WT) is a single axle tractor used to perform agricultural activities such as land preparation, transportation, and shelling of maize and other grains, among others.
[4] A full ox-cart of maize in husk yields roughly 400 kg grain when shelled. A full oxcart of groundnut with stalks can yield roughly 100-125 kg of groundnut grain. A full oxcart of groundnut in pods (without stalks – which is 12-15 50 kg bags) yields roughly 350-450 kg of groundnut grain. A full oxcart of soybean with stalks yields roughly 200-250 kg of soybean grain.

face-to-face interview is deemed the best method to collect data on willingness to pay (Guo et al., 2014).

During the elicitation, the enumerators informed the respondents to assume that some individuals will provide land preparation, shelling, and transport services using a tractor. The respondents have to pay a certain amount for the mechanization services. The enumerators also informed the respondents that the amounts they pay for the services are based on their need for the service, affordability, and other necessary expenditures needed to prioritize. The enumerators informed the respondents about the unavailability of credit services; instead, they will pay using their own available money to reduce a hypothetical bias (Loomis, 2014). First, the enumerators asked if the respondents would pay a certain amount of cash (initial bid) to obtain the service. The enumerators then asked follow-up questions to determine if the respondents were willing to pay a lower amount for the 'No' response and a higher one for the 'Yes' response to the initial bids. All initial bids were randomly assigned to respondents (one initial bid per respondent per service). Table 1 presents the percent of responses.

Table 1. Percent of the responses to the first and follow-up bids (n=1512)

Responses	Land preparation	Maize shelling	Transport
"No" to the initial and follow-up bids (NN)	47.88	45.44	35.91
"No" to the initial bid and "Yes" to the follow-up bid (NY)	6.15	9.19	3.70
"Yes" to the initial and follow-up bids (YY)	31.15	29.03	47.69
"Yes" to the initial bid and "No" to the follow-up bid (YN)	14.82	16.34	12.70
Total	100	100	100

4. VARIABLE DEFINITION AND DESCRIPTIVE STATISTICS

We selected the variables included in the analysis based on economic theory and past empirical work on WTP for mechanization services in Africa and beyond (Benin, 2015; Paudel et al., 2019). Table 2 presents the definitions of the variables, expected signs in influencing willingness to pay for the different mechanization services, and the descriptive statistics of the variables. We include variables such as the age of the respondent, sex of the respondent, education level of the respondent, household size, the total number of adult males and females working full time on the farm, size of cultivated land, ownership of different types of assets, experience in the use of draft power for agricultural activities, awareness of the use of 2WT of farming activities, and participation in farmers organization. We incorporated information on the distance of the section to the district capital, the section terrains, and whether the section is waterlogged or not at the section level. We have also controlled for inter-district differences by using district dummies. We expect the following variables to positively affect the willingness to pay for mechanization services. The variables are the household head's education, the number of adult male members working full time on the farm, the total size of cultivated land, awareness of the use of draft power and 2WT for agricultural activities, and ownership of assets.

The results of the descriptive analysis show that the household heads are 44 years old and attended formal school for more than six years, and 36% of them or their spouses were members of farmers' organizations. The surveyed households had more than five persons and had more than two adult males and females working full-time on-farm. They also resided in section trains with flat and medium terrain, 48 km from the district capital, and cultivated 2.3 acres. On average, 96% of the respondents wish to obtain transportation services to transport maize from the farm to the homestead.

Table 2. Description of the variables used in the analysis

Variable	Description	Expected signs of influence of the variable on WTP for			Mean	St. dev
		Tilling/ripping	Shelling	Transport		
age	Age of the household head (years)	-/+	-/+	-/+	43.95	16.22
sex	Sex of the respondent (1=female)	-	-	-	0.50	0.50
education	Education level of the household head (years of schooling)	+	+	+	5.93	3.69
size	Number of members of the household	-	-	-	5.27	2.11
male	Total number of adult male members working full time on the farm	+	+	+	0.90	0.70
female	Total number of adult female members working full time on the farm	-	-	-	1.14	0.58
land	The total size of cultivated land (acre)	+	+	+	2.30	1.86
ox	Household owned ox (1=yes)	-	-/+	-	0.03	0.17
draft	Household have ever used draft power for agricultural activity (1=yes)	+	+	+	0.14	0.35
tractor	Heard or know about the use of 2TW tractor for agricultural activity (1=yes)	+	+	+	0.38	0.49
player	The household owns radio and/or CD player (1=yes)	+	+	+	0.36	0.48
phone	The household owns phone (1=yes)	+	+	+	0.63	0.48
oxcart	The household owns oxcart (1=yes)	-	-	-	0.03	0.17
motorbike	The household owns motorbike (1=yes)	+	+	+	0.04	0.20
bicycle	The household owns bicycle (1=yes)	+	+	+	0.39	0.49
organization	Household head or spouse member of farmers' organization (1=yes)	+	+	+	0.36	0.48
distance	Distance of the section to the district main market (km)	-	-	-	48.05	24.24
farm distance	Distance from crop field to homestead (in minutes of walking)	+		+	32.90	35.97
maize	Wish to obtain transport service to transport maize from farm to homestead (1=yes)			+	0.96	0.19
groundnut	Wish to obtain transport service to transport groundnut from farm to homestead (1=yes)			+	0.14	0.35
soybean	Wish to obtain transport service to transport soybean from farm to homestead (1=yes)			+	0.04	0.20
beans	Wish to obtain transport service to transport beans from farm to homestead (1=yes)			+	0.01	0.09
tobacco	Wish to obtain transport service to transport tobacco from farm to homestead (1=yes)			+	0.05	0.21
flat	The terrain of the section is flat (1=yes)	+	+	+	0.43	0.50
medium	The terrain of the section is medium (1=yes)	-/+	-/+	-/+	0.37	0.48

Variable	Description	Expected signs of influence of the variable on WTP for			Mean	St. dev
		Tilling/ripping	Shelling	Transport		
steep	The terrain of the section is steep (1=yes)	-	-	-	0.21	0.40
waterlogged	The section is waterlogged (1=yes)	-	-	-	0.17	0.38

5. RESULTS AND DISCUSSION

5.1. Labor shortage and mechanization

Even though agricultural production in the study areas relies mainly on family labor, about 41% of households reported using hired labor (Fig.1). These results align with the situation in many countries in SSA, where humans are the primary source of agricultural power (Bishop-sambrook, 2005).

