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Demand for Agriculture Mechanization in the Hauts-Bassins Region in Burkina Faso

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This study aims to assess the status of agriculture mechanization in the Hauts Bassins Region (HBR) of Burkina Faso and elicit demand levels for machine services via a survey of 946 farm households. Overall, animal traction remains the primary means of land preparation while small engines are widely used for threshing and winnowing. Labor saving from engine power is greatest for harvest activities. Willingness to pay (WTP) elicitation suggests that access to machines remains a key concern. The mean WTP for custom hire tractor plowing, 28,409 CFA (\$48), was 36% higher than reported rental costs, and approximately 30% of the sample not using custom hire plowing services were willing to pay the prevailing price. Further, farmers in households with high proportions of women and children were least likely to use and demand tractor services, while irrigators had the highest stated demand.

Key words: Agriculture, Mechanization, Smallholder Farmers, Sustainable Intensification

Building rural capacity to serve the growing needs of production, storage, and processing of agricultural products for sustainable food security remains a major challenge for Sub-Saharan regions (Side and Havard, 2015). Agricultural production and processing in Sub-Saharan Africa (SSA) using engine-based machine power has lagged other regions (United Nations Food and Agriculture Organization (FAO), 2018). Appropriate mechanization can make farming systems more sustainable by improving the timeliness of field operations and reducing the drudgery of hand labor for land preparation, planting, weed control, and harvest.

Estimates in SSA from turn-of-the-century studies suggest that 65% of agriculture energy is from manual power, 25% from draft animals, and 10% from engine or electrical power (Clarke and Bishop, 2002). An FAO (2018) report indicates that those numbers were largely unchanged as of 2010, with Southern and Eastern Africa providing the most tractor power, followed by West and Central Africa. Even within less mechanized West Africa, the use of machine power is extremely heterogeneous. While tractor use has risen steadily in Nigeria and Cote d'Ivoire since the 1980s, growth in other regions has been sporadic or non-existent (Zhou, 2016).

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Competing explanations have been offered to explain the machine-power gap. While Houmy, Kienzle, and Ashburner (2012) have focused on low demand from farmers as a key factor in slow mechanization in Sub-Saharan Africa, the Malabo Montpellier Panel (2018) and Diao, Silver, and Takeshima (2017) focused on poorly designed state interventions and sub-optimal public sector coordination and support for mechanization supply as primary reasons.

Despite the seeming lack of progress, several demand- and supply-side factors have pushed the subject of mechanization back to the forefront of African agricultural development. A recent study by Diao, Silver, and Takeshima (2017) in Ghana reveals an increasing use of machine and animal power for plowing, threshing, harvesting, and other tasks. Behind this emerging demand for mechanization, they note the importance of rapid urbanization, growth of medium-sized farms, rising rural wages, and seasonal labor shortages. Yet, the market for mechanization services remains thin in many SSA countries. In Nigeria, for instance, most of the tractor services are either directly provided by the government or heavily subsidized (Diao, Silver, and Takeshima, 2017).

This paper focuses on the West African country of Burkina Faso. In comparison to other African countries, the introduction of mechanized agriculture in Burkina Faso came quite late and through very informal processes. At the inception of its agricultural mechanization program in the 1970s, the country promoted animal traction, an effort that never flourished due to pastoralist and agriculturalist conflicts (Faure, 1994). Tensions between farmland expansion induced by mechanization, on one hand, and traditional land tenure policies, on the other hand, have also hampered the adoption of machine power in Burkina Faso (McCauley, 2003; Fonta et al., 2018). Yet, FAO and World Bank statistics reveal a growing number of tractors per hundred hectares of arable land. From only 29 tractors in 1960, the country had 1,933 tractors in use as of 1995 (FAOSTAT, 2019; World Bank, 2019). Research from the early 2000s noted that 70% of farmers used manual labor, 29% had access to animal traction, and only 1% used wheeled tractors (Direction General de la Promotion de l'Economie Rurale (DGPÉR), 2001). While these estimates are likely outdated, they do highlight a large farming mechanization gap that does not appear to have been closed. Overall, access to machines at the farmer level in this West African country remains poorly studied.

The current study aims to assess both the current status of mechanization in rural Burkina Faso and the supply and demand for mechanized services. We have two main contributions. First, we provide detailed descriptive evidence on labor and equipment disaggregated across the range of farming activities. Second, we estimate the important determinants of both actual use and stated demand for mechanized services.

The analysis relies on data from the Appropriate Scale Mechanization Consortium (ASMC) for the sustainable intensification baseline survey that occurred in the Hauts-Bassins Region (HBR) of Burkina Faso in 2016. We first profile intra-household labor allocation on farms and highlight the current level of agricultural mechanization. Though animal traction remains the predominant mode of land preparation, nearly 10% of the sample reported tractor usage for plowing. Further, post-harvest activities such as threshing, and winnowing are thoroughly mechanized. Using a logistic regression model, we also estimate the determinants of tractor and animal usage in key farming activities.

In addition to assessing the current penetration of mechanized services, we also analyze the stated demand for agricultural machines. We find that average stated WTP exceeds current average prices of mechanized plowing services. Nearly three in 10 farmers not yet utilizing machine power for land preparation would be willing to pay the prevailing custom hire rate, and that proportion would nearly double if prices fell by just 20%.

Demand appears to depend on both on-farm factors (land size by crop type and irrigation access) as well as household labor characteristics. Farms with proportionately more women and children use less mechanization and express lower demand, suggesting that child labor is a substitute for mechanizing tasks.

These results are consistent with more recent literature emphasizing supply-side issues in the slow growth of mechanization. Access appears to be a major driver of low utilization in our study area. Given that our findings point to a strong potential for mechanization to reduce child labor, policies that alleviate private sector barriers to operating custom hire services are likely to have significant welfare impacts.

Our paper is structured as follows. Section II briefly summarizes the literature on mechanization in SSA, while Section III describes the conceptual and empirical models used in the estimation. Section IV gives the key features of the data, while Section V specifically describes the patterns of existing labor and machine use in the study area. The econometric estimates of the determinants of current mechanization and stated demand for mechanized services are detailed in Section VI, while Section VII concludes our findings.

A Brief Literature Review of Supply and Demand for Agricultural Mechanization in Sub-Saharan Africa

Agricultural mechanization refers to the use of farming machinery, including basic hand tools to more sophisticated and motorized equipment (FAO, 2016). Following this definition and distinguishing machinery use by power sources, the Malabo Montpellier Panel (2018) distinguishes three levels of mechanization: human power-based mechanization, animal power-based mechanization, and mechanical power-based mechanization. Notwithstanding the substantial state-led efforts to promote agricultural mechanization during the 1960s and 1970s, African agriculture remains the least mechanized in the world (Daum and Birner, 2020). In SSA, 65% of land preparation activities for food production are powered by human muscle. By comparison, the share in Asia is below 35% (Zhou, 2016).

Much of the literature has focused on specific demand- and supply-side factors that have hindered the spread of mechanization in SSA. Several factors including farming systems, relative wages, farming products, and the agro-ecological and socio-economic conditions of farmers determine the demand for custom hired services (Sims et al., 2012). Of these, mechanization's labor-saving features have received the most attention. Several studies have found a positive correlation between rising rural wages and costs of draught animals, on one hand, and mechanization, on the other hand (Takeshima, Nin-Pratt, and Diao, 2013; Takeshima and Liu, 2020; Diao, Silver, and Takeshima, 2017). In some countries, a combination of production

intensification and rising rural wages have created a labor bottleneck for several activities including land preparation, weeding, and harvest. This has triggered increasing demand for labor-saving technologies such as mechanization (Daum et al., 2019). However, mechanization may play a diversity of roles beyond reducing labor costs. These include increasing the quality of production, expanding farm acreage under production, and even potentially allowing a shift towards conservation-friendly planting practices (Marenya et al., 2017).

