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Tractor Owner-Operators in Nigeria

Insights from a Small Survey in Kaduna and Nasarawa States

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ABSTRACT

Agricultural mechanization is integral to agricultural transformation in countries like Nigeria. Despite the perceived rise in farm labor costs, most farmers still rely on manual labor or draught animals for farming activities, and tractor users are limited. In Nigeria, private tractor owners, rather than government hiring service units, provide a majority of plowing service. Unlike other more scale-neutral inputs, such as fertilizer and improved seeds, significant economies of scale may exist in tractors, which may justify certain public interventions. Understanding the characteristics of tractor service providers is therefore essential in designing an appropriate agricultural mechanization policy. However, information regarding the nature of tractor service provisions is scarce, especially in countries like Nigeria. This paper presents results of a small survey of tractor owner-operators conducted in Kaduna and Nasarawa states in Nigeria. Following are the key findings from simple descriptive statistics: (1) owner-operators who buy tractors from the private market or from private individuals are more efficient than those who receive tractors through government programs, providing services to a greater area at lower costs, including during the off-peak season; (2) providing access to a wider range of tractor horsepowers may improve efficiency over diverse soil types; (3) similar to some Asian countries in the 1980s, tractor operations are mostly concentrated in interviewees' local home districts, though a fraction form groups and serve in distant locations to earn greater revenues. This paper concludes with a discussion of some policy implications.

Keywords: tractor owner-operators, government-sourced tractor owners, market-sourced tractor owners, agricultural mechanization, Nigeria

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1. BACKGROUND

Farming involves physically moving and removing objects. Land clearing removes unwanted objects from the field. Harrowing and plowing move soils from under the ground to the surface. Irrigation moves water from water sources to the plants. Weeding removes weeds from the soil, and harvesting removes crops from plants. Processing removes shells from grains. Transporting moves harvests from the field to the market. Agricultural mechanization, which is an attempt to speed up or increase the capacity of these operations, is unique from other modern inputs and technologies.

Agricultural mechanization has been an integral component of agricultural transformation processes around the world, often shifting production from labor-intensive to capital-intensive systems. Substituting labor use with mechanization can reduce production costs and food prices, which, in turn, can reduce poverty. The ability to prepare or harvest larger areas of land allows for the expansion of cultivated areas across both space and time. The ability to plow deeper into soils, as well as to plan for timely land preparation, can lead to yield increases. Thus, agricultural mechanization is likely to be an important component of agricultural transformation in Africa south of the Sahara. However, promoting agricultural mechanization in the absence of significant off-farm labor demand can lead to increased rural unemployment. Thus, it is important to correctly identify market failures that the government can address efficiently.

Agricultural mechanization is driven by both demand and supply factors. Demand for agricultural mechanization generally increases with the evolution of intensive farming systems in response to rising population density and market opportunity (Boserup 1965; Binswanger 1987; Pingali 2007). The exact nature of the demand depends on various factor endowments, including land size distribution, availability of high-yielding technologies, farm wages, economic institutions, soil types, and agricultural market conditions. Supply of agricultural mechanization is driven by the price of tractors of different designs (including different horsepower) and spare parts. Advancements in tractor and spare parts manufacturing have lowered these prices, though the pace might vary depending on the types of tractors and spare parts. Thus, physical and institutional infrastructures affect both demand and supply of tractor services.

Nigeria appears to have reached the level at which demand for agricultural mechanization may start increasing at a substantial speed, due to labor requirements in farming and rural wage levels (Takeshima, Nin Pratt, and Diao 2013). Agricultural machinery—in particular, tractors—is often one of the largest capital investments that farmers make, and it exhibits economies of scale. Machinery costs per area decline with an increase in machinery size (Fulton, Heady, and Ayres 1978). Around the world, trends toward fewer but larger farms have increased demand for larger horsepower tractors (Hlavacek and Reddy 1986). The existence of such economies of scale can be one justification for public interventions. In some countries, major machineries were often relatively smaller in the beginning of the agricultural mechanization process (for example, in the past, many single-digit horsepower tractors were used in the United States or Thailand), which means that agricultural machineries were relatively scale-neutral technologies. On the contrary, as is partly observed in this paper, typical tractors in Nigeria are larger and with higher horsepower, even though Nigeria is still at the entry stage of mechanization. Although many factors have led to these outcomes, factor endowments and lack of high-yielding technologies may be partly creating this equilibrium in which it makes sense to invest only in large tractors.

In Nigeria, public-sector hiring services have generally been unable to meet much of the demand for tractors during the peak season. Thus, many state governments have started using the private sector to provide the service by subsidizing tractors. This service has often turned out economically viable, and private tractor owner-operators now serve greater areas (Akinola 1987; Takeshima, Nin Pratt, and Diao 2013). And yet information is generally lacking regarding these tractor owner-operators, because many of them and their tractors are unregistered, even though their incentives and nature of operations are quite important. Given Nigeria's highly diverse production environment (especially in terms of soil types and topographies), machine characteristics (such as horsepower and other brand-specific features) may affect the productivity of machine operations. Poor infrastructure and underdevelopment of tractor services

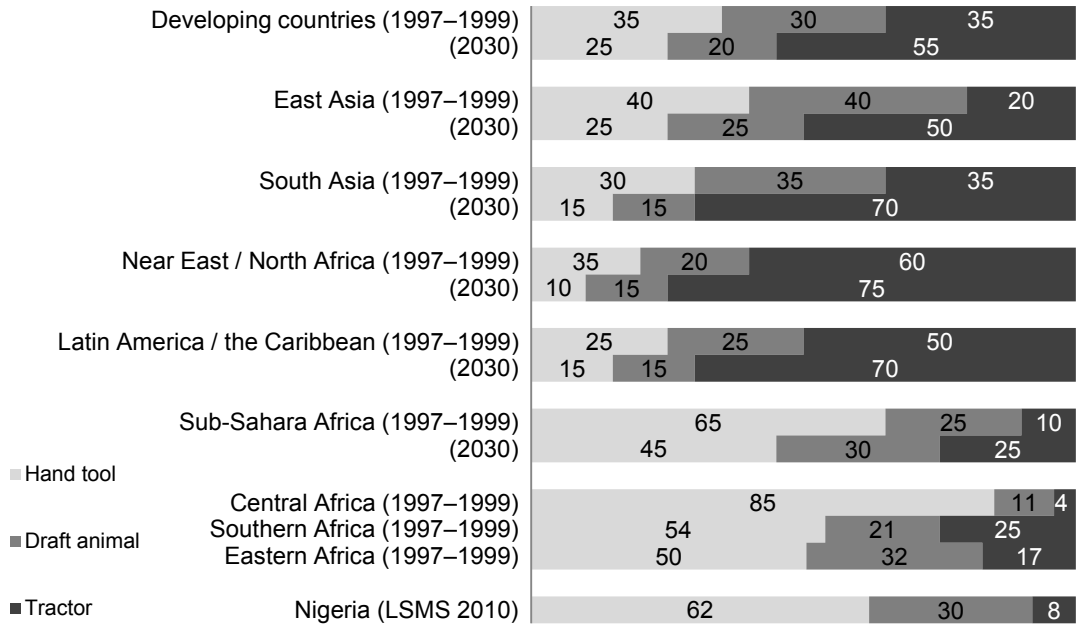
(including spare parts and repairs and maintenance) may also affect the productivity. A particularly important question is whether any efficiency loss results from the government tractor distributions, and if so, what kind of efficiency loss. For example, will vouchers for tractor purchases be better than subsidized distribution of government-selected tractors to government-selected recipients?

Private enterprises providing tractor services are increasingly being studied in countries like Ghana (Diao et al. 2012; Houssou et al. 2013; Benin 2014). Although recent studies shed some light on the current patterns of tractor owner-operator businesses in Nigeria (PrOpCom 2011; Olaoye 2007), knowledge gaps still exist in Nigeria. This paper attempts to fill part of these gaps by providing recent information on the characteristics of tractor owners and their tractor operations, as assessed by a survey of approximately 100 tractor owners in Kaduna and Nasarawa states in Nigeria. Due to the small sample size, analyses are based on simple descriptive statistics. In addition, because samples are not representative of all tractor owners in Nigeria, this paper does not establish any causal relationships. However, implications based on these samples do provide insights regarding the appropriate public-sector interventions into agricultural mechanization, which also helps identify further research questions.

2. TRACTOR-RELATED POLICIES IN NIGERIA

Tractor use in Nigeria is still minor, covering roughly 8 percent of cultivated areas in Nigeria between January and August 2010 (Takeshima, Nin Pratt, and Diao 2013, Table 2.2). This level is well below other regions in the world, including eastern and southern Africa (Figure 2.1). Although the optimal level of mechanization depends on the level of demand for mechanization, seemingly low mechanization levels have often concerned the Nigerian government.

Figure 2.1 Percentage of land cultivated by different tools and machineries



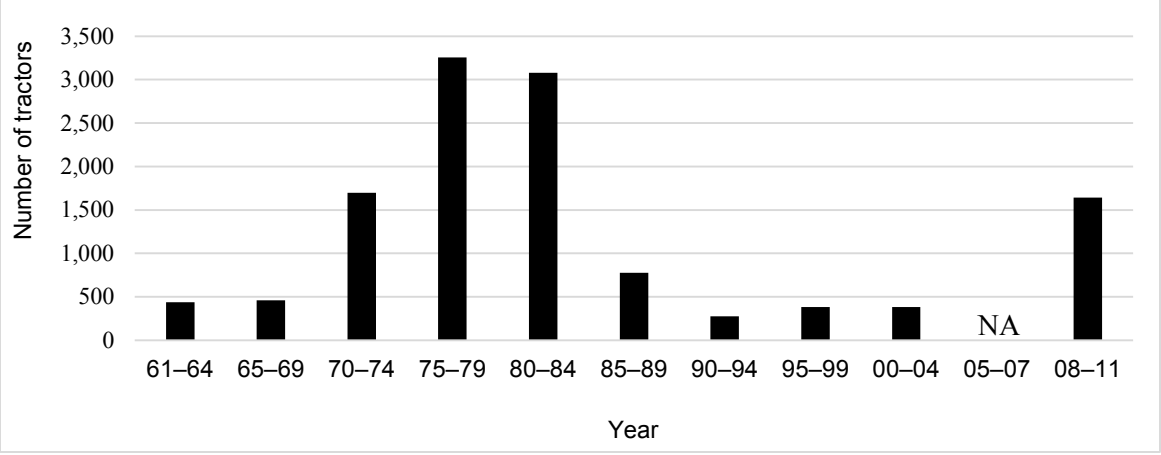
Source: Bishop-Sambrook (2001), cited in Mrema et al. (2008), for three-year average 1997–1999 (West Africa); for Nigeria, authors' estimation based on LSMS 2010 data. Bruinsma (2003) for all others.

The Nigerian government has long intervened into domestic tractor markets, including by subsidizing the distribution of tractors. Until recently, subsidized tractor distribution was similar to the nation's fertilizer subsidy program, in which both federal and state governments procure tractors and distribute with subsidy. Subsidy rates have varied over time—for example, the rates in Kaduna state were 40 percent subsidy (25 percent by the federal government and 15 percent by the state government) in 2010 (PrOpCom 2011, 3), but rose to 60 percent (state government contribution increased to 35 percent) in 2013.[1] Government loans have also been made available, providing indirect subsidies in the form of interest rate subsidies. Details of government loan arrangements were not revealed to the authors and are expected to vary across states and over time. Informal interactions with the beneficiaries of subsidized tractors indicate that a common arrangement is an interest free loan with a three-year payback period. Effective subsidy levels may be affected by delays in loan approval or by various transaction costs on the part of beneficiaries for subsidy applications or on the part of the government for monitoring repayment, which are all common in Nigerian agricultural sector; direct evidence is scarce.

[1] Personal communication with the Kaduna State Ministry of Agriculture.