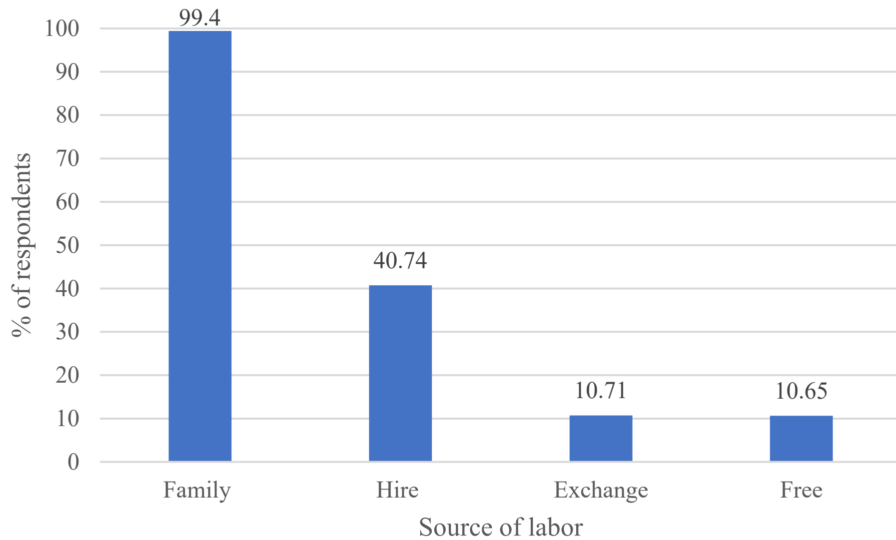

Fig. 1 Sources of labor for agricultural activities.

Limit access to labor and other sources of farm power such as draft animal power or tractors, limit land productivity in agriculture. According to Baudron et al. (2020), land-to-labor ratios are low in most African farming systems and are projected to decrease. However, as shown in Fig. 2, farmers reported labor constraints for farm operations associated with major crops in Malawi. The results show that smallholder farmers face severe labor shortages primarily for weeding, followed by land preparation and transportation of produce from the farm to homestead, implying the need for mechanization of farm operations. The labor shortage in weeding and land preparation differs between female and male farmers. A higher proportion of male farmers than female farmers reported facing serious labor shortages during weeding and land preparation.

Fig. 2. Serious labor constraints for major farm operations.

Assessment of existing mechanization can help to suggest mechanization options that benefit smallholder farmers. Fig. 3 shows smallholder farmers' knowledge, usage, and ownership of mechanization options. The results show that draft animal power is the most known agricultural mechanization option, as 86% of the respondents reported being aware of the use of draft animal power in farming activities. However, the usage and ownership of draft animal power are very low. Less than 15% of the sample households reported using draft animal power, and less than 3% reported owning draft animal power. Most (79% of the respondents) know a four-wheel tractor (4WT), but only very few farmers reported using it for any agricultural activity, and no farmer in the sample owns it. No farmer also said possessing and using 2WT, but about 38% reported being aware of its use. The findings concur with a study that ranked draft animal power as the second reliable farm power source in SSA after human power and its contribution to 25% of the farm labor (Bishop-sambrook, 2005). Bishop-sambrool (2005) reported that motorized farm machinery is not widely used because they are not economically feasible for most smallholder farmers.