The ability of farmers to participate in mechanization schemes hinges on timely supply or availability of the technologies and services (Benin et al., 2013). Baudron et al. (2019) find high latent demand for mechanization services in four SSA countries limited by access and supply constraints. As a consequence, both the spread of agricultural mechanization and the extent to which increased mechanization spurs growth in production, income, consumption, assets, and other desirable outcomes will depend on how well local markets and institutions function for custom hired services. However, the rise of custom hire services, and potential for digital technologies to reduce the transaction costs of these services, has renewed interest in the potential for growth in mechanization technologies in SSA (Daum and Birner, 2020).

The most commonly used agricultural machinery in West Africa include tractors, combine harvesters, threshers, manure spreaders and fertilizer distributors, plows and cultivating machines, and seeders and planters (Zhou, 2016). While specialized mechanical seeding technologies can reduce soil disturbance, such conservation-improving technologies are less widespread (Marenya et al., 2017).

Similar to other Sub-Saharan countries, the market for mechanization services in Burkina Faso is underdeveloped. Supply is uneven across locations, and much of the tractor services are provided by government through either subsidized direct sales or public tractor hiring service (Weiner et al., 1988; Abdulquadri and Mohammed, 2012; Zhou, 2016). As a result of the uneven distribution of subsidized tractors, and high fixed costs, the adoption of mechanization is highly constrained, leaving potential demand unmet for the majority of small-holder farmers (Ksoll et al., 2017; Takeshima, Nin-Pratt, and Diao, 2013).

Historically, demand for agricultural mechanization in Burkina Faso has been closely linked to the production system, with small- and medium-sized farms utilizing animal traction and mechanized power reserved for larger operations (Stephane and Harvard, 2014). Further, access to credit is a primary constraint on purchases of improved agricultural equipment in the country. The combination of these limiting factors has traditionally limited the market for mechanization, but the increasing trend of custom hire services potentially changes those dynamics (Stephane and Harvard, 2014; McCauley, 2003; Mrema, Kienzle, and Mpagalile, 2018).

Conceptual Framework and Empirical Model

A key component of this study is the assessment of the determinants of stated WTP for mechanized plowing services. As in Ulimwengu and Sanyal (2011), we conceive of WTP as the expenditure level for mechanized services at which producers are just indifferent between adopting and foregoing the new production practice. Following their notation, we represent this formally using a money-metric utility specification as follows:

$$(1) \quad WTP = e(p, EU_0, F_0) - e(p, EU_0, F_1)$$

where p is the vector of prices, EU_0 represents the current expected utility level, and the optimal farming system with and without mechanized services is given by F_1 and F_0 , respectively.

The marginal utility of adopting mechanized services will depend on both the expected difference in productivity and the savings from the reallocation of resources away from the newly mechanized service (e.g., plowing). For a commercial farmer, where production and consumption decisions are separable, the value of such changes can be evaluated at prevailing market prices for outputs and inputs. However, when production decisions are non-separable, the value of mechanized services will depend on the household level characteristics that determine the relevant shadow prices. Therefore, household labor availability, for example, will be important as optimal allocation of labor depends heavily on household composition under such conditions (Benjamin, 2009).

Because separability is an unrealistically strong assumption for our sample of rural farmers in Burkina Faso, we estimate the household WTP for custom plowing services based on consumption and production parameters. These include socio-economic information; farm characteristics such as location, land area, crop choice, and irrigation use; and household composition based on age and gender. Because knowledge and attitudes towards new technologies influence their perceived value, we include measures of current agricultural technology use (improved seed), and the age and education level of the household head which are socio-economic factors likely to shape attitudes towards proposed technology (Ulimwengu and Sanyal, 2011).

Empirical Model

In this study, we estimate both the determinants of tractor use and the factors affecting the WTP for custom hired services. In each case, the unit of observation is the household.

We first estimate the determinants of tractor use separately for plowing and harvest using a logit model. For household i , the outcome variable y_i takes the value 1 if the household reports using mechanization for the relevant activity, and 0 otherwise. Based on the standard logistic distribution, the model of the predicted probability can be written:

$$(2) \quad P(Y_i = 1) = P_i = \frac{1}{1 + e^{-w_i}}$$

where $W_i = b_0 + \sum_{j=1}^M b_j x_{ij}$ is a linear combination of the M independent variables and a set of coefficients $b = (b_1, b_2, \dots, b_M)$ estimated via maximum likelihood. As noted in the discussion of the model of WTP, the independent variables in this model include household characteristics such as size, female ratio, land use, livestock possession, household head age and education level; access to irrigation and credit; use of improved seeds; and geographic localization. We also control for being a native or immigrant in the region. For this specific study, the relevance of being native of

the region or immigrant relates to farmland ownership.¹ The survey did not include a direct question on farmland ownership, though ownership is likely a key determinant of tractor use (McCauley, 2003). Native status serves as a proxy for ownership because the majority of farmland in Burkina Faso is inherited (Korbeogo, 2015).

We then estimated the determinants of the WTP for custom hired service using a standard Ordinary Least Square (OLS) model:

$$(3) \quad WTP_i = \beta_0 + \sum_{k=1}^M \beta_k X_{ki} + \varepsilon_i$$

where β_0 is the intercept and $\sum_{k=1}^M \beta_k X_{ki}$ is a linear combination of the independent variables and a set of coefficients $\beta = (\beta_1, \beta_2, \dots, \beta_k)$ which are to be estimated. We include the same independent variables as those included in the estimation of equation (2). Unlike in Chiwaula et al. (2018), very few respondents (less than 1%) reported a WTP of zero, so the use of two-stage models is not required to alleviate censoring concerns.

Description of Study Area and Data

Burkina Faso is an agricultural-based economy. Approximately 80% of the population live in rural areas and rely on agriculture for food production (Institut National de Statistiques et de la Démographie, 2008). Smallholder farmers are the main food providers (Agence Française de Développement, 2015). Agriculture provides income, food security and accounts for 35% of the gross domestic product of the country (Consumer Price Index, 2012).

Most farmers are smallholders and grow mainly millet, sorghum, and maize (corn) as cereals on less than 0.5 ha. Maize is grown in Burkina Faso in areas where rainfall is at least 700 mm a year and soils are suitable, primarily in the western and southern parts of the country. Maize yield potential ranges from 2,000 to 6,000 kg/ha and increases in productivity could greatly enhance domestic food security (FAO, 2014; Ksoll et al., 2017).

This study was conducted in the HBR, located in western Burkina Faso. This region is known as an economic and business hub. The region is crossed by two international railroads and, therefore, occupies a strategic position for agricultural trade with neighboring countries such as Côte d'Ivoire and Mali (Badolo, 2009). The region encompasses three administrative units called provinces: Houet, Kenedougou and Tuy.

The survey was conducted in all three provinces in 2016 from August 19 to 29, which was after planting and before the main harvest season. The questionnaire was designed in French and translated into local languages of Dioula, More, and Fulfulbe. The theoretical and practical training of enumerators included a pre-test and a pilot phase of the questionnaire held from August 16 to 17.