In the early 1970s, the following tractor-related policies were put in place in Nigeria (Manyong et al. 2005): the operation of tractor hire units by states and a liberalized import policy regarding tractors and agricultural equipment, combined with assistance on land clearing through cost subsidies. Earlier tractor hire units did not always provide services for farms. For example, at Akure tractor station in southwestern Nigeria, 86 percent of the total work done in 1970 consisted of mowing school and police compounds (Kolawole 1972). Mechanics who could repair tractors were often few (Kolawole 1972). In 1980, a machinery ownership scheme was launched in which the federal government provided half of the purchase cost of farm machinery to be owned and used by farming cooperatives or group farms. At the same time, two tractor assembly plants and a national center for agricultural mechanization were established with the aim of releasing 5,000 tractors per year. From 1975 to 1983, 22,000 (mostly imported) tractors were sold at subsidized prices to parastatal agencies, such as River Basin Development Agencies, and to large-scale private companies (Jabbar 1995, 101). The federal government's expenditure on the tractorization program increased from 11 million naira (NGN) (about US$3.2 million per year, or US$17 million per year in 2010 dollars) during the first five-year plan (1970–1974) to NGN54 million in 1975–1979 (about US$17 million per year, or US$64 million per year in 2010 dollars), and NGN240 million during the third plan in 1980–1985 (about US$57 million per year, or US$129 million per year in 2010 dollars; Jabbar 1995, 101). By the mid-1980s, approximately 3,000 tractors were being imported annually on average (Figure 2.2). By then, efficient private tractor operators had emerged, outperforming government tractor hire units (Akinola 1987).

Figure 2.2 Estimated number of tractors imported into Nigeria annually (average by period)



Source: FAO (2014) for 1961–2007. Figures for 2008–2011 are authors estimation based on informal information from National Bureau of Statistics.

Notes: The National Bureau of Statistics reported "net weight" of "agricultural tractors" and "tractors other fully built agric." Assuming that each tractor weighs 5 tons, the approximate number of imported tractors is derived. Some of the earlier figures are consistent with other studies. For example, figures for 1973–1976 are generally consistent with IBRD (1978), as cited in Bates (1981). Figures for 2005–2007 are excluded due to unusually large importation recorded in 2006.

Since the structural adjustment program in 1986, the government's interventions into the tractor market have diminished, partly due to the devaluation of the naira and the subsequent almost eightfold increase in the price of imported tractors (Okolie 1995). During this time, private-sector tractor importation was unregulated, except for the imposition of tariffs. However, tractor importation has still been mostly led by government purchase, and the private sector's importation of four-wheel or two-wheel tractors has been small. According to the records of the customs office in Nigeria, between January 2010 and May 2013, 335 power tillers (approximately 100 annually) were imported into Nigeria. Assuming power tillers last 5–10 years, this level of importation indicates that there may be close to 500–1,000 functional power tillers in the country.

Recently, the federal government of Nigeria shifted its focus from direct distributions of subsidized tractors to the promotion of private-sector tractor-hiring services. Currently, the Nigerian government is pursuing a mechanization implementation program (MIP), which focuses on establishing private sector–managed tractor-hiring enterprises called the Agricultural Equipment Hiring Enterprise (AEHE). MIP also provides subsidies for small-scale farmers (those cultivating between 0.5 hectares (ha) and 4 ha) who use tractor services. The subsidy is provided as part of the Growth Enhancement Support (GES), which is an electronic wallet-based subsidy provided to farmers for the acquisition of various inputs and machineries. GES was implemented under the Agricultural Transformation Agenda of the Federal Ministry of Agriculture and Rural Development (FMARD 2014). As of 2014, the MIP is to establish 80 AEHEs within key industrial clusters, each with five tractors plus implements, five two-wheel tractors, and a few other harvesters or threshers, operated by the private sector, including farmers, cooperatives, or investors (FMARD 2014). Although at an early stage, the MIP also includes the establishment of the Agriculture Machinery Data Tracking Center, which will electronically monitor various data on tractors, such as locations, uses, and storing of records (FMARD 2014).

Currently, tractors in Nigeria are sold by both large importers and small and medium retailers. Several importers in Nigeria tend to serve institutional clients, such as state governments, for their tractor distribution program, sugarcane estates, international groups, and Zimbabwean farmers in Kwara state (Ajibola and Zalla 2007; authors' fieldwork in 2014). These importers import either the finished product or equipment in completely knocked down format, the latter of which is sold to distributors who assemble the machines. Some importers have specific clients and send technicians to provide services under contract (Ajibola and Zalla 2007). In addition, a number of tractor retailers, ranging from medium-scale retailers selling about 100 tractors per year to small-scale retailers selling 10–30 tractors per year (new, refurbished, or combined), also operate in Nigeria.[2] Small-scale retailers focus more on repair and maintenance; sales of tractors is often supplementary for them. These small retailers transact mostly with individual farmers. In Zaria, one of the largest cities in Kaduna state, there are several small-scale retailers of this type. Small-scale retailers are likely to be the major sources of secondhand tractors for individual buyers.

Tractor Distribution Systems in Kaduna State

Although the federal government of Nigeria discontinued subsidized distribution of tractors in 2012,[3] many state governments continue such distribution. In Kaduna and Nasarawa, subsidized tractor distribution is a major component of each state's agricultural mechanization policies. In Kaduna, the tractor-distribution program is implemented as follows: The state Ministry of Agriculture (MoA) procures tractors every few years for distribution. Distribution continues every year until the stocks are exhausted. At that time, new stocks are ordered. The MoA decides which brands of tractors should be procured for distribution, based on recommendations from the MoA's engineering department regarding prices and suitability to the prevailing production environments. In 2012, 186 units of Tak Tractors (all with attached implements) were distributed, of which 57 were 75 horsepower (hp) and 129 were 50 hp.[4] All of the 75-hp tractors and 50 of the 50-hp tractors were allocated to individuals, whereas 79 of the 50-hp tractors were allocated to cooperatives. The MoA awards contracts to in-country tractor distributors through a competitive bidding process. (The distribution process in Nasarawa state is expected to be similar, though the authors have not been able to obtain exact information.)

In Kaduna, tractors are distributed with one plow, one harrow, and one ridger, and recipients must buy all of it together. Attachments are procured from the same distributors that provide the tractors. Official subsidies applied to tractor and attachments are 60 percent, with federal and state governments providing 35 percent and 25 percent, respectively. No government loans were provided in 2012. The

[2] Information from here to the end of paragraph is based on authors' fieldwork in 2014.
[3] Personal communication with FMARD officials.
[4] Personal communication with Kaduna state MoA officials.

number of recipients of tractors each year is based on the budgets. In 2011, there were about 150 final recipients in Kaduna. From 2009 to 2011, the average in Nasarawa was 48.[5]

The recipients consist of individuals and farmer groups. To receive tractors and attachments, recipients must submit applications, which are screened by a committee set up within the MoA. Recipients are then selected based on various criteria, including their local reputations as successful farmers. The selection of recipients is therefore not strictly based on greater familiarity with farm tractors or tractor-use efficiency.

Tractor subsidies may still account for a sizeable share of government agricultural budgets, though detailed budget figures in recent years are often not available. For example, as discussed below, Kaduna's program of distributing 186 tractors and implements (typically priced at US$50,000) with a 25 percent state subsidy would cost roughly US$2.3 million (= 50,000 * 186 * 0.25). Total figures are higher once all administrative expenses are included. Between 2001 and 2005, the Kaduna state government allocated approximately US$12 million per year, though they actually spent only US$5 million per year (assessed by the authors based on Mogues et al. 2008, Table 6, and using an exchange rate of US$1 = NGN120 during the corresponding period). The state government's spending in 2012 was unlikely to be much different from these levels, though it may have been slightly larger given Nigeria's recent economic growth. In 2012, Kaduna's tractor subsidy program accounted for at least 10–20 percent of its total agricultural spending. Although information from other states is scarce, a number of states in Nigeria are providing similar tractor subsidy programs (Takeshima, Nin Pratt, and Diao 2013); those programs are unlikely to be funded by donors or nongovernmental organizations (NGOs) given the declining share of international agricultural aid dedicated for the provision of agricultural inputs (Herdt 2010; Islam 2011). These programs, if ineffective, can have significant fiscal drag effects in these states and therefore warrant deeper examinations.

[5] Personal communication with Kaduna MoA and Nasarawa MoA.

3. TRACTOR OWNER-OPERATORS IN KADUNA AND NASARAWA: SURVEY AND KEY FINDINGS

This section first describes the survey. It then provides the key descriptive results that have greater policy implications. Throughout this section, the conversion rate of US$1 = NGN160 is used.

Survey Methods

The survey was conducted in the states of Kaduna and Nasarawa in September–October 2013. In total, 111 interviewees were interviewed: 64 in Kaduna and 47 in Nasarawa states. Due to the nature of tractor owner-operators and the difficulty in gathering a sufficient number for a random sample, interviewees were purposively selected, sometimes through a snowballing method in which some interviewees were identified from previous interviewees. In both states, the initial sampling frame was the list of individuals who had obtained tractors from the state government's tractor-distribution schemes in 2009–2012, as well as individuals who were identified as having contact information and being reachable by local government area (LGA) extension officers. Although the initial sampling frame might have oversampled those purchasing tractors only from the government, more than half of the final sample turned out to be individuals purchasing tractors from the private sector. Recipients are also geographically spread throughout each state (Figure 3.1). Therefore, the sample reflects good combinations of tractor owners with diverse characteristics. The questionnaire was developed with Census and Survey Processing System (CSPro) software, and interviews were conducted using tablet PCs. September through October is generally the off-peak season for tractor owner-operators, and thus it was more appropriate to identify them in their home districts.

Figure 3.1 Locations of interviewees

Source: Authors.
Note: *E* indicates the location of interviewees on the map.

Results from the interviews led to the identification of two groups of tractor owners with sufficient sample sizes: (1) *government-sourced (GS)* tractor owners purchased tractors only from the federal or state governments or from NGOs, or received them through gifts or prizes in the past five years; and (2) *market-sourced (MS)* owners purchased at least one tractor from the market or from private individuals in the past five years. The remainder of this paper distinguishes between these two groups

because their performances seem substantially different and have implications for how agricultural mechanization policies can meet the demand for farm tractor services. More important, few MS owners had obtained tractors from the government, NGOs, or gifts/prizes in the past five years. Therefore, purchasing tractors from the government and from the market are often mutually exclusive behaviors; so, grouping tractor owners this way makes sense.

Key Characteristics of Interviewees and Tractors

This section briefly summarizes the general characteristics of interviewees, their tractors or power tillers, and the nature of their operations. The next sections highlight some of the major findings that allowed us to perform relevant hypotheses testing. Due to the small sample size, we use nonparametric tests (Mann and Whitney 1947; Wilcoxon 1945) to determine the statistical significance of mean and median figures across different subgroups whenever appropriate. Statistical significance at the 10 percent level is indicated by asterisks in each table.

In general, interviewees were predominantly male, with household members completing secondary education and endowed with various types of assets, such as concrete floors, generators, refrigerators, motorbikes, or cars and other vehicles (Table 3.1). At the national level, households with these assets are in the minority; therefore, interviewees are relatively asset-wealthy. Most interviewees started owning tractors recently (in 2007 or 2008). About one-third of interviewees belong to tractor-owner associations and own a certificate of occupancy for the land. Half of interviewees have some agricultural mechanical engineering background. About 70 percent of interviewees had used tractor-hiring services on their farm before they purchased their own tractors. On average, they had used hiring services for 10 years. (GS owners had used such services for 12 years, which is statistically significantly longer than MS owners' 9 years.)