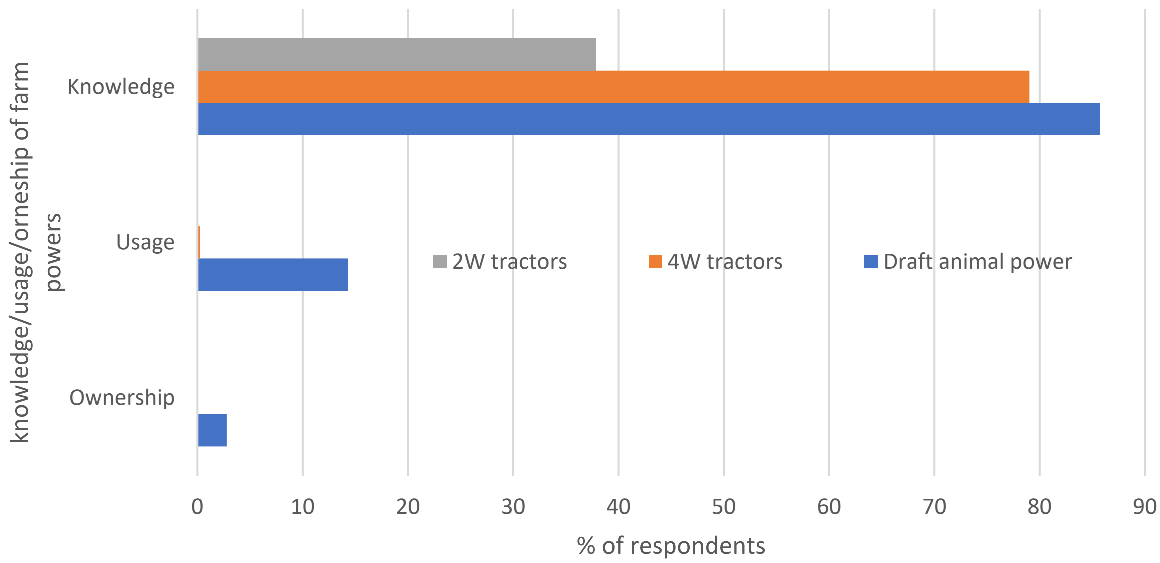

Fig. 3. Knowledge, usage, and ownership of draft animal power and tractors

5.2. Empirical results

5.2.1 Determinants of willingness to pay

Table 3 presents the results of the maximum likelihood estimation of the factors affecting WTP for two-wheel tractor-powered (2WT) mechanization services. The results show that WTP for mechanized land preparation service is significantly and positively affected by age, sex, and education level of the farmer; the size of cultivated land; radio, phone, and bicycle ownership; and prevalence of waterlogging. Age, education, cultivated land size, and asset ownership help obtain information on mechanization options such as radio, phone, and bicycle positively and significantly affect farmers' WTP for mechanized land preparation service. The positive and significant effects indicate that older farmers are more labor-constrained than younger farmers. Older farmers have more income to pay for the mechanized land preparation service than younger farmers. However, the significant and negative coefficient of the squared term shows that, after a certain age, the WTP for land preparation service declines. The positive and significant effect of the size of cultivated land on WTP for mechanized land preparation service is as expected and in line with the result of another study on WTP for mini-tillers among rice farmers in Nepal (Paudel et al., 2019). Ownership of radio, mobile phones, and bicycles help farmers to obtain updated information on technologies and related benefits. Thus well-informed farmers are willing to pay more than the less informed farmers.

On the other hand, the results show that female farmers have a lower WTP for land preparation services than male farmers. This lower WTP could be because of the difference in wealth between the two groups and is similar to Paudel et al. (2020). Our study shows that, on average, the value of farm assets for male farmers was double that of female farmers. Farmers in the districts such as Dowa, Rumphi, and Chitipa, where landholding is relatively large, have a higher WTP for land preparation services.

The factors that affect the WTP for maize shelling include the sex and education level of the farmers, bicycle ownership, and distance to the primary market. As expected, being a female farmer lowers the amount the farmer is willing to pay for the shelling services. This lower WTP could be due to the difference in the income level between men and women. More educated farmers are more likely to pay more for shelling services than their less-educated counterparts.

WTP for transportation of farm produce from farm fields to homestead is positively and significantly affected by the respondent's education level, radio, phone, and bicycle ownership, walking distance in minutes from the farm to homestead, and whether the farmer wishes to obtain transportation service for maize. As expected, well-informed farmers and farmers who have farms farther away from homestead are more likely to pay more for the transportation service than their counterparts. Oxen ownership negatively affects farmers' willingness to pay for transportation services, as oxen owners usually use carts for transportation.

Table 3. Determinants of WTP for land preparation, maize shelling, and transportation of agricultural produce from the farm to the homestead

Variable	Land preparation	Maize shelling	Transporting farm produce
age	186.760**	0.434	14.514
	(89.61)	(3.32)	(10.05)
age-squared	-1.591*	-0.009	-0.137
	(0.90)	(0.03)	(0.10)
sex	-2849.546***	-73.521***	-86.977
	(519.45)	(19.43)	(59.45)
education	230.691***	8.469***	30.847***
	(79.51)	(2.96)	(9.15)
size	31.060	-3.897	-12.534
	(137.54)	(5.10)	(15.54)
male	542.963	14.466	29.859
	(374.21)	(13.88)	(42.27)
female	-208.081	5.672	-16.898
	(445.86)	(16.60)	(50.63)
land	798.675***	4.101	20.607
	(178.16)	(5.50)	(19.07)
ox	-2933.390	34.645	-349.433*
	(1811.64)	(65.03)	(194.60)
draft	552.330	9.799	-27.427
	(717.04)	(26.70)	(82.70)
tractor	-174.679	-40.778**	-91.253
	(490.43)	(18.30)	(55.94)
player	1192.290**	26.235	206.288***
	(544.58)	(20.51)	(63.79)
phone	1451.554***	10.996	102.880*
	(549.96)	(20.32)	(61.69)
oxcart	2915.989	-90.152	-253.442
	(1885.56)	(62.71)	(197.48)
motorbike	994.415	-39.023	46.692
	(1225.37)	(46.39)	(142.76)
bicycle	1250.436**	54.585***	132.575**

Variable	Land preparation	Maize shelling	Transporting farm produce
	(546.19)	(20.44)	(62.28)
organization	279.692	-1.737	-29.959
	(500.78)	(18.66)	(57.59)
distance	2.546	0.942**	2.898**
	(11.74)	(0.41)	(1.25)
flat	-544.226		
	(772.13)		
medium	-1094.671		
	(718.62)		
waterlogged	2196.655**		
	(911.56)		
nsanje	1635.681	2.621	-295.984***
	(1027.54)	(33.81)	(105.00)
nkhotakota	318.564	-75.814**	14.634
	(956.21)	(34.84)	(105.30)
balaka	1108.785	-48.451	-58.393
	(935.24)	(33.70)	(101.09)
dowa	3763.269***	-80.379**	193.456*
	(1062.29)	(36.91)	(115.69)
rhumpi	4129.747***	-17.032	100.579
	(1028.87)	(35.40)	(111.14)
chitipa	1793.782*	-73.930**	-222.757**
	(1055.50)	(36.77)	(111.26)
farm distance			5.511***
			(0.86)
maize			729.550***
			(153.82)
groundnut			-120.904
			(81.07)
soybean			-82.207
			(140.00)
beans			322.974
			(343.05)
tobacco			93.334
			(144.08)
constant	11629.078***	422.740***	537.089*
	(2292.64)	(79.75)	(288.73)
Sigma			
constant	7240.322***	278.811***	824.320***
	(299.45)	(10.12)	(40.22)
N	1504	1504	1504

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Standard errors are in parentheses

5.2.2 Demand for mechanization services

Table 4 presents the average WTP for land preparation services estimated using the predicted values from the interval regression. The overall average WTP for land preparation services is 22,211 MWK per acre, which is 11% higher than the prevailing market rate (20,000 MWK per acre) for land preparation services using a tractor hire where a tractor is available. Men are willing to pay 26% more for land preparation services than women. The WTP for land preparation services increases with age, cultivated land size, farm asset value, and market access. High market access areas exhibit a 9% higher WTP than the low market access areas.