The survey sample was drawn from a complete list of villages and farm households provided by extension services in each province. From the extension agency pre-sampling list, villages were randomly selected to be representative of maize-growing areas in each district. Within villages,

¹ See Table 1 for a full list of variables used in the analysis.

respondents were randomly drawn from a list of maize-growing households. In order to prevent bias arising from enumerators substituting households, no changes or replacements were allowed in the field. All households were provided with informed consent agreements, and none refused to answer the survey questionnaire. Also, no incentives were given to respondents.

Despite the attempt to survey a representative group of maize farmers in the region, there are some reasons to be cautious about the survey's representativeness. Because the household registry used for sampling was derived from extension agency lists, these lists may have excluded more marginalized farms not tracked by extension agents. We highlight that the pre-sampling list might not be representative of Burkina Faso's entire rural population. The sample size for targeted households to be investigated was determined using Schwartz and Denne's (2006) formula, and an assumption that 80% of the region's residents were farmers. Based on the latter, a minimum of 589 households were targeted.

Questionnaires were administered to approximately 30 households per village in 32 villages. In total, we interviewed 946 households with a structured questionnaire administered to the selected households' heads (Kere, Schwab, and Hodjo, 2018). Administering the questionnaire required approximately 45 minutes to 1 hour. Three supervisors from agricultural extension services were responsible for the coordination of the survey in each province. The questionnaire included several sections, including household characterization, agricultural production, crop diversity, agricultural equipment, food diversity, crop utilization, and actions taken to adapt climate change.

Table 1 presents socio-demographic indicators of the surveyed households. The household sizes varied between 3 and 85 members, with an average of 15 and a median of 11 persons. Nationally representative data from Burkina, in contrast, suggest the average household size is 8 persons in rural areas versus 6 in urban areas (World Bank, 2016). Consequently, our sample includes relatively larger households, though the difference may also owe to slightly differing definitions of a household unit. Most of the surveyed households are headed by literate males, and most of the respondents are natives of their region. More than 97% reported living in the village in which they were surveyed for more than 10 years. While 50% of the households have a member living away from the region, only 23% reported receiving migrant remittances. Approximately 58% of the respondents self-reported as poor.

In the HBR, the average production area for cereal crops was 8.7 ha, of which 5.2 ha was for maize production. Household land area ranged from 5 to 20 separate fields.

The average rental cost for one hectare of land in the study region was 212,540 CFA (\$358.65USD). The average maize yield was 4,300 kg per household, and 1,000 to 1,700 kg/ha. That estimated yield is similar to the West African average of 1.5 tons per hectare (Macauley, 2015), but lags behind the 2,000 to 5,000 kg/ha estimate for improved varieties (Escalante-Ten and Maiga, 2012). Half of the households sold all their maize production, whereas 39% traded only a share. The price of maize received ranged from 116 to 130 CFA (\$0.20 to \$0.22USD/kg).

Table 1. Household Main Socio-economic Characteristics.

Variables	Mean	Standard Deviation
<i>Categorical Variables</i>		
Male household head	0.98	0.12
Household head attended primary school	0.99	0.04
Native of village	0.73	0.44
Received remittance	0.19	0.39
Self-described socio-economic group		
Very poor	0.08	0.26
Poor	0.5	0.5
Medium	0.35	0.47
Wealthy	0.07	0.26
Household has garden plot	0.27	0.44
Household used irrigation	0.12	0.33
Province the household lives in		
Kenedougou	0.36	0.48
Houet	0.38	0.49
Tuy	0.26	0.44
<i>Continuous Variables</i>		
Household head age (year)	45.24	11.11
Land area farmed for maize (ha)	5.19	6.32
Land area farmed for non-maize crops (ha)	5.6	12.22
Ratio of female to total household members	0.51	0.14
Number of adults (age>15) in the household	7.97	6.88
Number of children (age≤15) in the household	6.59	5.26
Animal units owned by household (excluding poultry)	15.17	21.83

Source: Authors' computation from household survey.

Patterns of Household Labor Utilization and Mechanization in Farming Activities

Mechanization is generally a labor-saving technology, and demand is often contingent on the labor costs and productivity for farm activities. Therefore, we first describe existing patterns of labor used in the study region based on the survey data.

For most households, men, women, and children all work in household farming and vegetable production (Table 2). While many food production activities are not gender segregated, land preparation and weeding were commonly reported to be performed by men only. For example, in 39% of households, land preparation was mainly done by males, while 59% equally shared the task. For harvesting, the proportions are reversed, with only 10% of households reporting male sole work, and 87% reporting joint work.

The majority of households reported that children or young people were involved in all crop production operations. Children were mostly used for planting, weeding, and harvesting, and were

least likely to participate in seeding and land preparation. Most commonly, young people work together with their parents, with rates of children working by themselves in weeding and harvest activities at below 2%. This is similar to figures reported by Shittu (2014) on family labor use in rural Nigeria. Weeding was the activity most commonly performed alone by children, with 9% of households reporting young people as the sole member responsible for weeding.

Table 2. Distribution of Household Labor Used in Each Crop Production Activity by Gender and Participation by Children.

Activity	Household Labor Participation by Gender		Household Labor Participation by Children	
	Actors	Percentage	Actors	Percentage
Field preparation	Male only	38.95	Child & Parents	67.03
	Female only	2.06	Child only	5.93
	Both	58.99	No Children	27.05
Seeding	Male only	11.27	Child & Parents	72.09
	Female only	2.74	Child only	1.51
	Both	86	No Children	26.4
Weeding	Male only	19.31	Child & Parents	72.25
	Female only	1.67	Child only	9.18
	Both	79.02	No Children	18.57
Harvest	Male only	10.39	Child & Parents	81.36
	Female only	2.84	Child only	1.51
	Both	86.76	No Children	17.13

For each agricultural activity (field preparation, seeding, weeding, and harvest), this table categorizes households by which members participate. For each activity, the "percentage" column on the left side of the table (Household Labor Participation by Gender) categorizes whether the activity is performed only by men, only by women, or by both men and women. For each activity, the "percentage" column of the right side of the table (Household Labor Participation by Children) categorizes whether the activity is performed by a combination of children and parents, children only, or adults only (i.e. no children). Source: Authors' computation from household survey.

Descriptive Statistics of Mechanization Use in HBR

We first analyze the status of machine use in the sampled households by identifying the key equipment used for each agricultural task. Respondents were asked to list the primary equipment used to complete nine separate agriculture tasks, and their answers are compiled in Table 3.²ⁱ

Overall, hand tools and animal equipment were the most frequently used farm equipment. For plowing, animal equipment predominated (85.5% of households), but four-wheeled tractors were used by nearly 10% of the sample. For tasks such as sowing, planting, and weeding, machine use was extremely rare. Instead, hand tools, such as hoes, predominated.

Tractor use was more common in harvesting, with 17% of households reporting their use. Unfortunately, our data does not allow us to distinguish what element of the harvest task for which tractors were used. Because farmers named equipment they deemed vital to each task, some of the responses include transportation modes used in that activity. For example, carts were commonly used to transport fertilizers to farms, harvested products to homes, and commodities to

² Note that some farmers identified more than one "primary" piece of equipment, so columns in Table 3 do not sum to 100.

marketplaces. Transportation usage may explain the relatively greater penetration of four-wheeled tractors in harvesting relative to plowing if respondents considered crop transport as part of the harvest activity.