Table 3.1 General characteristics of interviewees

Characteristics	All tractor owners		Nasarawa		Kaduna	National[a]
	Private (N = 75)	GS (N = 36)	Tractor / power tiller owners (N = 41)	Power tiller owners only (N = 6)	Tractor owners (N = 64)	
Age	49	53	49	46	52	50
Years of first purchase of tractors / power tillers	2007	2010	2008	2002	2008	–
% female	4	3	2	0	5	16
% someone in family completed secondary education	97	97	100	100	95	64
% with agricultural mechanical engineering background	54	42	46	50	52	–
% belonging to tractor owners' associations	35	42	29	0	42	–
% whose home has						
Concrete floor	90	89	88	50	90	–
Generator	87	78	78	67	87	21
Refrigerator	72	69	68	17	73	16
Motorbike	87	78	93	100	78	26
Car / other vehicle	62	58	46	17	70	9
Title (certificate of occupancy) to the land	32	25	39	33	24	–
Distance to the nearest 20-km town (in hours)	1.4	0.9*	1.1	1.0	1.3	2.5

Source: Authors' fieldwork.

Notes: GS = government-sourced. Asterisks indicate statistically significant difference from GS owners. [a] National average calculated by authors based on Living Standard Measurement Survey (LSMS) 2010 (World Bank 2013). Age and gender are for household heads.

Most interviewees are engaged in farming and use tractors for various crops (Table 3.2). A majority grow maize and rice, and half of all interviewees grow sorghum and legumes. A smaller share of interviewees also grow root crops, millet, vegetables, sugarcane, and tree crops. Whenever they grow these crops, they typically use tractors regardless of the crop. However, for yams and similar crops, tractors are not used. Compared with the national level reported in Takeshima, Nin Pratt, and Diao (2013), there are more rice producers among the interviewees. Tractor ownership therefore seems associated with rice production; those who own tractors use the tractors for most crops they grow.

Table 3.2 Interviewees growing major crops and using tractors or power tillers

Crop	All (N = 105)		Nasarawa				Kaduna (N = 64)	
			Tractor owners (N = 41)		Power tiller owners (N = 6)			
	% growing	% using machines	% growing	% using machines	% growing	% using machines	% growing	% using machines
Rice	71	66	83	73	100	100	64	61
Maize	91	82	90	76	100	67	92	86
Sorghum	53	47	56	41	50	17	52	50
Millet	13	10	12	7	33	17	14	11
Cowpea, groundnuts, soybean	56	46	49	34	100	67	61	53
Cassava	25	18	46	34	50	50	11	8
Yam	37	15	80	32	100	33	9	5
Sugarcane	15	12	7	2	17	17	20	19
Wheat	1	0	0	0	0	0	2	0
Vegetables	15	9	12	2	33	33	17	13
Tree crops (banana, plantain, cocoa, oil palm)	18	7	22	7	33	17	16	6

Source: Authors' survey.

Most interviewees rely on farming for their income source. However, 20–30 percent earn additional incomes from mechanic services of agricultural machinery or from transportation of such machinery (Table 3.3). In addition, 20–30 percent are public employees who earn salaries from government institutions.

Table 3.3 Percentage of interviewees earning incomes from nonfarm activities

Type of activities	MS owners	GS owners	Nasarawa	Kaduna
Trading agricultural inputs (fertilizer, chemicals, seeds, and so on)	6	8	10	5
Trading agricultural machinery or spare parts	10	3	0	13
Providing mechanics service for agricultural machinery	23	11	20	19
Mining	3	0	5	0
Retail	0	0	0	0
Construction	1	0	0	2
Transportation	20	28	22	23
Financial services (buying / selling insurance)	3	6	5	3
Salary from government institutions	22	28	29	20
Other nonfarm activities	23	25	22	25

Source: Authors.
Note: MS = market-sourced; GS = government-sourced.

A variety of tractor brands are observed, including Fiat, Ford, Massey Ferguson, Mahindra, New Holland, Steyr, and Tak (Table 3.4). In Nasarawa, Kubota power tillers are also found. In both Nasarawa and Kaduna, Fiat, Ford, and Steyr were obtained secondhand, whereas Massey Ferguson, Mahindra, Tak, and Kubota were often obtained as new machinery. Not surprisingly, new tractors were mostly from the federal or state governments, and used tractors were from private sales or dealers. However, Kubota power tillers, which were mostly new, were also obtained from the private market. In both Kaduna and Nasarawa, a significant share of interviewees obtained tractors or power tillers from the private market.

Table 3.4 Brands and sources of tractors or power tillers owned by interviewees

Brand	Total number of samples	Types of tractors at purchase		Sources					Owned by	
		New	Used	Federal govt.	State govt.	Private individual sale	Private dealer	Others[a]	GS owners	MS owners
Nasarawa										
Fiat	4		4			1	1	2	0	4
Ford	3		3	1		1	1		1	2
Massey Ferguson	16	9	7		10	3	2	1	11	5
Mahindra	5	4	1	1	2		2		3	2
New Holland	2	2	0		2				2	0
Steyr	9	1	8			3	2	4	1	8
Other	10	1	9						1	9
Kubota	9	9	0			1	8		0	9
									1	
Kaduna										
Fiat	6	1	5		2	3	1		2	5
Ford	10		10			7	3		0	10
Massey Ferguson	12	4	8		4	8			3	9
Mahindra	15	10	5	2	8	1	3	1	8	8
New Holland	1	1					1		0	1
Steyr	18	1	17			8	10		0	18
Tak	12	11	1		6		3	3	6	6
Other	3	1	2	1		1	1		1	7

Source: Authors.

Notes: GS = government-sourced; MS = market-sourced. [a] Others include gifts or prizes, cooperatives, and nongovernmental organizations.

Most tractors are large, with horsepowers greater than 50 (Table 3.5). Years of purchase differ based on the brand. Tractors purchased earlier are Fiat, followed by Steyr in the early-2000s, and then Massey Ferguson, Mahindra, and Tak, which were typically bought after 2005. The reason for the change could be that popular brands changed over time, or governments may have influenced brands that had gone into the market each period. Most brands were manufactured from the late 1970s to the early 1990s. The estimated current market price is substantially higher for Massey Ferguson (around US$25,500), compared with Ford or Steyr (around US$11,000). Other brands like Fiat, Mahindra, New Holland, or Tak are priced in between these two prices.

Table 3.5 Sample means of years of purchase, current market prices, and horsepower of each brand of tractors

Brand	Year manufactured	Year purchased	Average age of tractor at purchase (year)		Horsepower	Mean estimated current market price (current US$1,000 nominal)	
						Only tractor	Including attachments
			Used	New			
Fiat	1982 [78, 85]	1997 [89, 04]	10		59 [52, 66]	20 [6, 33]	
Ford	1984	2000	25		62 [55, 69]	11 [0, 22]	13
Massey Ferguson	1995 [85, 04]	2008 [06, 09]	13	16	73 [64, 81]	20 [7, 34]	30 [24, 35]
Mahindra	1989 [79, 99]	2009 [07, 11]	29	16	57 [47, 68]	20 [11, 29]	22 [15, 28]
New Holland		2010				20	20
Steyr	1979 [75, 82]	2003 [00, 06]	22		65 [55, 75]	10 [6, 14]	15 [5, 24]
Tak	1976	2011 [10, 12]		34 [14, 53]	61 [53, 69]		22 [16, 29]
Total			19 [16, 23]	17 [12, 22]			
Power tiller	1981 [79, 82]	2001 [00, 03]		21 [20, 23]	-	2	

Source: Authors.
Note: Numbers in brackets = 90% confidence interval.

Tractors were slightly older at the time of purchase, though not substantially (generally MS owners are more aware of manufactured year). Even new tractors are typically 17 years old at the time of purchase, which is similar but slightly older than in the United States—14 years old in Iowa in 1998 (Freeman 1999).[6] In Estonia, at the time of a 2005 survey, the average manufacturing date of about 45,000 tractors in the country was 1986 (Traat, Heinloo, and Aadusoo 2007). By 2013, the average manufacturing date of Estonian tractors most likely moved back by 5–10 years, or the early-1990s. Tractors in our samples are therefore likely to be slightly older than those in Estonia.

Most tractors bought from the private market or from private individuals were bought within the interviewee's state. Approximately 20 percent had been purchased within the interviewee's home LGA, and 70 percent were purchased within the home state. This pattern has not significantly changed over time. Proximity to sellers, therefore, seems to matter, although transportation costs may not fully explain such behaviors, as they are only a fraction of tractor prices. Transportation costs range from less than US$100 within the state to slightly higher if purchased from contiguous states to about US$600 if purchased from a noncontiguous state, the latter of which typically account for less than 5 percent of tractor sales (Table 3.6).

[6] In Iowa, 20 percent of tractors sold from dealers were manufactured in that year. One-third of tractors sold from dealers had been manufactured within the past five years. In the sample from Nigeria, only 1 out of 17 new tractors was manufactured in the same year it was purchased.

Table 3.6 Transportation costs at the purchase of tractor by location of purchase (in 2013 USD)

Location of purchase	Within LGA	Within state	Contiguous state	Noncontiguous state
Transport costs	37 [8, 66]	80 [54, 107]	102 [0, 238]	619 [120, 1,118]

Source: Authors.
Note: LGA = local government area; Numbers in brackets = 90% confidence interval.

Only 30 percent of interviewees have registered their tractors with the government. This rate is particularly low for MS owners—only 13 percent in the sample (Table 3.7). This is unlikely due to the registration fees, which typically range from US$100 to US$150, which is much smaller when compared with the tractor price itself. Rather, it is likely due to the government's weak regulatory capacity, as the tractor owner-operator business is vastly informal. However, it is important for the government to keep track of statistics (such as the number of tractor service providers) for effective agricultural policy formulation.

Table 3.7 Tractor registration

Percent of tractors registered (by owner status)			Registration fee (in 2013 USD)	
Total	GS	MS	Mean	Median
28 [20, 38]	57 [39, 74]	13* [6, 24]	166 [105, 228]	105 [87, 176]

Source: Authors.
Note: GS = government-sourced; MS = market-sourced. Numbers in brackets = 90% confidence interval. Asterisks indicate statistically significant difference from GS owners at 10% significance.

Attachments

Most interviewees also own a plow and a harrow. Other commonly owned attachments are a ridger and carts or trailers. A few interviewees own other attachments, such as a boom sprayer, planting machine, fertilizer dispenser, thresher, tractor-mounted harvester, or reaper (Table 3.8). In the sample, most attachments were manufactured in the late-1980s and purchased in the mid-2000s. MS owners tend to have older attachments, which were mostly purchased secondhand from the private market.

Table 3.8 Characteristics of tractor attachments

Attachments	% of interviewees owning attachments	Year manufactured (average)		Year purchased (average)		% new		% obtaining it from private market	
		GS	MS	GS	MS	GS	MS	GS	MS
Plow	89	1996	*1986	2008	*2004	77	36*	3	84*
Harrow	95	1992	1984	2008	*2005	74	31*	11	86*
Ridger	52		1985	2008	*2004	83	24*	0	81*
Cart / Trailer	71	1992	1985	2007	*2004	77	19*	14	85*

Source: Authors.
Note: GS = government-sourced; MS = market-sourced. Asterisks indicate statistically significant difference from GS owners at 10% significance.

Interestingly, there is weak evidence that more recent purchases of attachments have been taking place within the interviewees' LGA instead of outside the LGA (Table 3.9). Among MS owners' buying attachments (plow, harrow, or cart and trailer) from the market, only 13–17 percent of the attachments had been purchased within the LGA before 2009. Since 2009, however, these shares have increased significantly to 37–47 percent. Although this increase is partly due to more recent tractor purchasers

tending to be interviewed in major cities like Kaduna, Zaria, or Lafia, this pattern is consistent with the hypothesis that the supply network of tractor attachments has expanded. However, a majority of attachments are still purchased outside LGAs (about 75 percent prior to 2009 and 60 percent since 2009).