Table 4. Predicted mean willingness to pay (MWK[5]/acre) for land preparation services (LPS) by sex of respondent, size of cultivated land, market access, and agroecology

Items	Number of observations	Mean	Std. dev.
Overall	1504	22,211.06	4324.17
Sex			
Female	753	19689.08	3342.02
Male	751	24739.76	3672.08
Youth			
Young youth (<25 years)	151	19834.86	3692.59
Old youth (25 – 34 years)	346	21364.31	3781.12
Non-youth (>34 years)	1007	22858.31	4414.37
Land size			
Total cultivated land < 2 acres	687	19689.72	3178.55
Total cultivated land ≥ 2 acres	817	24331.21	4011.81
Farm asset (in MWK)			
1st quartile: ≤ 500	16	17220.09	2703.62
2nd quartile: (500, 22500]	737	19863.39	3184.68
3rd quartile: (22500, 56200]	377	23128.35	3204.39
4th quartile: > 56200	374	26126.22	4063.19
Market access			
Low market access (≥ 2 hrs travel time)	861	21391.63	3900.23
High market access (< 2 hrs travel time)	643	23308.31	4614.31
Agroecology			
Lowland (Lower shire and lakeshore, mid and upper shire)	646	20755.82	3793.02
Mid-elevation (includes highland)	858	23306.73	4378.01

The demand curve in Figs. 4–6 is constructed based on the predicted values of the WTP for the mechanization services. The demand curves for mechanized land preparation service presented in Fig. 4 decline with the service price for all categories – sex, cultivated land, market access, and agroecology – the demand curve is generally inelastic. The results show that 40% of female and 90% of male farmers are willing to pay the prevailing market rate (20,000 MWK per acre) for a 2WT-based land preparation service. This result shows a 50% gap between female and male farmers' demand for mechanized land preparation services between female and male farmers. The demand for land preparation services using a 2WT is higher in the high market access and mid-elevation agroecology. The results imply that institutions or private enterprises that promote mechanization services have to consider several factors that enhance the uptake of the mechanization for land preparation services. For instance, subsidies can help narrow the gap between males and females in demand for mechanization services for land preparation.

[5] 1 USD during the survey period was MWK 790.

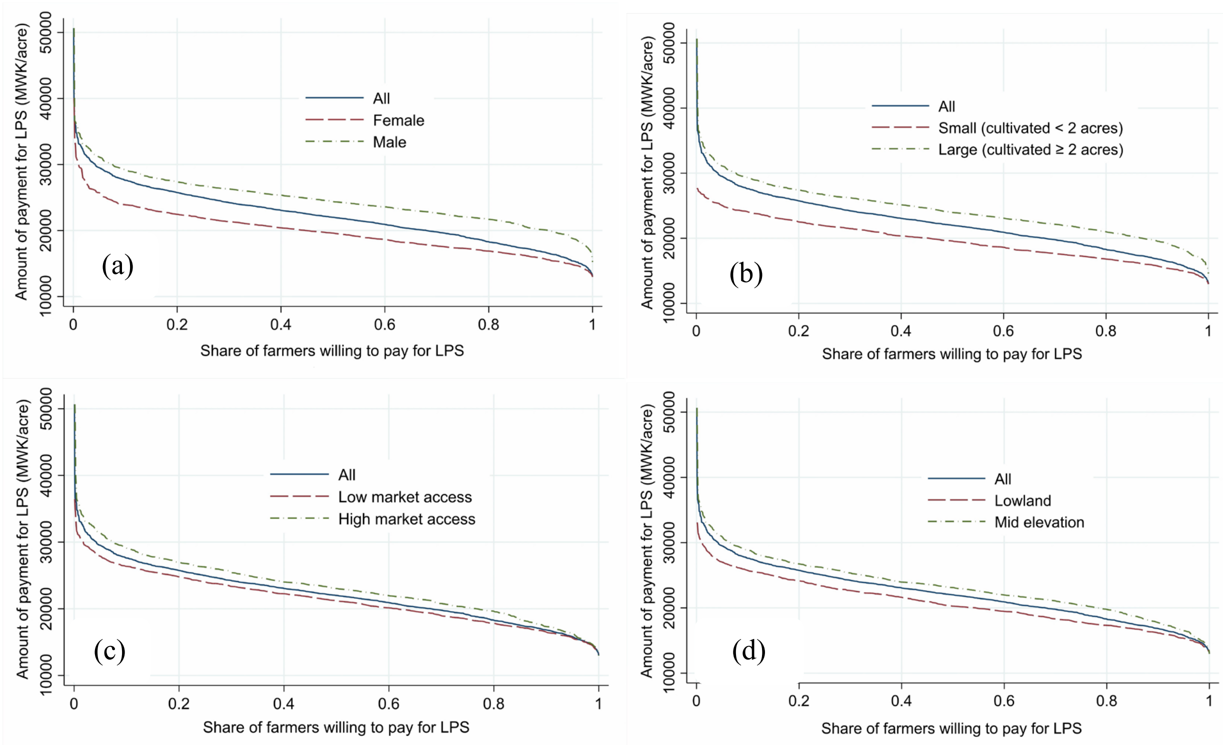

Fig. 4. Demand curves for mechanized land preparation service (LPS) by gender (a), area of cultivated land (b), market access (c), and agroecology (d).

Table 5 presents the average WTPs for 2WT-based maize shelling services estimated using the predicted values from the interval regression model. The overall average WTP for maize shelling service is 467 MWK per 50 kg shelled grain, which is 33% higher than the prevailing market rate (350 MWK per 50 kg). The WTP for men for maize shelling services is 25% higher than for women. The demand curves for 2WT-based maize shelling services decline with the service price for all categories – sex, size of cultivated land, market access, and agroecology. In general, all the curves are inelastic (Fig. 5). The demand curves' inelasticity shows the demand's low sensitivity to service charges.