Table 3. Percentage of Households Using Specified Agricultural Equipment by Agricultural Activity.

Equipment	Use of Equipment and Specific Practices ^b ...								
	Plowing/Tillage	Sowing	Planting	Weeding	Fertilizer application	Harvest ^a	Threshing/Winnowing	Drying	Sales/Marketing
Four-wheeled tractor	9.2	0.8	0.3	2.9	1.7	17.4	4.6	0.2	0.2
Two-wheeled tractor (power tiller)	0.2				0.1		0.1		
Generator		0.1							
Hand basket		5.4			23.9	6.2	1.3		0.4
Cart for horse/cow	0.3		0.1		6.9	4.3			10.1
Cart (like basket) for animal (horse/cow)	0.3	0.5	0.1	0.8	50	27.2		0.2	13.8
Cart attached to the tractor or motor vehicle					1.9	0.3	0.3		0.6
Animal equipment	85.5	13.7	7.4	31.8					
Motorized traction equipment		0.1			2.2	0.1	0.3	0.2	0.2
Hoe	4	4.7	0.8	34.7	0.1	0.1			
Other hand tool	8.6	76.2	20.7	60.1	8	18.5	13.2		4.9
Threshing machine	0.2			0.2	0.1	9.3	58.4		0.2
Bicycle				0.1	8.3	1.6			4.9
Motorcycle					3.3	0.7			9.2
Truck					0.1	0.6			6
No specific tool or equipment identified	3.8	6.5	78.1	2.4		20	25	99.4	67.2

^a Note that household definitions of tasks are subjective. Thus, harvest activities may include both cutting and transport of harvested products to threshing areas. ^b Because households may identify more than one piece of equipment per task, columns do not sum to 100. Source: Authors' computation.

Some degree of mechanization appeared to already exist among respondents in the survey region, with four-wheel tractors the dominant form. The 10% penetration in plowing and 17% penetration in harvest indicates both existing infrastructure and familiarity. Further, the nearly universal use of mechanization for post-harvest activities (threshing and winnowing) suggests minor engine diffusion in Burkina Faso.

Despite the apparent penetration of tractor services in the sample, the overall means mask substantial heterogeneity by province. Tractor usage was particularly large in Tuy (Figure 1) where 57% of the respondents reported having used a tractor for any reason at least once during the production cycle. The comparable figure in Houet is only about 5%. That difference likely owes to both larger scale commercial agricultural production in Tuy, as well as reports of a more active governmental subsidy program in the area. According to Ouedraogo et al. (2019), farmers in the cotton-growing region of Tuy receive support from the state for the procurement of agricultural machines.

Most households using a tractor report renting via a custom hire service, though 39% report ownership. However, that ownership figure may reflect cooperative ownership arrangements. In contrast, only 40% of those using animal equipment report renting.

The labor-saving properties of machine use are readily apparent in reports of time use for each activity by household. Except for sowing, use of mechanized equipment reduced required labor days considerably relative to the next fastest option (Table 4). The greatest labor saving occurred for harvesting, which required 7.5 to 10 days for those not using tractors, and only 0.5 days for those with tractors. Plowing time was nearly reduced in half for the sample reporting any tractor use.

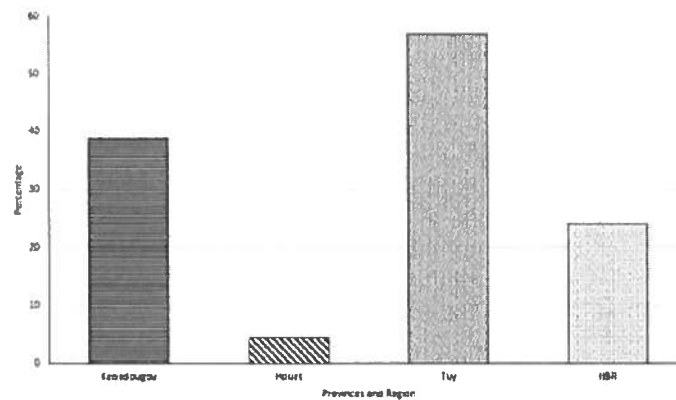


Figure 1. Proportion of Respondents Who Used a Tractor for Any Pre-harvest and Harvest Activity.
Source: Authors' computation. Excludes post-harvest activities (threshing/winnowing and sales/marketing).

Table 4. Labor Days per Hectare for Each Activity Performed, Categorized by the Primary Equipment Used (Mechanized, Animal, or Manual/Other).

Activity	Average Number of Days per Hectare ^a					
	Manual/Other Equipment		Animal		Tractors/Mechanized Equipment	
	# days	N	# days	N	# days	N
Plowing	11.2	84	5.9	737	3.5	87
Sowing	6.1	731	2.6	132	6.4	7
Planting	2.8	93	5.2	54	0.2	1
Weeding	10.4	596	6.3	291	3.1	1
Fertilizing	1.4	195	2.7	494	0.6	16
Harvest	10.2	276	7.5	338	0.5	156
Threshing/Winnowing	2.7	110	-	0	0.8	406
Marketing/Sales	1.8	28	1.5	67	2	37

^a Those not identifying specific equipment are excluded. For each group, mean reported days per hectare to complete a task is reported alongside the sample size. *Source: Authors' computation.*

Econometric Estiamtes of the Use of and Stated Demand for Mechanization

In this section, we estimate models of the determinants of both current use of mechanization (Equation (2)) and stated WTP for mechanized services (Equation (3)).

Logit Estimates of the Determinants of Mechanization Use

To further analyze which households utilize tractors, Table 5 reports the result of a logit estimation regressing tractor use on household characteristics by task. Larger maize farms are more likely to use machines for plowing, though the relationship for harvesting is not significant. However, non-maize farm acreage has a small and insignificant affect on tractor use for both plowing and harvest. One possible explanation is that non-maize farm size is captured somewhat by the number of livestock, which is counterintuitively positive associated with tractor use for plowing. Another

possible factor is the strong heterogeneity by province, as these within-province estimates of the extensive margin of tractor use may be dominated by the between-province differences.

The labor patterns presented in Table 2—where females are relatively less likely to be involved in land preparation, but more likely to be involved in harvest activities—appear to be reflected in the association of gender ratio and machine use. Whereas a higher proportion of females is insignificantly linked to tractor usage for plowing and harvest, the direction of the relationship is negative for both activities. If female time is not valued as highly by the individual making decisions on tractor use, saving female labor during harvest—where they are more likely to be used—may not be as high a priority for household heads. That interpretation is bolstered by the overall positive relationship between labor size and machine use, suggesting the gendered composition of the labor force has a unique relationship with adoption of machine services.

Similarly, the presence of children is negatively and significantly linked to tractor use for both plowing and harvesting. However, the magnitude of the effect for harvest—where children are more likely to be used for labor—is thrice as high as that for plowing. These results suggest two, non-mutually exclusive possibilities. One, higher numbers of children potentially repress the demand for tractor use in households with more minors. Two, mechanizing farm activities, particularly at harvest, would likely have the largest potential effect on reducing child farm labor.

In line with conventional wisdom, households reporting access to credit are more likely to use tractors for plowing. However, the relationship for using tractors at harvest is insignificant. Conversely, those receiving remittances are less likely to use a tractor, though the relationship is also not significant for harvest. Farms that use irrigation are significantly less likely to use tractors for plowing, and more educated household heads are more likely to use tractors for harvest. Further, farmers using improved seeds are more likely to use tractors for both plowing and harvesting. That last finding indicates those most likely to adopt mechanization also take on other agricultural technologies.