Table 3.9 Percentage of interviewees buying attachments from different locations

Attachments	Within LGA	Within the state but outside LGA	Contiguous states	Noncontiguous states
Plow	24	51	16	10
Pre-2009	16	59	19	6
Post-2009	*37	37	11	16
Harrow	26	46	21	7
Pre-2009	17	56	25	3
Post-2009	*40	*32	16	12
Cart / trailer	25	54	17	4
Pre-2009	13	61	23	3
Post-2009	*47	41	6	6

Source: Authors.

Note: LGA = local government area. Ridger dropped due to small sample size. Asterisks indicate statistically significant difference from pre-2009 at 10% significance.

Modifications, Maintenance, and Repair

Most of the used tractors had been modified or overhauled at the time of purchase, and one-third of new tractors had also been modified (Table 3.10). On average, used tractors purchased since 1999 had received about US$1,000 of modification or overhaul per tractor, which is substantially higher than the US$455 spent for new tractors.

Table 3.10 Types of modification and typical costs, per tractor

Type of modifications	Total	New	Used
No modification (%)	38	63	22
Overhaul (%)	24	15	30
Wheel modification (%)	16	9	20
Engine change (%)	7	0	12
Fixing operator's cab (%)	4	4	4
Installing extra lights (%)	2	2	2
Fuel tank expansion (%)	1	2	1
Other (%)	7	6	8
Average costs (in 2013 USD) (among those purchased since 1999)[a]	771	455	1,044*

Source: Authors.

Note: [a] The average includes 0's. Due to the complication of exchange rates prior to 1999, the authors only use cost figures from 1999. Asterisks indicate statistically significant difference from new tractors at 10% significance.

In addition to modifications at the time of purchase, tractor owners spent an average of US$500–1,000 per year for maintenance and repairs (M&R), whereas power tiller owners spent about US$100 per year (Table 3.11). Typically, interviewees incur two or three M&R expenditures per year. Relatively frequent repair items are tires, electrical systems, fuel supply systems, and hydraulic systems. Expenditures on tires account for approximately one-third of total M&R costs, and electrical systems, fuel supply systems, and hydraulic systems account for another 25–30 percent. Although engines are expensive to repair, owners repair them only every five years or so. M&R on engine cooling systems or transmission systems is relatively rare.

Table 3.11 Annual maintenance and repair cost (per owners, all tractors combined)

Parts	Average number of times per year (all machines owned)		% who repaired at least once in the past 3 years		Mean payment per year (mechanic, spare parts) (USD)	
	Tractor (N = 105)	Power tiller (N = 6)	Tractor (N = 105)	Power tiller (N = 6)	Tractor (N = 105)	Power tiller (N = 6)
Total	2.8	0.9	89	67	742	106
Engine	0.2	0.1	31	17	103	10
Gear	0.2		25		24	0
Hydraulic system	0.3		37		100	0
Axle	0.2	0.3	31	33	30	22
Tire	0.5	0.2	59	50	243	17
Fuel supply	0.5		44		59	0
Engine cooling system	0.2	0.1	27	17	15	13
Electrical system	0.5		44		50	0
Transmission system	–		–		0	0
Other	0.3	0.2	31	33	116	44

Source: Authors' estimation.
Note: US$1 = NGN160.

These M&R patterns are similar for both GS and MS owners. A majority of owners also had problems with plow and harrow in the past 12 months (Table 3.12). On average, they spent US$200–US$300 per year to fix tractor attachments, including plows, harrows, ridgers, and carts. Among the interviewees, 80 percent of repairs were done in the village and 90 percent were done within the LGA" (Table 3.13). Our informal interactions with tractor owners indicate that tractor repairers often migrate to areas with tractor owners, indicating that if demand is sufficient, a tractor service market will emerge. These patterns are similar for power tillers, and there are no significant differences between GS and MS owners.

Table 3.12 Costs incurred for repairing attachments (USD per year, among 96 tractor owners who used tractors in 2013)

Attachments	% owning this attachment	% who had problems with the attachment in the past 12 months	Mean payment per year (spare parts) (in USD)	Mean payment per year (spare parts + mechanic) (in USD)
Plow	89	42	80	93
Harrow	96	56	76	97
Ridger	55	20	29	37
Cart / trailer	74	29	36	45
Thresher	4	2	2	2
Pump for irrigation	1	1	2	2
Total	99	69	224	278

Source: Authors' estimation.
Note: US$1 = NGN160.

Table 3.13 Percentage of interviewed tractor owners repairing their machines or purchasing spare parts in each location

Category	Within the village	Outside the village but within the LGA	Outside the LGA but within the state	Outside the state
Typically repairing[a]	79	13	9	
Typically buying spare parts	20	30	35	15
Kaduna	19	40	35	5
Nasarawa	20	15	35	30

Source: Authors' fieldwork.
Notes: LGA = local government area. [a] No significant difference across states or government/private status.

Financing and Insurance

The majority of owners purchased the recent tractors with their own personal finances (Table 3.14). In particular, 82 percent of the money came from MS owners' personal savings, and only a fraction was provided by a bank loan, government loan, or family and friends. Even for GS owners, 41 percent of the total finance came from personal savings. Direct subsidies accounted for 10 percent of the purchase price (19 percent for GS owners and 5 percent for MS owners, though these subsidies may be understated if the owners prefer not to reveal the entire amount). Indirect subsidy is included in the government loan; given the higher interest rates in rural Nigeria, this indirect subsidy is likely to be substantial.[7] Typically, current owners had saved for 4.2 years before buying their first tractors (Table 3.15)—MS owners had saved for almost 5 years, which is significantly longer than the 3 years that GS owners saved. Insuring tractors is still rare, particularly among MS owners (Table 3.16). Only 6 percent of MS owners sampled insure their tractors, as opposed to 18 percent of GS owners.

Table 3.14 Percentage of tractor purchase financing (sample average)

Sources	All (N = 105)		MS owner (N = 69)		GS owner (N = 36)	
Subsidy	10	[6, 15]	5	[1, 9]	19	[8, 29]
Government loan	14	[10, 20]	3	[1, 5]	34	[23, 45]
Other own contribution	76	[71, 80]	92	[88, 96]	47	[37, 56]
Personal finance	67	[61, 72]	82	[76, 86]	41	[30, 52]
Bank loan	5	[2, 7]	4	[1, 8]	4	[0, 9]
Nongovernmental organization	0	[0, 0]	0		1	[0, 2]
Inheritance / family / friends	5	[2, 7]	5	[2, 9]	2	[0, 7]
Other sources	1	[0, 2]	2	[0, 3]	1	[0, 2]

Source: Authors based on the survey.
Notes: MS = market-sourced; GS = government-sourced. Numbers in brackets are 90% confidence interval of sample means.

Table 3.15 Number of years saving before buying the first tractor / power tiller

All (N = 105)		GS (N = 36)		MS (N = 69)		Power tillers	
4.2	[3.6, 4.9]	2.9	[2.0, 3.9]	4.9*	[4.1, 5.8]	2.7	[0.8, 5.5]

Source: Authors.
Notes: GS = government-sourced; MS = market-sourced. Numbers in brackets are 90% confidence interval. Asterisks indicate statistically significant difference from GS owners.

Table 3.16 Percentage of interviewees with insurance for their tractors

Total	GS	MS
10 [6, 17]	18 [8, 33]	6* [2, 14]

Source: Authors.
Notes: GS = government-sourced; MS = market-sourced. Numbers in brackets are 90% confidence interval. Asterisks indicate statistically significant difference from GS owners at 10% significance.

Typical interviewees cover a total of 124 ha (208 ha at the mean) per year using all the tractors they own. Approximately 25 percent of 124 ha is from their own farms (Table 3.17). Most of the activities performed by tractors are either harrowing (60 ha, 94 ha at the mean) and plowing or tilling (45 ha, 64 ha at the mean). Some owners also provide extensive ridge-making services, though they are a minority among the sample. Use of tractors for land clearing, rotovating, planting, weeding, and harvesting is rare, as are tractor uses for nonfarm activities. Only transportation of own-farm products was

[7]For example, if a 30 percent annual interest rate (typical interest rates in rural area), which is a 120 percent compound rate in three years, were applied to a government loan that accounts for 34 percent of the total financing, it is roughly equivalent to 40 percent of the cost of the tractor and its attachments.

done by more than half of the interviewees. Own use, instead of hiring, accounted for about 40 percent of the hours spent on nonfarm use of tractors. In general, tractor use for nonfarm purposes is much more concentrated among fewer owners than the use for farming. In most cases, lack of demand is the major reason for not using tractors for certain farming operations. However, many owners indicated that they do not use tractors for planting, mainly due to the unavailability of attachments.

Table 3.17 Annual tractor uses by farming activities (all tractors combined)

Type of activities	Hiring		Own farm		Total	
	Mean	Median	Mean	Median	Mean	Median
Farming (hectares)						
Land clearing	1 [0, 2]	0	0 [0, 0]	0	1 [0, 2]	0
Harrowing	74 [56, 92]	33	21 [16, 26]	11	94 [75, 113]	60
Plowing / tilling	49 [34, 65]	11	16 [12, 21]	8	64 [48, 81]	45
Ridge making	30 [16, 44]	0	12 [8, 17]	0	42 [26, 58]	0
Rotovating	2 [0, 6]	0	1 [0, 1]	0	3 [0, 8]	0
Planting / weeding	2 [0, 5]	0	1 [0, 2]	0	3 [0, 4]	0
Harvesting	1 [0, 2]	0	0 [0, 0]	0	1 [0. 3]	0
Total farming	156 [114, 198]	74	51 [38, 64]	25	208 [163, 252]	124
Nonfarm activities (hours)						
Milling / threshing / processing	2 [0, 6]	0	7 [0, 21]	0	9 [0, 23]	0
Transporting farm products	103 [67, 139]	0	75 [50, 100]	18	178 [132, 224]	98
Transporting nonfarm goods	44 [21, 67]	0	22 [12, 33]	0	67 [40, 93]	0
Local transportation	6 [0, 14]	0	1 [0, 2]	0	7 [0, 16]	0
Fetching water	8 [0, 15]	0	3 [0, 7]	0	10 [1, 19]	0
Firewood transport	13 [0, 26]	0	5 [1, 8]	0	17 [2, 32]	0
Total	177 [114, 241]	10	112 [72, 153]	30	290 [212, 367]	179

Source: Authors.
Note: Figures may not add up to total due to rounding errors. Numbers in brackets are 90% confidence interval.

Underdeveloped Tractor Markets, Limited Spatial Mobility, and Gender-Biased Effects

Underdeveloped Tractor and Spare Parts Markets

Only about 40 percent of tractor owners could choose from more than one brand or horsepower when buying tractors (Table 3.18). These shares are not statistically significantly different between GS and MS owners, though MS owners are significantly more likely to buy tractors based on performance (76 percent of MS owners compared with 56 percent or GS owners). Table 3.19 lists some of the popular performance criteria, such as easiness to inspect and maintain, low fuel consumption, high speed of operations, greater field capacity, stronger draught force, or less wheel slippage. Price was usually a less-important consideration, though it was relatively more important among Kaduna interviewees who had acquired tractors from the private market. MS owners may have a richer knowledge about the performance of different types of tractors in their production environments; however, the lack of options may be constraining them.

Table 3.18 Percentage of tractor owners who had multiple options

Category	GS	MS
Could select from many brands	42 [25, 59]	42 [31, 54]
Could select from range of horsepower	39 [22, 56]	45 [33, 56]
Bought at least one tractor based on their performances	56 [41, 70]	*76 [67, 84]

Source: Authors.
Note: GS = government-sourced; MS = market-sourced. Numbers in brackets are 90% confidence interval. Asterisks indicate statistically significant difference from GS owners at 10% significance.

Table 3.19 Reasons for selecting particular brands

Reasons	Nasarawa MS N = 26	Nasarawa GS N = 17	Kaduna MS N = 33	Kaduna GS N = 11
Easy to inspect, maintain	21	16	20	5
Effective field capacity	15	10	5	5
Fuel consumption	14	11	17	4
Speed of operation	12	8	13	7
Draught force	9	6	8	
Wheel slippage	8	5	5	2
Price	3	2	13	2
Soil compaction	2	1		
Drawbar power	2	1	9	4
Volume of soil disturbed	1	1		1
Resistant to humidity	1		1	2
Tire configuration	1	1	3	
Seating configuration			1	1

Source: Authors.