Table 5. Predicted mean willingness to pay for maize shelling service (MSS) by sex of respondent, size of cultivated land, market access, and agroecology

Items	Number of observations	Mean	Std. dev.
Overall	1504	467.27	83.01
Sex			
Female	753	416.18	64.11
Male	751	518.50	66.65
Youth			
Young youth (<25 years)	151	472.34	71.45
Old youth (25 – 34 years)	346	482.20	73.97
Non-youth (>34 years)	1007	461.38	86.85
Land size			
Total cultivated land: < 2 acres	687	443.32	77.74
Total cultivated land: ≥ 2 acres	817	487.41	82.00

Market access			
Low market access: ≥ 2 hrs of travel time	861	459.89	82.18
High market access: < 2 hrs of travel time	643	477.17	83.16
Agroecology			
Lowland (Lower shire and lakeshore, mid and upper shire)	646	452.37	81.04
Mid-elevation (includes highland)	858	478.49	82.76
Farm asset (in MWK)			
1st quartile: ≤ 500	16	366.19	45.12
2nd quartile: (500, 22500]	737	430.09	69.31
3rd quartile: (22500, 56200]	377	490.88	73.43
4th quartile: > 56200	374	521.07	78.33

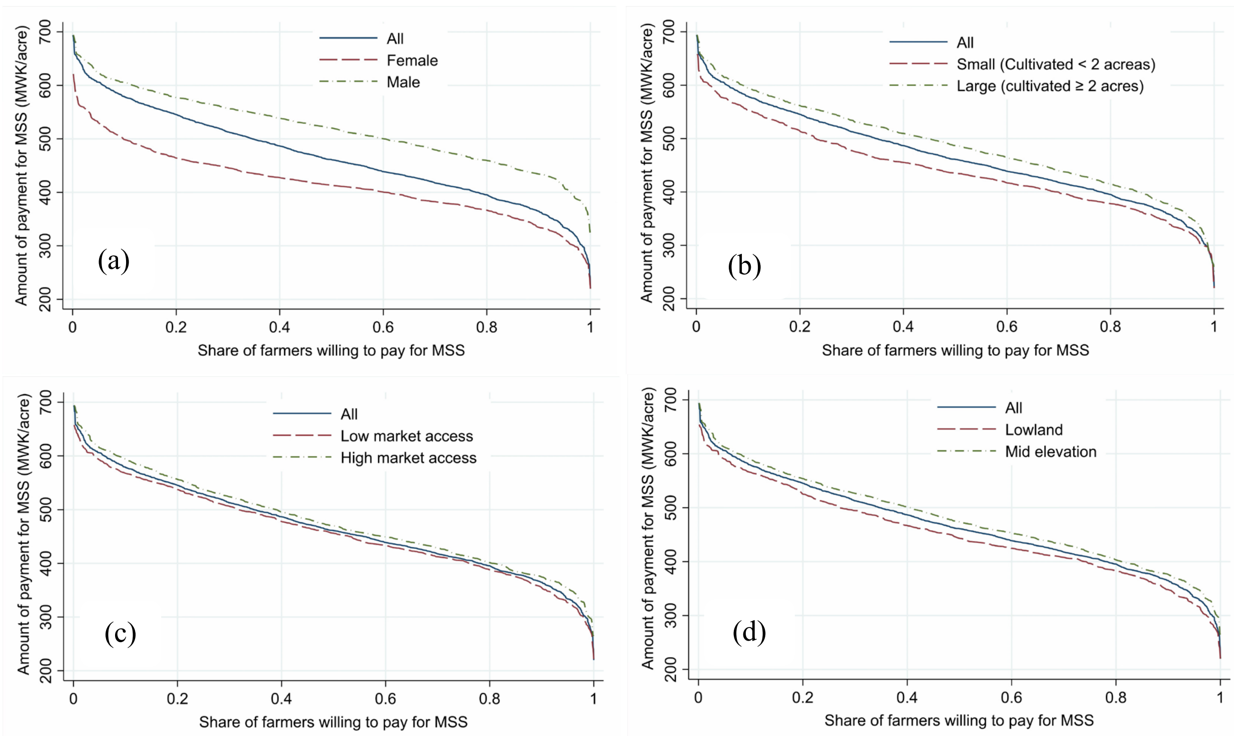

Fig. 5. Demand for mechanized maize shelling service (MSS) by gender (a), area of cultivated land (b), market access (c), and agroecology (d).

Table 2 presents the crops for which households want transportation services from the farm to the homestead. Ninety-six percent of the sample farmers indicated they wished to obtain transport services for their maize from farm to homestead. The proportions of farmers that stated the need for transportation services are meager for other crops could be due to the low production quantity.

Table 6 presents the WTP for transport service for agricultural produces using a 2WT-powered cart. The overall average of WTP for the transport service is 2,096 MWK per trip which is 5% higher than the prevailing market rate (2,000 MWK) and depends on the sex of the respondent, age group, and the size of cultivated land, market access, and agroecology. On average, the WTP values are less than the prevailing market price for women and those with low asset endowments, especially in lowland agroecology and low market access areas. The average value of WTP shows no demand for transportation services by female-headed households, households cultivating one acre or less, households in low market access areas, households in the lowland agroecology, and households with farm assets worth less than 23,000 MWK.

Table 6. Predicted mean willingness to pay for transportation service (TRS) by sex of respondent, size of cultivated land, market access, and agroecology

Items	Number of observations	Mean	Std. dev.
Over all	1504	2096.26	396.65
Sex			
Female	753	1977.62	392.04
Male	751	2215.21	364.54
Youth			
Young youth (<25 years)	151	2045.99	389.60
Old youth (25 – 34 years)	346	2111.00	387.08
Non-youth (>34 years)	1,007	2098.73	400.73
Land size			
Total cultivated land: < 2 acres	687	1979.49	376.17
Total cultivated land: ≥ 2 acres	817	2194.44	386.91
Market access			
Low market access: ≥ 2 hrs. travel time	861	1981.50	372.44
High market access: < 2 hrs. travel time	643	2249.92	375.77
Agroecology			
Lowland (Lower shire and lakeshore, mid and upper shire)	646	1995.18	388.51
Mid-elevation (includes highland)	858	2172.36	385.78
Farm asset (in MWK)			
1st quartile: ≤ 500	16	1725.25	383.92
2nd quartile: (500, 22500]	737	1946.74	365.54
3rd quartile: (22500, 56200]	377	2193.45	328.39
4th quartile: > 56200	374	2308.78	388.28

Fig. 6 shows that the demand curves for 2WT-powered transport services for agricultural produce decline with the service rates for all categories–sex, size of cultivated land, market access, and agroecology. The results show that 48% of women and 73% of men are willing to pay the prevailing market rate (2000 MWK per acre) for 2WT-based agricultural produce transportation from the farm to the homestead.