Mechanization Costs and the Stated Demand for Mechanization

The survey also assessed the stated demand for mechanization services by including several questions on the amount that producers would be willing to pay for such services across different production activities. We present the results of this part of the survey alongside the actual reported rental rates from the subsample of those who reported renting mechanized equipment.

To determine market rental rates, we use data from the 16 farming households in the sample that reported renting tractor services for plowing. These farmers received custom hire service (e.g. rental and labor), though an additional four reported renting the equipment by itself. For the pooled sample, the mean and median per hectare rental costs for custom hire plowing services for tractors were 20,833 CFA (\$40.17) and 25,000 CFA (\$42.18), respectively (Table 6). In Kenedougou, all tractor plowing rentals were performed on a custom-hire basis. Prices in Houet were slightly more than those reported in Tuy. These reported rates are very close to national level cost estimate of \$51 per ha reported by Diao, Silver, and Takeshima (2016).

Table 5. Logit Estimates for the Determinants of Tractor Use.

Variables	Plowing	Harvest
Age of household head	0.0005	0.0015
	-0.001	-0.002
Native of village	0	-0.0466
	-0.023	-0.046
Receiving remittances	-0.0583**	-0.083
	-0.029	-0.05
Land area farmed (maize) (ha)	0.0031**	0.0018
	-0.001	-0.003
Land area farmed (non-maize) (ha)	0.0003	0.0036*
	-0.001	-0.002
Practicing some gardening	-0.0352	0.0229
	-0.033	-0.061
Used irrigation	0.0111	0.0066
	-0.044	-0.087
Female ratio in household ^a	-0.0329	-0.1854
	-0.069	-0.125
Adult (age >15) number	0.0031**	0.0074*
	-0.001	-0.003
Child (age <=15) number	-0.0033*	-0.0123**
	-0.002	-0.004
Number of livestock units (excluding poultry)	0.0011***	-0.0025**
	0	-0.001
Head of household attended primary school	-0.0043	0.0425
	-0.019	-0.032
Access to credit	0.0642***	0.1653***
	-0.02	-0.033
Uses improved seed	0.0425*	0.1037***
	-0.022	-0.036
Province (reference = Kenedougou)		
Houet	-0.0248	
	-0.019	
Tuy	0.1325***	0.0662*
	-0.029	-0.061
Observations	854	518
Pseudo R-squared	0.27	0.14

The dependent variable equals 1 if mechanized equipment was used for the activity in the column header, and 0 otherwise. Marginal effects of the logit estimation are reported. Standard errors are in parentheses below coefficient estimates. ^a Female ratio in the household is the number of females divided by the household size.

*** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Table 6. Amount Paid for Renting Tractors for Plowing, by Province (CFA/hectare).

Province	Mean	Standard Deviation	Median	Minimum	Maximum
Renting machines only for plowing					
Houet	19444	9623	25000	8333	25000
Tuy	25000	0	25000	25000	25000
Pooled	20833	8333	25000	8333	25000
Renting machines and operator for plowing (e.g., custom hire)					
Kenedougou	25000	0	25000	25000	25000
Houet	25000	-	25000	25000	25000
Tuy	11073	4911	11073	7600	14546
Pooled	22215	6096	25000	7600	25000
Renting machines for threshing by province (CFA/hectare)					
Kenedougou	7469	9926	3000	1200	40000
Houet	5362	8371	3000	1050	69000
Tuy	3980	2142	3375	1087	8333
Pooled	5549	8194	3000	1050	69000

All WTP measures winsorized, with largest 1% of observations top coded at the 99th percentile. Pooled means are averaged over the entire sample. All values in CFA. World Bank official exchange rate for 2016 in Burkina-Faso was \$1 USD = 591.61 CFA or 1 CFA = \$0.002 USD. Source: Author computation from household survey.

For the entire sample, we obtain data on farmers' maximum willingness to pay (WTP) for custom hire plowing services. We first report in Table 7 the unadjusted and adjusted mean WTP summary statistics, which are winsorized (top-coded) at the 99th percentile of the elicited WTP distribution in order to reduce the influence of extremely high values. Adjusted mean WTPs are calculated for key subgroups, holding all other variables at the mean. We report results based on irrigation use and self-assigned income groups to shed light on the within-sample and cross-province variability. For comparison, Table A2 of the Appendix displays OLS-adjusted averages for both the winsorized and full non-winsorized sample.

For one hectare of farmland, the mean WTP for custom hire plowing, 28,409 CFA (\$47.94), is 36% higher than the mean rental cost of 20,833 CFA (\$40.17). The average WTP for custom hire plowing services for those not currently using those services is 33,762 CFA (\$56.97) and higher than the average WTP for the service for existing users (28,820 CFA or \$48.63). While the elicitation method here is subject to hypothetical bias common to all WTP studies that lack incentivized mechanisms (e.g. like Becker-de Groot-Marschak auctions), respondents would need to be significantly overstating valuation for the mean rental rates to exceed average valuations.

Irrigation users across all provinces are willing to pay substantially more for custom hire plowing services—nearly triple those not currently irrigating. The average WTP for irrigating households (50,356 CFA, or \$84.97) more than doubled the mean rental rate, while WTP for non-irrigators

(23,803 CFA, or \$40.17) exceeded the mean rental rate by less than 15%. Furthermore, the difference in stated demand between self-identified very poor and very wealthy respondents is low.

Table 7. Unadjusted and Adjusted Average WTP for Machine Rental by Province (CFA/hectare).

Item	OLS with Winsorized Observations			
	Pooled	Kenedougou	Houet	Tuy
Unadjusted mean for all households	28409	34769	22967	27663
Unadjusted mean for non-users of tractors	33762	18333	45455	27575
Unadjusted mean for users of tractors	27820	34928	20560	27688
Adjusted means				
Adjusted at mean of all variables	27360	31442	24514	26051
Used irrigation	50356	56230	44650	50906
Did not use irrigation	23803	29678	18097	24354
Did not use irrigation and number of adults at median	23650	29465	18075	24082
Self-assigned income groups				
Very poor	30737	36463	26907	30541
Poor	26655	31511	23443	23740
Wealthy	27551	29753	24735	28882
Very wealthy	28100	34814	25644	20793

All WTP measures winsorized, with largest 1% of observations top coded at the 99th percentile. Pooled means are averaged over the entire sample. All values in CFA. World Bank official exchange rate for 2016 in Burkina-Faso was \$1USD = 591.61 CFA or 1 CFA = \$0.002 USD. Source: Authors' computation from household survey.

Further investigation of the distribution of WTP provides insight into the proportion of farmers currently willing to pay market rates for mechanized plowing services. The median WTP of 20,000 CFA (\$33.75) was 80% of the median custom hire rate (25,000 CFA, or \$42.19). Median WTP for irrigators and non-irrigators was identical. Exactly one-third of the sampled farmers reported a WTP at or above the median rental rate. Among those not currently using a tractor for plowing, that number drops to 28%.

Thus, even at prevailing prices, nearly three in 10 farmers were willing to use machine power for plowing, but unable to do so. In fact, were prices to fall by 20%—which would bring the cost closer to nearby Northwestern Nigeria (Diao, Silver, and Takeshima, 2016)—59% of those currently using a tractor for plowing would have a WTP above the median rental rate. That suggests supply constraints are a key source of lagging mechanization in the HBR. Thus, while information or sensitization-based campaigns may be useful in further improving demand, farmer responses suggest that further stimulating demand is likely insufficient to increase mechanization rates.