Notes: GS = government-sourced; MS = market-sourced. Table shows the percentage of those who know better brands based on the performance selected (among those who could choose from many brands); approximately half of them knew.

Spare parts are often obtained outside the LGAs or the states—50 percent and 15 percent, respectively. For tractor owners in Nasarawa, typical locations outside the state are Jos or Shendam (Plateau), Abuja, Kaduna, and Zaria (Kaduna state), which are typically two hours from interviewees' locations. Many interviewees indicated that they buy spare parts from the nearest location (Table 3.20). These findings indicate that a supply network of spare parts may be less developed than in Asian countries in the 1970s. For example, the situation in India in the 1970s is equivalent to having 2,000–3,000 spare part retailers in Nigeria, or three or four per LGA (authors' calculations based on IRRI 1983). The patterns in this survey indicate that no such density of outlets exists within most of the LGAs currently in Nigeria. However, MS owners are slightly more likely to visit multiple outlets and may not necessarily buy spare parts from the nearest outlets. For example, whereas 85 percent of GS owners bought engines from the nearest locations, only 65 percent of MS owners did so; these differences are statistically significant despite the small sample (Table 3.20). A similar difference is observed for hydraulic parts. MS owners may therefore be slightly more efficient in obtaining better spare parts, despite the sparse supply network.

Table 3.20 Percentage of interviewees buying spare parts from the nearest locations

Type of parts	All	GS	MS
Engine related	72*	85*	63*
Fuel systems	88	86	89
Cooling systems	84	82	86
Electricals	83	76	86
Transmission systems	86	86	86
Hydraulic systems	84	95*	77*
Axle / drawbar	90*	96	86
Tires	86	78	92

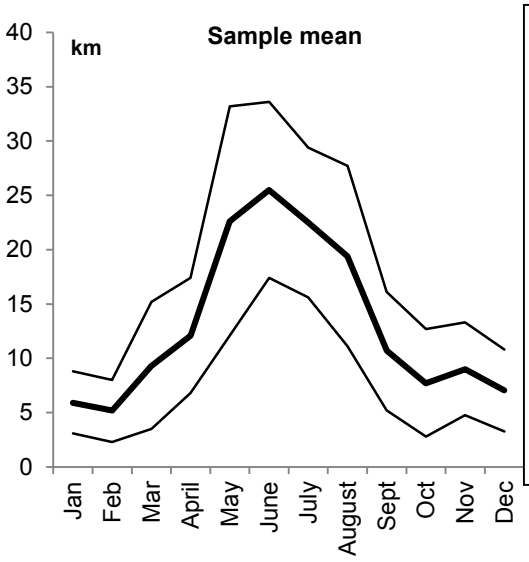
Source: Authors' fieldwork.

Note: GS = government-sourced; MS = market-sourced. Asterisks indicate statistically significant difference from GS owners at 10% significance.

Extent of Travel and Seasonality in Locations of Operations

Tractor owners increase tractor use intensity mostly by geographical expansions of service areas, rather than by increased intensity within their locality. Figure 3.2 illustrates the extent of such expansions in terms of Euclidean distance from home districts in each month. For example, on average, tractor owners stayed 6 km away from their home districts in January. This could mean either they spent the whole month in a district that is 6 km from their home district, or they spent half the month in their home district (0 km away) and the rest of the month in a district that is 12 km away (so that the within-month average is 6 km), regardless of the directions. This is a crude, yet useful, indicator of how the extent of their migration varies across seasons.

Figure 3.2 Distance from home districts in each month (in km)



(a) Sample mean

	Jan	Feb	March	Apr	May	June	July	August	Sept	Oct	Nov	Dec
90%	30	16	32	56	61	90	81	61	48	29	30	30
80%	0	0	0	8	25	45	39	16	3	0	4	5
70%	0	0	0	0	4	16	16	0	0	0	0	0
60%	0	0	0	0	0	5	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0	0
10%	0	0	0	0	0	0	0	0	0	0	0	0

(b) Percentile among the sample

Source: Authors.
Note: Thin lines are 90% confidence interval.

In general, the extent of travel is low. On average, tractor owners stay only 10–15 km away from their home districts throughout the year. Distribution is also highly skewed, however, and the average is driven by a fraction of owners who spent time far away from their home districts. For example, in January, the bottom 80 percent of owners stayed in their home districts, whereas the 90th percentile owners were 30 km away (Figure 3.2). The operations are therefore generally confined to interviewees' home districts and to neighboring adjacent districts. Even during the peak season, interviewees typically operate within a 25–30-km radius of their home districts, which is also consistent with the fact that most tractor owners hire out within the LGA and often within the village (Table 3.21). Typically, 75 percent of hiring services are provided within the LGA, and half of all hiring services are provided within the village. Moreover, a substantial share of operations is conducted on interviewees' own farms. Therefore, tractor owners typically conduct more than 80 percent of the operations within their own LGAs. This pattern was also observed in many Asian countries in the early-1980s. In Thailand, for example, most contractors serviced neighboring areas after finishing their own work, though some owners traveled more than 100 km in the off-season, mainly due to high fuel costs (Wattanutchariya 1983, 46). In Munshigonj, Bangladesh, only 48 percent of power tiller owners traveled 16–40 km by boat to provide service, whereas 11 percent traveled 8–10 km (Jabbar, Bhuiyan, and Ban 1983, 77). In South Sulawesi, Indonesia, about 86 percent of the area plowed had been custom work for local farmers. Some owners did travel as

far as 50 km (Hafsah and Bernsten 1983), but their tractors were much smaller—typically around 15 hp (though they were four-wheel tractors in Thailand and Indonesia).

Table 3.21 Percentage of days hiring out in each location

Location	Total	GS	MS
Within village	52 [45, 60]	48 [38, 57]	55 [45, 65]
Outside village but within LGA	23 [18, 27]	27 [21, 34]	20 [14, 26]
Outside LGA but within state	12 [9, 16]	11 [6, 16]	13 [8, 18]
Outside state	12 [7, 17]	13 [4, 22]	11 [6, 17]

Source: Authors.

Notes: LGA = local government area. GS = government-sourced; MS = market-sourced. Numbers in brackets are 90% confidence interval.

Most owners (about 90 percent of the sample) travel alone, instead of as a group. On average, those who travel in a group travel in a group of five. Most travelers do not pay rent at the destination location. If they do, they typically pay US$3–US$5 per day for a stay. Of all interviewees, 90 percent drive tractors to travel, instead of transporting the tractor with a truck. This is probably because trucks can be as expensive as tractors.[8] However, in Nasarawa, a significantly higher percentage of MS owners use trucks (23 percent, compared with 0 percent among GS owners). Those who travel in a group or who travel on a truck tend to travel longer distances. Group travelers are farther from home districts during the off-peak season, whereas truck travelers travel long distances during the peak season of May–August (Table 3.22).

Table 3.22 Average distance from home by travel status

Month	Travel in group or alone		Travel on tractor (driving tractor) or on truck	
	Travel alone (N = 79)	Travel in group (N = 11)	Travel on tractor (N = 83)	Travel on truck (N = 6)[a]
January	4	*20	6	15
February	4	*15	5	11
March	5	*45	10	10
April	9	*39	12	25
May	21	45	21	*73 (Taraba)
June	28	23	23	*95
July	25	20	22	*62 (Niger state)
August	20	24	16	*84 (Niger state)
September	9	*23	11	10
October	5	*32	8	10
November	6	*39	7	*53
December	7	10	7	15

Source: Authors.

Note: [a] Names in parentheses are major destination states. Asterisks indicate statistically significant difference from the other types of travelers at 10% significance.

Typically, the furthest locations traveled on tractors are between five and seven hours away (Table 3.23). MS owners tend to spend less per hour of moving tractor, typically paying an average of US$12 (US$9 at the median), as opposed to an average of US$14 (US$11 at the median) spent by GS owners. This finding indicates the greater cost efficiency of MS owners. About 35–40 percent of owners follow their operators to traveled destinations. Many MS owners travel to the same community every year—more so than GS owners do. However, at the traveled destination, 40 percent of owners serve new customers every year. Tractor owners typically serve 20–30 farmers in the traveled destinations. Reasons

[8]According to the authors' interactions with one small tractor retailer, a truck can cost about NGN3.6 million, or US$22,500.

for not traveling farther distances include the difficulty of monitoring operators or a lack of machinery. Relatively few interviewees mentioned logistical challenges as a constraint.

Table 3.23 Costs of transporting tractors

Statistics	Distance to the farthest locations (hours taken by driving tractors on road, excluding those transporting tractors by truck)		Cost of bringing tractors (in USD per hour of move)				
	Kaduna	Nasarawa	Fuel	Driver		Total	
				GS	MS	GS	MS
Mean	7.4 [4.6, 10.1]	5.1 [3.7, 6.5]	9.5 [7.8, 11.2]	4.5 [3.5, 5.5]	3.1* [2.5, 3.7]	14 [11, 17]	12 [10, 15]
Median	2.5 [2.0, 4.0]	4.0* [2.5, 6.0]	6.3 [6.3, 7.8]	4.2 [2.4, 6.3]	2.6* [1.6, 3.1]	11 [9, 15]	9* [8, 10]

Source: Authors.
Note: GS = government-sourced. MS = market-sourced. Numbers in brackets are 90% confidence interval. Asterisks indicate statistically significant difference from GS owners at 10% significance.

Tractors and Gender

Gender aspects are an important part of rural mechanization, as mechanization projects often have outcomes that are gender-biased (Gass, Biggs, and Kelly 1997, 118). This gender bias may result from various pathways, including substitutions of female farm labors with mechanical power and spillover of benefits from tractor ownership by male household heads. In our survey, tractor owners are predominantly male, as shown in Table 3.1. Anecdotal evidence indicates that this is generally so for Nigeria and likely around the world.

Traditionally, plowing has been a male activity. Thus, plowing may establish cultural norms or beliefs about gender roles (Alesina, Giuliano, and Nunn 2013), which may partly explain male dominance in transition to tractorization. However, this hypothesis must be assessed with future studies. Literature in intrahousehold bargaining suggests that households often fail to equalize returns to factors of production allocated among different household production activities (Jones 1983; Udry 1996), where asset holdings by members affect their outputs (World Bank 2007, 83). Thus, male dominance in tractor ownership may reflect disproportionately large assets held by men and their ability to invest in tractors. Our survey finds that earnings from tractor ownership are rarely shared with spouses; returns from investment in tractor ownership are therefore largely captured by males.[9] Views regarding male dominance in tractor ownership are mixed among interviewees (Table 3.24). Only half of the interviewees think tractors owned by females are as well maintained as those owned by males. Many agree with the rarity of female ownership of tractors or power tillers; however, 80 percent of interviewees think it is not strange because females are more capable in other businesses or simply because this has been the norm. Further studies are needed to assess gendered effects of current tractor-ownership patterns.

Table 3.24 Percentage of interviewees agreeing with views regarding gender in tractor ownership

Views	%
Female should not own tractors / power tillers.	42
Tractors owned by females are as well maintained as those owned by male.	45
Do you think the female owners of tractors / power tillers are less common than males?	74
It is strange that there are more male owners than female owners.	18
It is not strange because females are more capable in other businesses (trading, processing, and so on) than machinery hiring.	41
It is not strange because this is the norm.	40

Source: Authors.

[9] They are mostly saved in their bank accounts, though some owners invest in productive assets such as livestock.