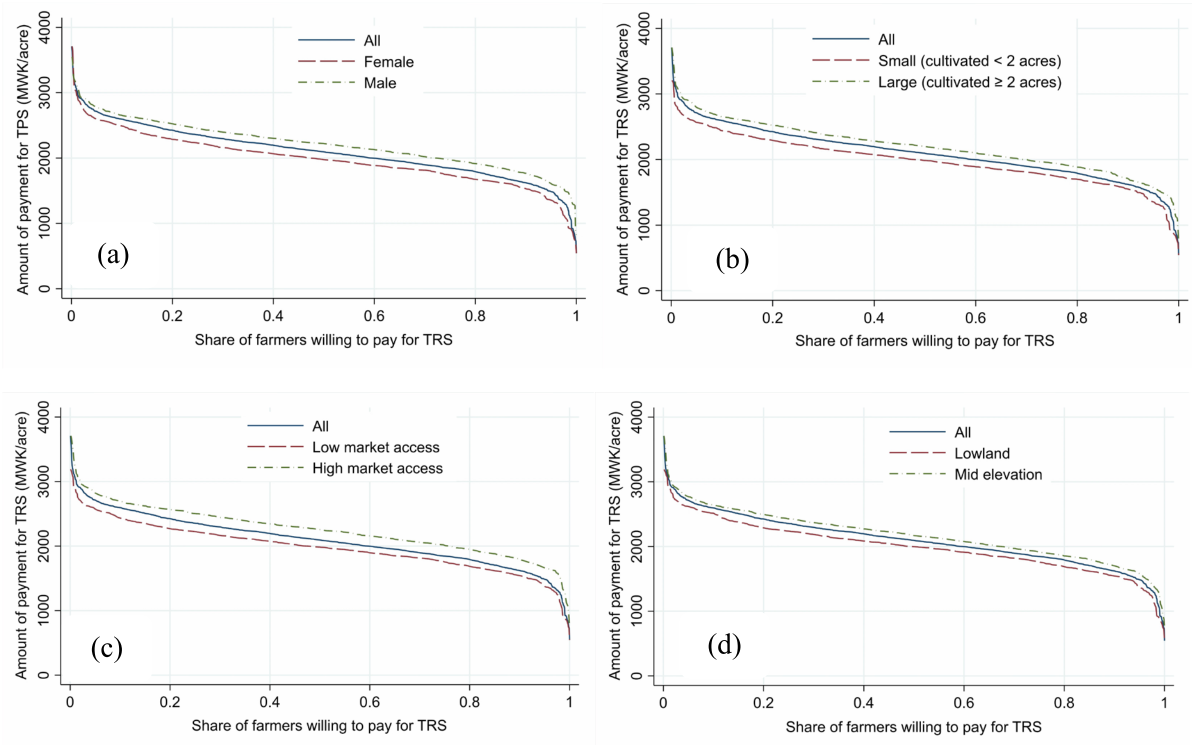

Fig. 6. Demand for transport service (TRS) by gender (a), area of cultivated land (b), market access (c), and agroecology (d).

6. CONCLUSIONS AND POLICY IMPLICATIONS

The main objective of this study is to investigate the labor constraints and the farmers' willingness to pay for agricultural mechanization services such as land preparation, maize shelling, and transporting agricultural produce from farm to homestead. Family labor is the primary source of agricultural labor in Malawi. However, more than 40% of households use hired labor, implying a farm labor shortage. The results show that farmers face severe labor shortages for weeding, land preparation, and transporting agricultural produce. The willingness to pay estimates also show that, on average, the WTP are 5, 11, and 33% higher than prevailing market rates for mechanized land preparation, maize shelling, and transportation services. The WTPs vary by sex, age group, cultivated land size, farmer asset value, market access, and agroecology for all the services. Men are more likely to pay higher amounts for all the mechanization services than women. Compared to women, men are willing to pay 26%, 25%, and 11% more for land preparation, maize shelling, and transportation services. Moreover, 40% of female and 90% of male farmers are willing to pay more than or equal to the prevailing market rate for mechanized land preparation services.

This study shows high demands for mechanization services for land preparation, maize shelling, and transportation. It suggests a need to promote two-wheel tractor-based affordable mechanization services that can eventually be run by the private sector, especially those engaged in agriculture and based in rural areas. Diao et al. (2014b) reported that private sector-led hiring markets or mechanization services provided by medium- to large-scale farmers to the nearby small-scale farmers were successful in Ghana. Malawi also can use the private sector-led hiring market as the number of medium and large-scale farmers has been increasing from time to time (Anseeuw et al., 2016; Deininger & Xia, 2018). The other option for promoting mechanization services is the introduction of low-cost small two-wheel tractors through medium-scale farmers. The medium-scale farmers can provide the hiring service while operating their agricultural activities.

REFERENCES

Alwang, J., & Siegel, P. B. (1999). Labor shortages on small landholdings in Malawi: Implications for policy reforms. *World Development*, *27*(8), 1461–1475. https://doi.org/10.1016/S0305-750X(99)00065-0

Anseeuw, W., Jayne, T., Kachule, R., & Kotsopoulos, J. (2016). The quiet rise of medium-scale farms in Malawi. *Land*, *5*(3). https://doi.org/10.3390/land5030019

Asenso-Okyere, K., Asante, F. A., Tarekegn, J., & Andam, K. S. (2011). A review of the economic impact of malaria in agricultural development. *Agricultural Economics*, *42*(3), 293–304. https://doi.org/10.1111/j.1574-0862.2010.00515.x

Baudron, F., Misiko, M., Getnet, B., Nazare, R., Kaumbutho, P., Baudron, F., Misiko, M., Getnet, B., Nazare, R., & Sariah, J. (2020). *A farm-level assessment of labor and mechanization in Eastern and Southern Africa*.