While most farmers either owned and operated their own threshing machines or did not use mechanized services, a small portion of the sample (n=37) received threshing services in the rental

market. Reflecting their wide penetration in the survey area, median WTP for threshing machine services exceeded reported rental costs in all three provinces. Overall, median rental rates were 56% of the median WTP.

Determinants of Demand for Custom Hire Tractor Plowing Services

We estimate the determinants of stated WTP for custom hire tractor plowing services. The distribution of WTP for custom hire tractor plowing is highly variable across the 888 households that responded with potentially large outlier values. In order to limit the influence of these outliers, assess the sensitivity of the results, and provide evidence on the importance of various determinants across the distribution of WTP, we estimate the determinants using three empirical specifications. In the first approach, we estimate the determinants of WTP using an OLS which, as before, are top-coded at the 99th percentile. We name this base model the winsorized approach. In the second approach, we transform the dependent variable using the inverse hyperbolic sine (IHS) transformation and assess the consistency of the coefficient estimates. For both approaches, we run the estimation for the pooled sample, as well as separately for existing tractor users and non-tractor users. Results of these first two approaches are included in Table 8. We report in Table A3 of the Appendix the winsorized OLS and IHS model of WTP estimated without controlling for self-identified wealth group to provide insight on how controlling for the latter impacts the reported estimates. The diagnostic tests for multicollinearity were performed on the winsorized OLS model. We report variance inflation factor (VIF) in Table A1 of the Appendix. None of the independent variable exhibits a VIF greater than 10. All estimation tables report heteroscedasticity robust standard errors.

As a robustness check, we estimate quantile regressions as a third approach. Quantile regressions permit us to estimate relationships between covariates and the WTP outside the mean of the data. We estimate the quantile regressions at the median (model 1), lower 25% (model 2), and lower 75% (model 3) to uncover how estimates change along the WTP distribution. Results are reported in Table 9.

From Table 8, basic demographic factors, such as household head age and educational and native status, did not appear to significantly influence demand. These coefficient estimates are both small and insignificant in the linear and IHS specifications. The size of the livestock herd has an expected negative effect on WTP—livestock can substitute for machine power—but the coefficient is estimated imprecisely.

Notably, we find that having proportionately more females and children has a large and negative effect on a household head's reported WTP for plowing tractor rental. This is suggestive of gender discrimination in valuation of women's time use, as a lower perceived shadow value of female time may make males less willing to adopt household labor saving technology. The direction of the results echoes, to some extent, the gender differences observed by Chiwaula et al. (2018) in WTP for capital-intensive agricultural technologies in Malawi.

The robustly negative relationship between number of children and demand in both the pooled and non-using sample, taken together with lower machine utilization rates for households with more children, suggests households view child labor and mechanization as substitutes. Thus, high rates of child labor in agriculture in Burkina Faso may contribute to low willingness to adopt mechanization more widely.

Table 8. Winsorized and Inverse Hyperbolic Sine (IHS) Estimates of the Determinants of WTP for Custom Hire Tractor Plowing Services.

Variables	WTP Winsorized at 99 th Percentile			IHS of WTP		
	Pooled	Machine Users	Non-users of Machines	Pooled	Machine Users	Non-users of Machines
Age of household head	90.21	-36.04	113.9	0.004	0.009	0.004
	-127.6	-335.5	-131.8	-0.004	-0.007	-0.004
Native vs. migrant (native =1)	2,597	-6,467	2,316	0.084	-0.253	0.101
	-3,003	-15,745	-2,805	-0.081	-0.286	-0.081
Remittance received	-4,801**	-16,098*	-3,242	-0.212**	-0.616**	-0.155
	-2,101	-9,098	-2,103	-0.096	-0.277	-0.098
Self-assigned income group (omitted=very poor)						
Poor	-6,059	--	-4,927	0.03	--	0.069
	-7,647	--	-7,555	-0.191	--	-0.191
Wealthy	-7,912	9,610	-7,688	0.132	0.311*	0.151
	-7,366	-8,809	-7,225	-0.189	-0.172	-0.188
Very wealthy	-5,548	12,680	-8,523	0.143	0.345	0.0468
	-7,622	-23,672	-6,832	-0.22	-0.371	-0.219
Land area farmed (maize) (ha)	-1,265***	31.38	-1,379***	-0.060*	-0.015	-0.069***
	-436.8	-3,075	-448.1	-0.024	-0.05	-0.026
Land area farmed (maize) (ha) - squared	40.34**	-9.666	46.32**	0.002**	0.001	0.002**
	-16.81	-81.76	-18.63	-0.001	-0.001	-0.001
Land area farmed (non-maize) (ha)	980.6***	120.7	1,009***	0.009*	-0.008	0.010*
	-188.5	-406.3	-197.4	-0.005	-0.01	-0.005
Practiced some gardening	-4,542**	-9,990	-3,510	-0.07	-0.188	-0.049
	-2,114	-14,917	-2,140	-0.083	-0.225	-0.089
Used irrigation	26,553***	79,476**	21,508***	0.425***	1.487***	0.324**
	-5,240	-35,988	-4,323	-0.157	-0.547	-0.154
Female ratio in household	-19,344**	-56,723*	-19,096**	-0.169	-0.562	-0.18
	-9,080	-32,715	-9,416	-0.298	-0.57	-0.309
Adult (age >15) number	71.15	323.1	-205.7	0.016**	0.005	0.01
	-222.3	-445.6	-195.4	-0.007	-0.009	-0.008
Child (age ≤15) number	-767.6***	159	-655.4***	-0.018**	0.014	-0.014
	-209	-459.3	-204.6	-0.008	-0.01	-0.01
Livestock units (excluding poultry)	15.77	170	-26.62	-0.001	0.004	-0.002
	-45.14	-296	-45.81	-0.002	-0.005	-0.003
Household head attended primary school	789.7	3,049	548.8	-0.044	0.2	-0.057
	-2,167	-11,895	-2,064	-0.073	-0.189	-0.077
Access to credit	2,997	1,019	3,895*	0.243***	-0.099	0.259***
	-2094	-11,478	-2,048	-0.08	-0.229	-0.082
Uses improved seed	4,715**	5,068	3,794*	0.111	-0.012	0.095
	-2,076	-11,573	-2,104	-0.091	-0.183	-0.097
Province (Omitted = Kenedougou)						
Houet	-9,439***	39,004	-9,667***	-0.36***	0.33	-0.344***
	-2,127	-28,871	-2,095	-0.091	-0.45	-0.093
Tuy	-8,712***	-3,520	-6,585**	-0.205**	-0.602**	-0.133
	-3,079	-17,818	-3,264	-0.101	-0.272	-0.118
Constant	41,404***	38,534*	41,318***	10.56***	10.76***	10.57***
	-11,525	-20,125	-11,763	-0.275	-0.449	-0.285
Average WTP (CFA)	28409.07	38569.02	27319.59	33797	31571	54557
Observations	803	83	720	803	83	720
R-squared	0.233	0.41	0.261	0.087	0.585	0.078

Dependent variable in all regressions is WTP for custom hire tractor plowing services. In the first three columns, the dependent variables are winsorized (top coded) at the 99th percentile. In the last three columns, the dependent variable is transformed via IHS. Separate estimates obtained for the pooled sample, machine users and non-users of machines for both winsorized and IHS specifications. The exchange rate is 1 CFA = \$0.002 USD. Tractor user and non-user subsamples (columns 2 and 3) are based on definitions in Table 4 for plowing activities. See Table 1 for additional information on variables used for coefficients. Robust standard errors in parentheses *** p < 0.01, ** p < 0.05, and * p < 0.1.