Potentially Higher Efficiencies of MS Owners

The survey indicates that MS owners are more efficient than GS owners in a number of aspects. *Efficient*, in this case, simply means their efficiency in making greater use of tractors, as described in previous sections. Despite various market limitations, MS owners are more aware of manufactured year and likely to be more knowledgeable about the performance of different types of tractors. MS owners are also more likely to visit multiple outlets and may not necessarily buy spare parts from the nearest outlets, thus allowing them to obtain better spare parts at lower prices. Although owners mostly travel by driving tractors, a significantly higher percentage of MS owners in Nasarawa use trucks, enabling them to travel to distant locations where returns are higher. MS owners also tend to spend less per hour of moving tractors than do GS owners.

Greater economic efficiencies of service provisions by MS owners are also suggested by their greater extent of tractor use, relatively low cost of operations, and selection of tractors suitable for given soil. These aspects are described in this section.

Extent of Service Provisions

MS owners operate each tractor more than GS owners do. In the past 12 months, MS owners used each tractor for an average of 977 hours (691 hours at the median), whereas GS owners typically used tractors for 692 hours on average (499 hours at the median). However, both types use tractors for farming and nonfarm activities (Table 3.25);[10] this pattern is particularly clear in Kaduna. In both Kaduna and the entire sample, differences between GS and MS owners are statistically significant at the 10 percent level. The figures are similar to the 700 hours per year recorded in the 1980s in Oyo state (Akinola 1987), but greater than the 344 hours per year recorded by the Government Hire Unit (Akinola 1987) and the 400 hours per year in Ogun state in 2007 (Dauda, Gbabo, and Shotunde 2010).

Table 3.25 Annual use of tractors (hours per year)

Category	All (N = 88)	GS (N = 28)	MS (N = 60)	Nasarawa		Kaduna	
				GS (N = 14)	MS (N = 15)	GS (N = 14)	MS (N = 45)
Per tractor owner							
Mean	998	740	1118*	769	920	711	1184*
	[873, 1,123]	[530, 949]	[967, 1,269]	[418, 1,120]	[701, 1,138]	[440, 982]	[996, 1,373]
Median	801	499	929	545	699	489	990
Per tractor[a]							
Mean	886	692	977*	769	846	614	1021*
	[763, 1,009]	[492, 892]	[823, 1,131]	[418, 1,120]	[599, 1,093]	[384, 846]	[830, 1,211]
Median	662	499	691	545	680	489	720

Source: Authors.

Notes: GS = government-sourced; MS = market-sourced. Asterisks indicate statistically significant difference from GS owners at 10% significance. Figures in brackets are 90% confidence interval. [a] Figures are obtained by dividing the total hours by the number of working tractors owned.

MS owners not only operate longer hours but also likely have cultivated greater areas per tractor per year (Table 3.26). On average, MS owners operated 169 ha at the mean and 133 ha at the median. These are statistically significantly higher than the mean and median among GS owners—103 and 70 ha, respectively. These figures include both own-farm and hiring-out operations and are similar to the private enterprises in Ghana (Houssou et al. 2013).

[10] These are much more than the figure for power tillers. One interviewee owning a power tiller indicated its use as 133 hours per year.

Table 3.26 Area cultivated annually per tractor (hectare per year, tractor)

Category	GS		MS	
	Mean	Median	Mean	Median
Total farming	103 [65, 142]	70 [52, 89]	169 [140, 198]*	133 [110, 178]*
Hired out farming	74 [38, 110]	30 [7, 65]	128 [98, 158]	88 [35, 144]
Own farming[a]	29 [19, 39]	16 [10, 24]	41 [31, 51]	23 [17, 39]

Source: Authors.

Notes: GS = government-sourced. MS = market-sourced. Asterisks indicate statistically significant difference from GS owners at 10% significance. Figures in brackets are 90% confidence interval. [a] Counted multiple times if multiple operations (plowing, harrowing, ridge making) are applied to the same plots.

In the past 12 months, typical MS owners' gross benefits are about US$11,000 at the median (US$13,000 at the mean) from both own-farm use and hiring services, when own-farm use is evaluated with owners' willingness to pay for such services (Table 3.27). Consistent with the hours of tractor use in Table 3.25, these figures are statistically significantly higher than those of GS owners (US$5,000 at the median and US$8,000 at the mean). For both types of owners, earnings from farming-related uses account for 80–90 percent of total earnings. Earnings from hiring services account for 70 percent of total earnings. MS owners therefore use tractors to a greater extent than do GS owners for both own-use and hiring, as well as for farm and nonfarm activities. Differences of fuel and operator payments are smaller and statistically insignificant between MS owners and GS owners, as compared with the differences in the gross benefits. This is because MS owners pay statistically significantly less for fuels, and sometimes for operators per unit of farming and nonfarm operations, than GS owners do (Table 3.28).[1] The M&R costs are not statistically significantly different between MS and GS owners. In addition, in Nasarawa, a significant share (23 percent) of sampled MS owners travel in a group. These group travelers earn more from hiring services than those who travel alone (Table 3.29), indicating that forming a group is motivated by potentially greater returns (though the authors do not have information on net profits).

Table 3.27 Annual benefits from using all owned tractors (in current US$1,000)

Category	GS		MS	
	Median	Mean	Median	Mean
Total gross benefits per year	**5**	**8**	**11***	**13***
[90 % confidence interval]	[4, 9]	[6, 11]	[8, 13]	[11, 15]
Monetary values of own-farm use	***1***	***2***	***3***	***4***
Farming activities for tractor	*1*	*2*	*1*	*3*
Nonfarm activities	*0*	*0*	*0*	*1*
Gross earnings from hiring out	***4***	***6***	***6***	***9***
Farming activities for tractor	*3*	*5*	*5*	*7*
Nonfarm activities for tractor	*0*	*1*	*1*	*2*
Payment for operators and fuel	**1**	**3**	**3**	**5**
Payment for operators	***0***	***1***	***1***	***2***
– Farming	*0*	*1*	*1*	*1*
– Nonfarming	*0*	*0*	*0*	*0*
Payment for fuels	***1***	***2***	***2***	***3***
– Farming	*1*	*1*	*1*	*2*
– Nonfarming	*0*	*1*	*0*	*1*
Maintenance & repair	**1**	**1**	**1**	**1**

Source: Authors.

Notes: GS = government-sourced; MS = market-sourced. Asterisks indicate statistically significant difference from GS owners at 10% significance. Figures in brackets are 90% confidence interval. Median figures may not add up to the total if distributions are skewed. When calculating figures, the authors considered the following as outliers and replaced them with sample median: (1) daily rate for farming exceeding NGN30,000; (2) daily rate for nonfarm exceeding NGN10,000; (3) daily rate for farming per hectare exceeding NGN15,000.

[1] This may partly be because GS owners are located closer to the nearest town (0.9 hour away) than MS owners. The price of basic goods like fuel may be slightly higher for MS owners due to higher rent. However, fuel is often transported from towns to rural areas, with transport costs added. Therefore, the locations do not explain the lower fuel cost for MS owners.

Table 3.28 Charges for service and payments for operators and fuels (in USD per ha for farming, USD per day for nonfarm service)

Category	Charges		Payment for operator		Payment for fuel	
	GS	Private	GS	Private	GS	Private
Farming						
Harrowing	58	61	14	*10	25	*17
Plowing / tilling	68	73	15	13	28	*21
Ridge making	50	49	10	8	18	*12
Nonfarming						
Transporting farm products	101	86	14	13	26	*21
Transporting nonfarm goods	128	100	17	14	34	*22
Firewood transport	74	48	17	*8	21	21

Source: Authors.

Note: GS = government-sourced. MS = market-sourced. Asterisks indicate statistically significant difference from GS owners at 10% significance.

Table 3.29 Gross revenues by the form of travel

Category	Those who migrate alone		Those who migrate in group	
	N = 79		N = 11	
Total gross benefits per year	**9**	**11**	**16**	**16***
Monetary values of own-farm use	***2***	***4***	***3***	***4***
Farming activities for tractor	*1*	*3*	*2*	*3*
Nonfarm activities	*0*	*1*	*1*	*1*
Gross earnings from hiring out	***5***	***8***	***15***	****12***
Farming activities for tractor	*3*	*6*	*13*	*10*
Nonfarm activities for tractor	*0*	*1*	*1*	*2*
Payment for operators and fuel	**2**	**4**	**4**	4
Payment for operators	***1***	***2***	***1***	***2***
– Farming	*1*	*1*	*1*	*1*
– Nonfarming	*0*	*0*	*0*	*0*
Payment for fuels	***2***	***3***	***3***	***2***
– Farming	*1*	*2*	*1*	*1*
– Nonfarming	*0*	*1*	*0*	*1*
Maintenance and Repair	**1**	**1**	**1**	**1**

Source: Authors.

Note: Median figures may not add up to the total if distributions are skewed. Asterisks indicate statistically significant difference from GS owners at 10% significance.

Due to the difficulty in obtaining accurate figures, the authors do not have estimates for depreciation costs and opportunity costs of keeping tractors, which may account for some of the remaining profits. Depreciation costs for MS owners, however, may not be any higher than for GS owners, despite the former's extensive use of tractors. First, many tractor owners are more willing to hire out their tractors if there are demands, and they seem less concerned about the possibility of their tractors breaking down from overuse (Table 3.30). In particular, MS owners desire hiring out their tractors more than GS owners do. Median MS owners desire to hire out 150 days, which is statistically significantly higher than the 90 days indicated by median GS owners. Peak-season operations are highly profitable, and returns to scale (over time) are not diminishing, but the demand is highly seasonal. Second, a significant share of MS owners have been using the tractors for more than five years, and those tractors are still in working condition. Opportunity costs may be similar, given that GS owners receive more subsidies, whereas MS owners purchased relatively cheaper tractors. If opportunity costs are higher for MS owners, it means they are using tractors more extensively than GS owners, even when they have greater alternative investment options.

Table 3.30 Hiring out: Actual and desired (number of days per year)

Actual / desired		Total	GS	Private
Actual days hiring out	Mean	81	75	85
		[68, 94]	[44, 106]	[70, 100]
	Median	62	60	77
		[56, 81]	[34, 71]	[56, 91]
Desired days hiring out	Mean	157	133	170
		[135, 179]	[89, 176]	[142, 198]
	Median	128	90	150*
		[100, 167]	[72, 120]	[120, 200]
% not hiring out maximum desired		77	73	79
		[70, 84]	[54, 87]	[70, 87]

Source: Authors.