Baudron, F., Misiko, M., Getnet, B., Nazare, R., Sariah, J., & Kaumbutho, P. (2019). A farm-level assessment of labor and mechanization in Eastern and Southern Africa. *Agronomy for Sustainable Development*, *39*(2). https://doi.org/10.1007/s13593-019-0563-5

Baudron, F., Sims, B., Justice, S., Kahan, D. G., Rose, R., Mkomwa, S., Kaumbutho, P., Sariah, J., Nazare, R., Moges, G., & Gérard, B. (2015). Re-examining appropriate mechanization in Eastern and Southern Africa: two-wheel tractors, conservation agriculture, and private sector involvement. *Food Security*, *7*(4), 889–904. https://doi.org/10.1007/s12571-015-0476-3

Benin, S. (2015). Impact of Ghana's agricultural mechanization services center program. *Agricultural Economics (United Kingdom)*, *46*, 103–117. https://doi.org/10.1111/agec.12201

Benson, T., Mabiso, A., & Nankhuni, F. (2016). *Detailed crop suitability maps and agricultural zonation scheme for Malawi: Spatial information for agricultural planning purposes* (No. 17; Issue June).

Bignami-Van Assche, S., Anglewicz, P., Van Assche, A., Fleming, P., & van de Ruit, C. (2011). HIV/AIDS and time allocation in rural Malawi. *Demographic Research*, *24*(27), 671–708. https://doi.org/10.4054/DemRes.2011.24.27

Bishop-sambrook, C. (2005). *Contribution of farm power to smallholder livelihoods in sub-Saharan Africa. Agricultural and dood engineering technical report no. 2*.

Daum, T., & Birner, R. (2020). Agricultural mechanization in Africa: Myths, realities and an emerging research agenda. *Global Food Security*, *26*(May), 100393. https://doi.org/10.1016/j.gfs.2020.100393

Deininger, K., & Xia, F. (2018). Assessing the long-term performance of large-scale land transfers: Challenges and opportunities in Malawi's estate sector. *World Development*, *104*, 281–296. https://doi.org/10.1016/j.worlddev.2017.11.025

Diao, X., Cossar, F., Houssou, N., & Kolavalli, S. (2014). Mechanization in Ghana: Emerging demand, and the search for alternative supply models. *Food Policy*, *48*, 168–181. https://doi.org/10.1016/j.foodpol.2014.05.013

FAO-AUC. (2018). Sustainable Agricultural Mechanization: A Framework for Africa. In *Addis Ababa*.

Feder, G., Just;, R. E. ., & Zilberman, D. (1985). Adoption of Agricultural Innovations in Developing Countries : A Survey. *Economic Development and Cultural Change*, *33*(2), 255–298.

Guo, X., Liu, H., Mao, X., Jin, J., Chen, D., & Cheng, S. (2014). Willingness to pay for renewable electricity: A contingent valuation study in Beijing, China. *Energy Policy*, *68*, 340–347. https://doi.org/10.1016/j.enpol.2013.11.032

Hanemann, M., Loomis, J., & Kanninen, B. (1991). Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation. *American Journal of Agricultural Economics*, *73*(4), 1255–1263. https://doi.org/10.2307/1242453

Hodjo, M., Schwab, B., Kere, M., Millogo, V., & Srivastava, A. (2021). Demand for agricultural mechanization in the Hauts-Basin region in Burkina Faso. *Journal of Agribusiness*, *39*(1), 39–64.

Houssou, N., Aboagye, P. O., & Kolavalli, S. (2016). *Meeting Ghanaian farmers' demand for a full range of mechanization services* (Issue September). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/130752

Leonardo, W. J., van de Ven, G. W. J., Udo, H., Kanellopoulos, A., Sitoe, A., & Giller, K. E. (2015). Labour not land constrains agricultural production and food self-sufficiency in maize-based smallholder farming systems in Mozambique. *Food Security*, *7*(4), 857–874. https://doi.org/10.1007/s12571-015-0480-7

Loomis, J. B. (2014). *2013 WAEA Keynote Address : Strategies for Overcoming Hypothetical Bias in Stated Preference Surveys Published by : Western Agricultural Economics Association 2013 WAEA Keynote Address : Strategies for Overcoming Hypothetic Bias in Stated Preference Surve*. *39*(1), 34–46.

Lopez-Feldman, A. (2012). *Introduction to contingent valuation using Stata* (Issue MPRA Paper No. 41018).

Mbalule, J. C. (2000). The use of animal power for weed control in Malawi. In *Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen, The Netherlands. ISBN 92-9081-136-6.* (Vol. 51, Issue Figure 1).

Mrema, G. C., Baker, D., & Kahan, D. (2008). Agricultural mechanization in sub-Saharan Africa: time for a new look. In *Food and Agriculture Organization of the United Nations, Rome*.

Olasehinde-Williams, G., Adedoyin, F. F., & Bekun, F. V. (2020). Pathway to achieving sustainable food security in Sub-Saharan Africa: The role of agricultural mechanization . *Journal of Labor and Society*, *23*(3), 349–366. https://doi.org/10.1111/wusa.12483

Paudel, G. P., Gartaula, H., Rahut, D. B., & Craufurd, P. (2020). Gender differentiated small-scale farm mechanization in Nepal hills: An application of exogenous switching treatment regression. *Technology in Society*, *61*(March), 101250. https://doi.org/10.1016/j.techsoc.2020.101250

Paudel, G. P., KC, D. B., Rahut, D. B., Khanal, N. P., Justice, S. E., & McDonald, A. J. (2019). Smallholder farmers' willingness to pay for scale-appropriate farm mechanization: Evidence from the mid-hills of Nepal. *Technology in Society*, *59*(July), 101196. https://doi.org/10.1016/j.techsoc.2019.101196

Seager, P. J., & Fieldson, R. S. (1984). *Public Tractor Hire and Equipment Hire Schemes in Developing Countries (with special emphasis on Africa)* (Issue November).