Table 9. Quantile Regression Estimates of WTP for Renting Tractor for Plowing.

Variables	Model 1 (Median Regression)			Model 2 (25 th Percentile)			Model 3 (75 th Percentile)		
	Pooled	Machine Users	Non-users of Machine	Pooled	Machine Users	Non-users of Machine	Pooled	Machine Users	Non-users of Machine
Age of household head	29.18	333.5**	19.06	20.35	129	10.51	145.5***	271.1	121.3**
	-17.79	-165.3	-14.21	-17.53	-133.9	-13.09	-53.44	-472.4	-56.96
Native vs. migrant (native =1)	600.5	-7,575	457.6	784.7*	-5,716	406	2,620**	-8,414	2,073
	-424.7	-7,869	-444.4	-447.3	-4,830	-442.2	-1,220	-8,486	-1,398
Remittance received	-1,023***	-7,154	-824.0**	-421.7	-6,297	-115	-3,850***	-10,886	-3,553***
	-366.5	-6,011	-378.1	-583.9	-5,228	-390.2	-994.6	-12,569	-969.1
Self-assigned income group (omitted=very poor)									
Poor	794.2*		956.5	313.3		98.11	307		-1,201
	-440.6		-769.4	-880.6		-752.9	-3,387		-3,256
Weakly	1,334***	7,739	1,127	985.9	4,410	367.8	638.6	14,485**	-422.3
	-477	-5,752	-808.5	-846.6	-3,909	-761.4	-3,376	-6,813	-3,275
Very weakly	3,338***	5,056	3,124***	1,322	8,014**	85.4	1,264	4,830	-1,352
	-838.7	-11,150	-1,149	-1,149	-3,386	-939.9	-3,457	-8,204	-3,395
Land area farmed (maize) (ha)	-149.3	-1,045	-164.5***	2,251	-580	-0.148	-247.4	-1,168	-333.8
	-100	-694.2	-59.96	-122.3	-752.6	-158.2	-241.5	-1,691	-399.1
Land area farmed (maize) (ha) - squared	4.6	22.49	5,630***	-2,507	13.96	-2,299	7,722	21.12	13.33
	-3.671	-16.27	-2,131	-3,855	-18.9	-6,666	-11,38	-43.12	-20.49
Land area farmed (non-maize) (ha)	50.7	-104.6	27.57	-103	-227.5**	-123.5	1,004***	-181.9	1,029***
	-99.11	-190.5	-69.56	-94.74	-113.5	-174.1	-216.3	-455.8	-331
Practiced some gardening	-1,299***	-6,893	-1,483***	-508.9	-1,900	-84.9	-1,751*	-8,844	-460.3
	-396	-6,510	-452.9	-436.7	-4,806	-299.9	-1,025	-11,446	-1,092
Used irrigation	6,053	32,585	3,291	-1,765	9,111	-2,125	46,544***	203,711*	43,188***
	-4,338	-96,895	-2,413	-1,520	-17,526	-1,702	-8,220	-106,800	-9,442
Female ratio in household	-3,561***	-10,595	-2,322**	60.94	745.8	-845.5	-6,083*	-21,904	-7,734*
	-1,225	-17,910	-1,078	-1,603	-14,838	-1,141	-3,560	-33,640	-4,005
Adult (age >15) number	93.1	-9,778	27.13	132.4***	113.4	60.34	56.71	-41.48	-118
	-56.74	-321.7	-40.83	-43.1	-182	-56.54	-147.3	-553.3	-190.3
Child (age <=15) number	-143.1***	68.41	-79.02	-27.22	188.7	7,428	-475.9***	232.9	-448.1***
	-54.39	-300.7	-54.88	-44.28	-261.3	-56.81	-143.2	-703	-160.7
Livestock units (excluding poultry)	-15.93**	147.6	-21	6,214	64.28	1.73	-2,951	101	-47.44
	-7,558	-118.6	-12.9	-14.59	-62.23	-12.02	-37.2	-246.8	-47.91
Household head attended primary school	24.47	6,493	124.9	-728.7*	-1,025	-383.5	276.6	7,315	723.6
	-363.6	-5,055	-268.8	-400.6	-4,284	-438	-1,193	-13,077	-1,303
Access to credit	1,239**	-1,093	1,113***	372.8	-1,583	216.5	1,445	335.2	2,200
	-485.2	-5,531	-348.8	-460.3	-4,019	-420	-1,216	-9,531	-1,480
Uses improved seed	1,091**	-2,955	1,111***	1,998***	-1,484	3,118***	2,455*	-2,013	1,590
	-430.2	-4,684	-328.3	-477.7	-2,767	-497.3	-1,437	-8,521	-1,055
Province (Reference = Kenedougou)									
Houet	-4,081***	-13,836	-3,693***	-3,761***	-14,539*	-4,502***	-11,722***	-6,475	-9,834***
	-536.9	-13,553	-388.6	-517.2	-7,510	-594.2	-2,533	-18,705	-2,430
Tuy	-1,053	-26,318***	163.7	-890	-17,998***	425.8	-10,150***	-31,738***	-7,457***
	-674	-8,096	-369.5	-828.9	-3,967	-931.3	-2,773	-9,154	-2,796
Constant	19,737***	35,967**	19,443***	14,689***	29,413***	15,730***	27,176***	52,045*	29,787***
	-1,132	-13,607	-980.8	-1,620	-9,707	-1,285	-5,077	-30,033	-4,813
Average WTP (CFA)	33797	31571	54557	33797	31571	54557	33797	31571	54557
Observations	803	83	720	803	83	720	803	83	720

Dependent variable in all regressions is WTP for custom hire tractor plowing services. Each model is a separate quantile regression estimate at the conditional median (model 1), lower 25% (model 2) and lower 75% (model 3). See Table 1 for additional information on variables used for coefficients. Separate estimates obtained for the pooled sample, machine users and non-users of machines for all models. The exchange rate is 1 CFA = \$0.002 USD. Tractor user and non-user subsamples (columns 2 and 3) are based on definitions in Table 4 for plowing activities. Robust standard errors in parentheses *** p < 0.01, ** p < 0.05, and * p < 0.1.

Remittances negatively and significantly affect the WTP for tractor services. Earlier, we found that remittance receivers were also less likely to rent machines. Benefiting from remittance reduces the WTP by about 5,000 CFA for an average respondent. However, this effect reaches 16,000 CFA for tractor users, or a roughly 62% reduction in the IHS specification. The surprising finding that, in HBR, remittance reception drives farmers away from machine use appears counter to the conventional wisdom that such households would be early adopters of these services, given that they are assumed more likely to be labor constrained and less likely liquidity constrained. One possibility is that the negative relationship highlights the degree to which farm specialization is important, as perhaps non-remitting households are more likely to be fully specialized farm enterprises with higher demand for machinery. However, further research needs to be conducted in order to shed more light on the remittance effect on mechanization.