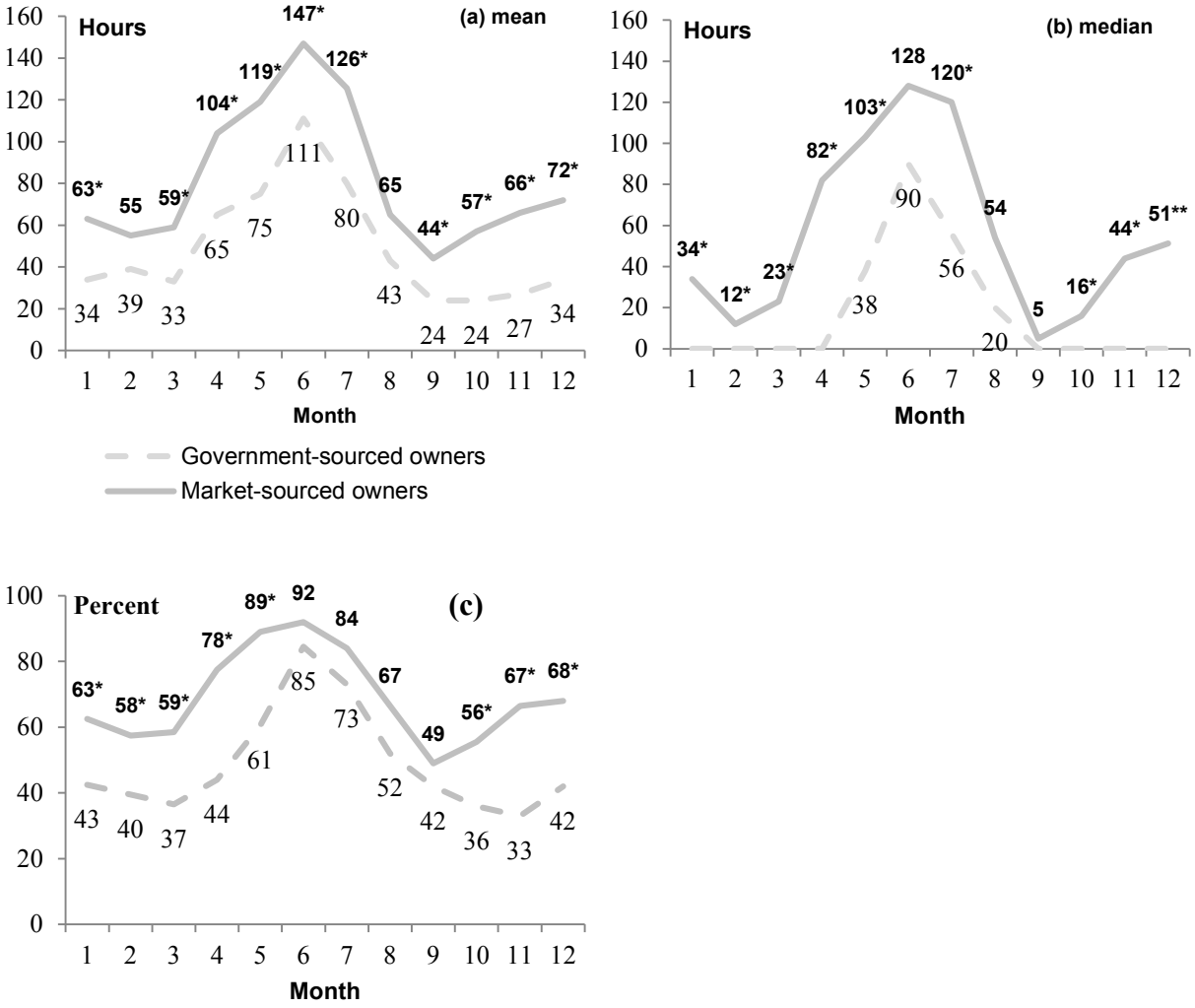
Notes: GS = government-sourced. MS = market-sourced. Figures in brackets are 90% confidence interval. Asterisks indicate statistically significant difference from GS owners at 10% significance.

These findings further indicate that MS owners may be economically more efficient. For example, MS owners may be more efficient in completing the work and earning more and consuming less fuel and operators' time (or having access to more competitive fuel and operators' markets), without incurring any more depreciation costs and M&R costs than GS owners do. The service charges are not statistically significantly different.

Efficiency in Smoothing Seasonal Demand

Considerable seasonality is observed for tractor uses, but MS owners are more active than GS owners throughout the year. Figures 3.3a and 3.3b show the average and median hours of operation per tractor in each month for GS and MS owners. The asterisks in the figure indicate statistically significant differences between the two groups (at 10 percent statistical significance). Figure 3.3c shows the same trends for the percentages of interviewees using tractors in each month. In June, MS tractor owners operated close to 150 hours per tractor on average (128 hours at the median), while operating only 44 hours (5 hours at the median) in September. The off-season hours operated by MS owners are, however, often greater than those operated by GS owners. Hours of operations by GS owners remain low, at around 20–40 hours on average during the off-peak season. However, MS owners resume some activities targeting dry-season producers and operate up to 70 hours per tractor in December. Similarly, the percentages of those operating tractors show a statistically significantly difference between GS and MS owners in most of the months. Although not shown, differences across months are also statistically significant, and seasonality is clearly observed. Tractors are used in ways that satisfy certain types of farm power demands that vary across seasons. Their use for nonfarm activities, or farming activities different from land preparation, is limited. Such seasonality, however, does not seem to affect decisions to own tractors. MS owners tend to mitigate such seasonality.

Figure 3.3 Seasonality of tractor uses ((a) and (b) sample average and median of hours operated per tractor in each month; (c) percentage of sampled tractor owners using tractors in each month (Nasarawa and Kaduna combined))



Source: Authors' estimation based on the survey.
Note: Asterisks indicate statistically significant difference from government-sourced owners at 10%.

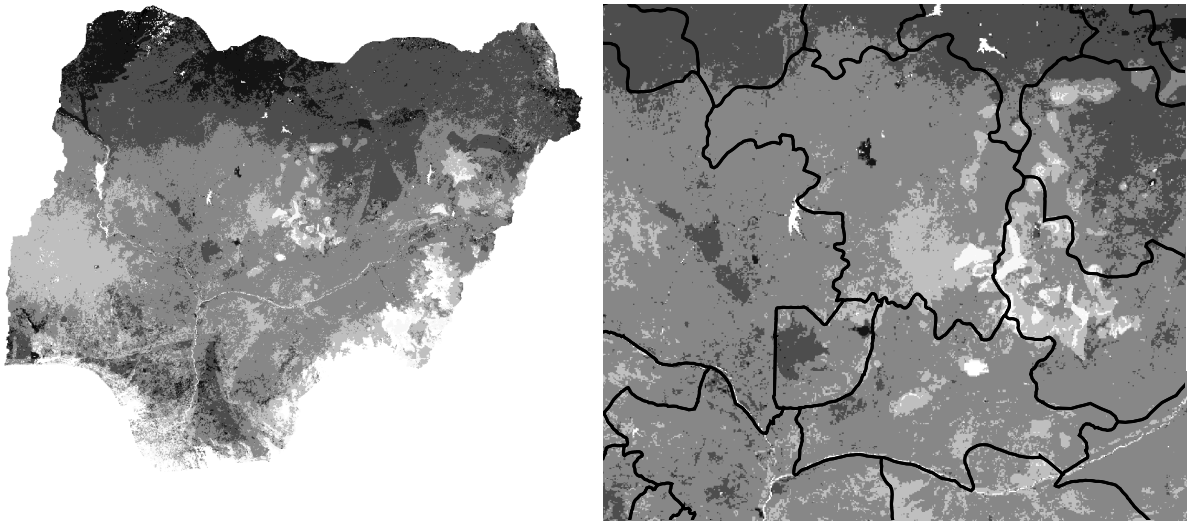
Tractor Horsepower and Soil Types

Another important finding relates to the choice of tractor horsepower and types of soils. Associations between tractor horsepower and soil types (bulk density, clay contents) are generally weak, even though it is often argued that stronger tractors are more suitable on heavier soils with greater bulk density. Such weak associations reflect some market imperfection—either in terms of a lack of options to choose different ranges of horsepowers or insufficient knowledge of soil types.

However, some MS owners could choose among a range of horsepowers when buying tractors. When traveling outside their LGA to operate service, average heaviness of soil (soil bulk density, Figure 3.4) in destination LGAs were often statistically significantly correlated with the horsepower of tractors (Table 3.31). Although the number of observations is small, the correlation with soil heaviness in home LGAs is not statistically significant. Therefore, the positive correlation is through the travel to other LGAs, which is consistent with the hypothesis that tractors with higher horsepower travel to and operate

longer in areas with heavier soils. MS owners appear more capable in doing so, as they are often more aware of the horsepower of their tractors. These patterns are not observed among GS owners, even when they were able to choose among a range of horsepower. However, the small sample size for GS owners partly explains the lack of statistical significance.[1]

Figure 3.4 Bulk density of soils in Kaduna and Nasarawa (darker = heavier soils)



Source: ISRIC (2013).

Table 3.31 Correlation coefficients between tractor's horsepower and bulk density of soil where tractor is operated

Type of owners	Type of owners	Kaduna		Nasarawa		Both	
		# of obs	Corr. Coefficient	# of obs	Corr. Coefficient	# of obs	Corr. Coefficient
MS owners	Could select from a range of horsepowers	138	.196*	26	.577*	164	.241*
	All	238	.011	71	.180	309	-.027
All	Could select from a range of horsepowers	156	.162*	48	.543*	204	.201*
	All	289	.002	112	-.023	401	-.069

Source: Authors' calculations based on the field survey.

Notes: MS = market-sourced. Asterisks indicate statistically significant difference from 0 at 10%. This information is conditional on operating outside the home local government area. The number of observations is larger in this table compared with the number of interviewed owners because the locations of operations were asked each of 12 months for each interviewee.

[1] Fewer GS owners have knowledge about the horsepower of their tractors than MS owners. In addition, fewer GS owners travel outside their LGAs. Therefore, fewer observations are available for GS owners.

4. DISCUSSIONS

The survey reveals important patterns among tractor owner-operators in Kaduna and Nasarawa states. Mobility is generally limited. Several years of financial savings are required for purchasing tractors. The supply of tractor service may therefore be constrained, and some demand may be unmet. In the long run, the private sector is likely to find a way to fill the gap; however, subsidizing some tractors may be effective. Current beneficiaries of subsidies are not necessarily the most efficient suppliers of the service.

Those who purchased tractors from the private market (MS owners) seem more efficient than those who obtained tractors only from the government (GS owners). MS owners operate tractors more extensively, providing services to more land throughout the year at costs that are not much different from costs incurred by GS owners. The difference is unlikely due to the type of soils these owners typically operate on—that is, it is not because the latter owners tend to operate in areas with heavier soils where extensive use of tractors can be hazardous. In fact, those who bought tractors from the market, if they were able to choose tractors from among various horsepowers, tend to travel to areas where their tractors are better suited to the soil types. MS owners seem to have spent less on tractors but meet greater demand in the market. Despite the sparse network of spare parts supply, MS owners may be slightly more efficient in obtaining appropriate spare parts by visiting multiple outlets.

MS owners therefore appear generally more efficient. Put differently, efficient tractor owners are more likely to buy tractors from the private market. In Nasarawa and Kaduna, current private tractor markets are likely to be more efficient than government distributions of relatively more expensive tractors. Encouraging private tractor markets is therefore likely to help reduce farm production costs efficiently. Government distributions, on the other hand, may not always target those with efficient suppliers of tractor services.

At the same time, tractor use is still highly seasonal, possibly because demands are seasonal. However, MS owners also meet some of the off-season demands wherever they are (often near their home districts). Such seasonality in demand seems to allow tractor owners to hire out only half of the desired number of days. Migrating to other states may allow them to expand the number of days of operations, as many of them desire. Yet, relatively few of them do so. Most MS owners seem to operate mostly in their villages and sometimes for other customers within the LGA; rarely do they operate outside their LGAs and states. The operations limited to such locality, however, still seem to bring substantial profits for the MS owners.

Half of the interviewees did not have options to choose horsepowers, indicating that the private tractor market is still underdeveloped. Having such options can raise efficiency because many MS owners know in which soil to use their tractors. This finding also applies to government tractor distributions, as it is better to leave farmers to choose suitable brands. However, ordering bulk quantities of the same type of tractors, as Kaduna's state government does with Tak tractors, may reduce the cost per tractors. The government must therefore weigh the costs and benefits of the subsidized distribution of bulk quantities of standardized tractors and promote supply networks that provide a range of tractors depending on individual buyers' demands.

If subsidized tractor distribution remains in policy, targeting beneficiaries needs to be improved. GS owners seem generally more interested in meeting their own needs on the farm and may not be so interested in meeting the demand outside—or they may be less efficient in doing so. GS owners often bought more expensive brands. Thus, government distributions of tractors may be inefficient (at least in the short term) because they provide expensive brands of tractors with subsidies to those who may be either less efficient in meeting demands or facing less demand.

Further studies are needed to assess whether the government's distribution of tractors has had any positive impacts on addressing market failures. For example, has it helped increase the demand for more tractors or spare parts, so that the supply networks expand and the costs and accessibility of machinery, spare parts, or other services are reduced? Many tractor owners still buy spare parts from outside their LGAs, and many say those are the nearest locations to do so. Density of spare parts stores may still be

low compared with India and Bangladesh in the 1970s (using figures from India, Nigeria should have at least one or more spare part or repair shops per LGA to be comparable to India in the 1970s). It is thus crucial to assess whether the spare part supply network has grown in response to tractor subsidies.