Sims, B., & Kenzle, J. (2006). *Farm power and mechnization for small farms in sub-Saharan Africa*. file:///y:/10853.pdf

Sims, B., & Kienzle, J. (2016). Making mechanization accessible to smallholder farmers in sub-Saharan Africa. *Environments - MDPI*, *3*(2), 1–18. https://doi.org/10.3390/environments3020011

Takele, A., & Selassie, Y. G. (2018). Socio-economic analysis of conditions for adoption of tractor hiring services among smallholder farmers, Northwestern Ethiopia. *Cogent Food and Agriculture*, *4*(1), 1–15. https://doi.org/10.1080/23311932.2018.1453978

Vemireddy, V., & Choudhary, A. (2021). A systematic review of labor-saving technologies: Implications for women in agriculture. *Global Food Security*, *29*(April), 100541. https://doi.org/10.1016/j.gfs.2021.100541

Wodon, Q., & Beegle, K. (2006). Labor shortages despite underemployment? Seasonality in time use in Malawi. *World Bank Working Paper*, *73*, 97–116.

Appendix

Appendix Table 1. Description of study districts

Agroecology	District	Prevalence of CA	Market access
Lower shire valley (<250 m asl§) and lakeshore, mid and upper shire (200–760 m asl)	Nsanje	High	Low
	Balaka	High	High
	Nkhotakota	High	Low
Mid-elevation upland plateau (760–1300 m asl) and Highlands (>1300 m asl)	Dowa	High	High
	Rumphi	High	Low
	Chitipa	High	Low
	Zomba	High	High

§ asl = above sea level

Appendix Table 2a. Bid structure and responses of elicitation of willingness to pay for land preparation (MWK per acre) using 2-WT pulled plow/ripper

	Bid amount in MWK			% response§			
	Initial	Followup for 'No' response	Followup for 'Yes' response	NN response	NY response	YY response	YN response
Bid 1	17625	16500	18750	3.17	0.26	3.57	0.73
Bid 2	18750	17625	19875	3.44	0.20	3.37	1.46
Bid 3	19875	18750	21000	3.44	0.73	2.65	1.46
Bid 4	21000	19875	22125	3.24	0.99	3.24	0.93
Bid 5	22125	21000	23250	3.57	0.79	2.98	1.06
Bid 6	23250	22125	24375	4.37	0.53	2.71	0.79
Bid 7	24375	23250	25500	4.37	0.40	2.18	1.59
Bid 8	25500	24375	26625	4.30	0.20	2.25	1.06
Bid 9	26625	25500	27750	3.64	0.20	2.58	2.12
Bid 10	27750	26625	28875	5.75	0.60	1.65	1.06
Bid 11	28875	27750	30000	4.03	0.46	1.85	1.72
Bid 12	30000	28875	31125	4.56	0.79	2.12	0.86

§NN represents 'No' response to the initial bid and 'No' response for the follow-up bid; NY represents 'No' response to the initial bid and 'Yes' response for the follow-up bid; YY represents 'Yes' response to the initial bid and 'Yes' response for the follow-up bid; YN represents 'Yes' response to the initial bid and 'No' response for the follow-up bid.

Appendix Table 2b. Bid structure and responses of elicitation of willingness to pay for maize shelling service (MWK per 50 kg grain) using 2WT operated sheller

	Bid in MWK			% of response§			
	Initial	Follow-up for 'No' response	Follow-up for 'Yes' response	NN response	NY response	YY response	YN response
Bid 1	250	200	300	2.25	0.46	3.77	1.19
Bid 2	300	250	350	2.78	0.60	3.37	1.46
Bid 3	350	300	400	2.78	1.06	2.65	1.72
Bid 4	400	350	450	3.11	0.86	3.31	1.26
Bid 5	450	400	500	3.70	0.73	2.91	1.26
Bid 6	500	450	550	3.51	1.32	2.71	0.73
Bid 7	550	500	600	3.77	0.46	2.31	2.12
Bid 8	600	550	650	4.17	0.60	1.98	1.19
Bid 9	650	600	700	4.17	0.53	1.98	1.85
Bid 10	700	650	750	5.09	0.99	1.52	1.26
Bid 11	750	700	800	5.49	0.53	0.93	1.32
Bid 12	800	750	850	4.63	1.06	1.59	0.99

§NN represents 'No' response to the initial bid and 'No' response for the follow-up bid; NY represents 'No' response to the initial bid and 'Yes' response for the follow-up bid; YY represents 'Yes' response to the initial bid and 'Yes' response for the follow-up bid; YN represents 'Yes' response to the initial bid and 'No' response for the follow-up bid.

Appendix Table 2d. Bid structure and response for elicitation of willingness to pay for transporting service per full cart of maize

	Bid in MWK			% of response§			
	Initial	Follow-up for 'No' response	Follow-up for 'Yes' response	NN response	NY response	YY response	YN response
Bid 1	1400	1300	1500	2.31	0.33	4.56	0.53
Bid 2	1500	1400	1600	2.71	0.07	4.50	0.99
Bid 3	1600	1500	1700	2.45	0.46	3.90	1.46
Bid 4	1700	1600	1800	2.84	0.20	4.30	1.26
Bid 5	1800	1700	1900	2.98	0.40	4.17	1.06
Bid 6	1900	1800	2000	3.04	0.20	3.84	1.12
Bid 7	2000	1900	2100	3.17	0.26	3.97	1.19
Bid 8	2100	2000	2200	2.84	0.60	3.31	1.06
Bid 9	2200	2100	2300	3.31	0.26	4.10	0.99
Bid 10	2300	2200	2400	3.84	0.40	3.44	1.19
Bid 11	2400	2300	2500	3.37	0.26	3.77	0.66
Bid 12	2500	2400	2600	3.04	0.26	3.84	1.19

§NN represents 'No' response to the initial bid and 'No' response for the follow-up bid; NY represents 'No' response to the initial bid and 'Yes' response for the follow-up bid; YY represents 'Yes' response to the initial bid and 'Yes' response for the follow-up bid; YN represents 'Yes' response to the initial bid and 'No' response for the follow-up bid.