While farm size appears to influence tractor demand, the relationship depends on crop type. Each additional hectare of maize decreases the WTP by over 1,200 CFA for the pooled and non-using samples. In contrast, non-maize acreage significantly increases demand by approximately 1,000 CFA in both the pooled and non-using samples. Thus, while use of tractors is increasing in smaller sizes of maize farms, tractor demand is associated with larger non-maize farm sizes. The dependence of the relationship to crop type may also explain the strong influence of irrigation on demand because irrigation greatly increases demand in all subsamples. In fact, relative to non-irrigators, irrigation increases WTP for custom hired plowing by 26,553 CFA in the pooled sample, or an estimated 43% as estimated in the IHS specification. The importance of crop type and irrigation echo a strand of the literature that argues that mechanization development occurs in areas that shift to permanent cultivation (Pingali, 2007).

Further, households that use improved seed also have significantly higher demand, with the magnitude of the estimate about a fifth of the pooled sample mean. This result is striking for households in the first and second quantile of the WTP distribution (Table 9) and suggests interest in using mechanized services is positively correlated with technology adoption in other areas. In addition, while self-reported credit access is positively related to stated demand for mechanized plowing services, the estimate is only significant for non-users of machines.

Farmers in both Houet and Tuy are willing to pay less for tractor rental in comparison to those in Kenedougou. While the magnitude of the difference is significant for both provinces, it is smaller in Houet, where tractor use is least prevalent, and driven by non-users in both areas.

In Table 9, we estimate quantile regression models of WTP at the conditional median (model 1), 25th percentile (model 2), and 75th percentile (model 3) to assess how the estimates change along the WTP distribution.

We note first that the median regression reveals several important insights. First, in contrast to the null results of the linear model, the pooled model estimates the expected positive, significant, and smoothly increasing relationship between demand and self-described income. The relationship with self-described income at the first quantile is similarly smooth, albeit not statistically significant, suggesting the null relationship in the linear model was perhaps driven by the higher end of the distribution.

Second, also in contrast to the linear model, the relationship with the number of animal units has the expected negative sign in the median regression model. Thus, a household with more livestock is associated with a lower median willingness to pay for mechanized services. Third, the negative estimated relationship of WTP with remittance receipt, the number of children, and the density of female household composition from the linear models is robust to the median regression specification. Similarly, access to credit and use of improved seed are positive predictors of WTP in both models.

Turning to the estimates at the lower (model 2) and higher (model 3) conditional quantiles reveals that the key role of farming characteristics in the linear estimations are driven by the top of the distribution. Specifically, irrigation use has a very high and significant effect on WTP at the 75th percentile, but weakly positive effect at the median and weakly negative effect at the 25th percentile. Among the pooled sample, the same pattern holds for non-maize farm size. That suggests that irrigators, in particular, are likely driving the top end of the distribution of stated demand. Crucially, this is true even of current non-users of machines, indicating high unmet demand among this group of farmers.

Conclusion

Livelihoods in Burkina Faso rely heavily on agriculture and most farming activities are performed without machine power. The reliance on manual tools contributes to low on-farm labor and land productivity. Household farm labor allocation and micro-level tractor ownership, rental, and usage data remain scarce. For effective, evidence-based policy, mechanization demand at the household level must be known. The current study helps fill that gap by assessing agricultural mechanization use and demand in the HBR using baseline survey data from the ASMC project.

We find that, while animal-drawn equipment for plowing was most common, four-wheeled tractors were used by nearly 10% of farmers. For harvest-related activities, tractor penetration nearly doubled. Non-users of mechanization tended to have more children in their households, suggesting they compensate by using more child labor. Further, the mechanization of post-harvest activities (threshing and winnowing) was high, indicating widespread existing penetration of small engine technologies in agriculture.

While a minority of farmers used tractor services, many more were willing to pay for services at or near market rates. Nearly 30% of farmers not currently using machine plowing expressed demand levels at or above prevailing prices. More than half of farmers have stated demand at levels above the rental rate in neighboring Nigeria. That suggests supply constraints—rather than lack of interest or familiarity with machines—remain a major factor in restricting existing tractor usage. Regression results show farmers receiving remittances, operating garden plots, and living in households with proportionately more children and women had lower demand for tractor services. However, current use of improved seeds, access to irrigation, and larger non-maize plots were positively linked to higher household demand. The results were robust to differences in functional form, and we use quantile regressions to shed light on how estimates change across different quantiles.

Based on these findings, policy makers concerned with slow growth in custom hire services for tractors in Burkina Faso should remain concerned with constraints in supply. Conditions and policies that raise the cost of operating custom hire businesses—such as import duties on tractors and tractor parts, poor road networks, and high costs of capital or lack of financing—reduce the likelihood that farmers will be able to avail themselves of labor-saving mechanized services. Given the high correlation of use and demand with the number of children in a household, further expansion of tractor access may have important welfare and development impacts as well. Further studies that disentangle the links between the gender and age of household labor and mechanization adoption would further contribute to understanding this important channel.

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Appendix

Table A1. Variance Inflation Factors of Covariates Used in WTP Estimation.

Variable	VIF	1/VIF
Household head age	1.18	0.847889
Native vs. migrant (native =1)	1.16	0.861283
Remittance received	1.04	0.961996
Self-assigned income group		
Poor	4.97	0.201086
Wealthy	4.99	0.200551
Very wealthy	2.48	0.40372
Corn acreage	9.77	0.10237
Corn acreage - squared	8.76	0.114207
Non-corn acreage	1.27	0.785934
Practice some gardening	1.91	0.52432
Use some irrigation	1.7	0.586516
Female ratio	1.02	0.981461
Adult (age >15) number	2.18	0.459266
Child (age <=15) number	1.81	0.551297
Number of animal unit	1.61	0.621523
Head of household attended formal primary school	1.14	0.878481
Access to credit	1.17	0.855421
Uses improved seed	1.12	0.891534
Province (Reference = Kenedougou)		
Houet	1.65	0.607426
Tuy	1.42	0.703046
Mean VIF	2.62	

Table A2. Unadjusted and OLS-Adjusted WTP for Renting Machine, by Province (CFA/hectare) – Refers to Table 7.

Item	OLS with Actual Observations			OLS with Winsorized Observations			
	Pooled	Kenedougou Houet	Tuy	Pooled	Kenedougou Houet	Tuy	
Unadjusted means	33797	39287	27121	35827	28409	34769	22967
Unadjusted means for non-users of tractor	56489	18333	45455	65311	33762	18333	45455
Unadjusted means for users of tractor	31301	39490	25159	27688	27820	34928	20560
Adjusted Means							
Adjusted at mean of all variables	33214	36132	29256	35183	27360	31442	24514
Used Irrigation	75894	82140	66627	81316	50356	56230	44650
Did not use irrigation	26612	32858	17345	32033	23803	29678	18097
Did not use irrigation and adult number at median	32000	39450	18783	41738	23650	29465	18075
Self-assigned income groups							
Very Poor	74437	83178	64309	89125	30737	36463	26907
Poor	28896	32313	23503	30394	26655	31511	23443
Wealthy	30277	31349	24452	36980	27551	29753	24735
Very Wealthy	39942	47080	37563	26826	28100	34814	25644

Upper 1% observations of the WTP are top coded. We considered the World Bank official exchange rate for 2016 in Burkina-Faso (<https://data.worldbank.org/indicator/PY.NYUS.FC.RF>). Accordingly, \$1USD = 391.61 CFA or 1 CFA franc = \$0.002 USD. Source: Author computation from household survey.