Similar to subsidies for agricultural inputs in general (Jayne and Rashid 2013; Takeshima and Nkonya 2014), tractor subsidies can crowd out the private market, though direct evidence has been relatively scarce compared with those for other inputs. On the other hand, subsidies may not crowd out the private tractor market if they simply address a missing market arising from the economies of scale inherent in tractors. The survey results indicate that the effects of tractor subsidies on private tractor markets are complex. If the markets for new tractors and secondhand tractors are well-integrated, increased supply of subsidized new tractors may lower the prices of secondhand tractors either concurrently (through direct substitutions) or subsequently (as some of new tractors become secondhand tractors later on), which could discourage the development of private-sector tractor supply. However, survey results suggest a few factors that could limit these effects. First, subsidized tractors may not be well-integrated with private tractor markets; mobility of tractors (and tractor services) is low; and an increased supply of subsidized new tractors may not significantly affect the market for secondhand tractors if they are sufficiently far apart. Second, even if they are integrated, subsidized tractors may not be good substitutes for private-market tractors; whereas popular secondhand tractors are accompanied by relatively well-developed markets of spare parts and repair services, this is rarely the case for new tractors subsidized by the government. Demand for certain secondhand tractors may remain high if availability of spare parts and repair services matter for potential buyers. Further studies are needed to empirically test whether these conditions hold.

Lastly, though more evidence is needed from future studies, the findings from the survey of tractor owner-operators imply that the federal government's recent shift in direct distribution of subsidized tractors to the promotion of AEHE (FMARD 2014) is promising. If the private sector is given full opportunities, it is likely to more efficiently provide tractor services than the public sector. However, given the farming environment and soil types, large tractors of 50 hp or more are likely to be popular. Some type of subsidy or loan may need to remain to overcome investment constraints due to the economies of scale. Subsidies should, however, be small in order to avoid inviting rent-seeking. In addition, the government should not pick who to support for enterprise, nor type of tractors; instead, they should assist decisions made by private tractor buyers. Many tractor owners seem interested in using tractors first on their own large farm, where they have higher returns, before serving other farmers. It is unclear, however, whether the government allows AEHE to operate in such a way. Observed patterns indicate that serving many small farmers may not bring similar returns as serving owners' own large farms. AEHE locations will be critical in maximizing the demand met, given the limited mobility of tractor service providers described earlier. There may be a reduction in tractor services in the short term, especially in less profitable or marginal areas, which used to rely on tractors distributed by the government. Thus, it is important to allocate some of the savings from discontinued tractor distribution to support those areas, including feeder road construction so that they benefit from lower food prices or have a greater opportunity to participate in off-farm activities in town.

It is important to note that the agricultural mechanization process is generally responsive to broader agricultural policies that the government has historically had comparative advantages in intervening, such as agricultural research and development (R&D) and infrastructure (road or irrigation) development. Whether the new mechanization policies will turn out effective in Nigeria will critically depend on whether investments in agricultural R&D and infrastructure development are substantially increased. In addition, it is important to have the monitoring and evaluation system so that the patterns of tractor service market development are monitored and appropriate policies are designed given the stage of development.

REFERENCES

Ajibola, F., and T. Zalla. 2007. *Value Chain Study of Small-Scale Agricultural Mechanization.* DFID PropCom Monograph Series 9. London: Department for International Development.

Akinola, A. 1987. "Government Tractor Hire Service Scheme as a Tractorization Policy in Africa: The Nigerian Experience." *Agricultural Administration & Extension* 25: 63–71.

Alesina, A., P. Giuliano, and N. Nunn. 2013. "On the Origins of Gender Roles: Women and the Plough." *Quarterly Journal of Economics* 128 (2): 469–530.

Bates, R. 1981. *Markets and States in Tropical Africa: The Political Basis of Agricultural Policies.* Berkeley: University of California Press.

Benin, S. 2014. *Impact of Ghana's Agricultural Mechanization Services Center Program.* IFPRI Discussion Paper 01330. Washington, DC: International Food Policy Research Institute.

Binswanger, H. 1987. *Agricultural Mechanization: Issues and Options.* Washington, DC: World Bank.

Bishop-Sambrook, C. 2001. *Farm Power for Land Cultivation: Global Overview Followed by a Detailed Study of Sub-Saharan Africa*. Agricultural Support Systems Division Unpublished working document. Rome: Food and Agriculture Organization of the United Nations.

Bruinsma, J. (ed.). 2003. *World Agriculture towards 2015/2030. An FAO Perspective.* London: Earthscan.

Boserup, E. 1965. *The Conditions of Agricultural Growth. The Economics of Agrarian Change under Population Pressure*. London: George Allen and Unwin.

Dauda, S. M., A. Gbabo, and M. A. Shotunde. 2010. "Agricultural Tractor Ownership and Off-season Utilization in Ogun State, South Western Nigeria." *World Journal of Agricultural Sciences* 6 (1): 83–89.

Diao, X., F. Cossar, N. Houssou, S. Kolavalli, K. Jimah, and P. Aboagye. 2012. *Mechanization in Ghana: Searching for Sustainable Service Supply Models.* IFPRI Discussion Paper 01237. Washington, DC: International Food Policy Research Institute.

FAO (Food and Agriculture Organization of the United Nations). 2014. FAOSTAT database. Accessed March 25, 2014. http://faostat.fao.org/.

FMARD (Federal Ministry of Agriculture & Rural Development). 2014. *Private Sector Driven Agricultural Mechanization Framework (PSDAMF) and GES Application Strategy for ATA.* (CD-ROM.) Nigeria.

Freeman, S. A. 1999. "Potential Impact of a ROPS Retrofit Policy in Central Iowa." *Journal of Agricultural Safety and Health* 5 (1): 11–18.

Fulton, C. V., E. O. Heady, and G. E. Ayres. 1978. *Farm Machinery Costs in Relation to Machinery and Farm Size.* Center for Agricultural and Rural Development (CARD). Report. Book 82. Center for Agricultural and Rural Development. Aimes: Iowa State University.

Gass, G., S. Biggs, and A. Kelly. 1997. Stakeholders, Science, and Decision Making for Poverty-focused Rural Mechanization Research and Development. *World Development* 25 (1): 115–126.

Hafsah, J., and R. H. Bernsten. 1983. "Economic, Technical, and Social Aspects of Tractor Operation and Use in South Sulawesi, Indonesia." In *Consequences of Small-farm Mechanization,* edited by G. P. Hettel and G. S. Argosino, *86-94.* Los Baños, Philippines: IRRI.

Herdt, R. 2010. "Development Aid and Agriculture." In *Handbook of Agricultural Economics,Vol. 4.,* edited by P. Pingali and R. Evenson, 3253-3300. Elsevier. Amsterdam, Netherland.

Hlavacek, J. D., and N. M. Reddy. 1986. "Identifying and Qualifying Industrial Market Segments." *European Journal of Marketing* 20 (2): 8–21.

Houssou, N., X. Diao, F. Cossar, S. Kolavalli, K. Jimah, and P. Aboagye. 2013. *Agricultural Mechanization in Ghana: Is Specialization in Agricultural Mechanization a Viable Business Model?* IFPRI Discussion Paper 01255. Washington, DC: International Food Policy Research Institute.

IBRD (International Bank for Reconstruction and Development). 1978. *Nigeria: An Informal Survey*. Table 16. Lagos: IBRD.

IRRI and ADC (International Rice Research Institute and Agricultural Development Council). 1983. *Consequences of Small-farm Mechanization.* Los Baños, Philippines: IRRI.

Islam, N. 2011. *Foreign Aid to Agriculture: Review of Facts and Analysis.* IFPRI Discussion Paper 01053. Washington, DC: International Food Policy Research Institute.

ISRIC (International Soil Reference and Information Centre). 2013. Soil Property Maps of Africa at 1 km. http://www.isric.org.

Jabbar, M. A. 1995. "Energy and the Evolution of Farming Systems: The Potential for Mixed Farming in the Moist Savannas." In *Moist Savannas of Africa: Potentials and Constraints for Crop Production.* Proceedings of an IITA/FAO Workshop, Cotonou, Republic of Benin, September 19–23.

Jabbar, M. A., M. S. R. Bhuiyan, and K. M. Ban. 1983. "Causes and Consequences of Power Tiller Utilization in Two Areas of Bangladesh." In *Consequences of Small-farm Mechanization,* edited by G. P. Hettel and G. S. Argosino, 71-83. Los Baños, Philippines: International Rice Research Institute.

Jayne, T., and S. Rashid. 2013. Input subsidy programs in sub-Saharan Africa: a synthesis of recent evidence. *Agricultural Economics 44*(6): 547–562.

Jones, C. 1983. "The Mobilization of Women's Labor for Cash Crop Production: A Game Theoretic Approach." *American Journal of Agricultural Economics* 65: 1049–1054.

Kolawole, M. I. 1972. "Economic Aspects of Tractor Contracting Operations in Western Nigeria." *Journal of Agricultural Engineering Research* 17: 289–294.

Mann, H. B., and D. R. Whitney. 1947. "On a Test Whether One of Two Random Variables Is Stochastically Larger Than the Other." *Annals of Mathematical Statistics* 18: 50–60.

Manyong, V. M., A. Ikpi, J. K. Olayemi, S. A. Yusuf, B. T. Omonona, V. Okoruwa, and F. S. Idachaba. 2005. *Agriculture in Nigeria: Identifying Opportunities for Increased Commercialization and Investment.* IITA Working Paper. Ibadan, Nigeria: International Institute of Tropical Agriculture**.**

Mogues, T., M. Morris, L. Freinkman, A. Adubi, E. Simeon, C. Nwoko, O. Taiwo, C. Nege, P. Okonji, and L. Chete. 2008. *Agricultural Public Spending in Nigeria.* IFPRI Discussion Paper 00789. Washington, DC: International Food Policy Research Institute.

Mrema, G. C., D. Baker, and D. Kahan. 2008. *Agricultural mechanization in sub-Saharan Africa: Time for a New Look.* Rome: Food and Agriculture Organization of the United Nations.

Okolie, A. C. 1995. "Oil Rents, International Loans, and Agrarian Policies in Nigeria, 1970–1992." *Review of African Political Economy* 22 (64): 199–212.

Olaoye, J. O. 2007. "An Evaluation of Farm Power and Equipment Ownership and Management in Niger State, Nigeria." *Nigerian Journal of Technological Development* 5 (2): 94–102.

Pingali, P. 2007. "Agricultural Mechanization: Adoption Patterns and Economic Impact." In *Handbook of Agricultural Economics,* edited by R. Evenson and P. Pingali, 2779–2805. Amsterdam: Elsevier.

PrOpCom. 2011. *Making Tractor Markets Work for the Poor in Nigeria: A PrOpCom Case Study.* Abuja, Nigeria.

Takeshima, H., A. Nin Pratt, and X. Diao. 2013. *Agricultural Mechanization Patterns in Nigeria: Insights from Farm Household Typology and Agricultural Household Model Simulation.* IFPRI Discussion Paper 01291. Washington, DC: International Food Policy Research Institute.

Takeshima, H., and E. Nkonya. 2014. "Government Fertilizer Subsidy and Commercial Sector Fertilizer Demand: Evidence from the Federal Market Stabilization Program (FMSP) in Nigeria." *Food Policy* 47, 1–12.

Traat, Ü., M. Heinloo, and L. Aadusoo. 2007. "Trends of the Transformation of Estonia's Wheeled Tractor Park." *Agronomy Research* 5 (1): 73–85.

Udry, C. 1996. “Gender, Agricultural Production and the Theory of the Household.” *Journal of Political Economy* 104: 1010–1046.

Wattanutchariya, S. 1983. “Economic Analysis of Farm Machinery Industry and Tractor Contractor Business in Thailand.” In *Consequences of Small-farm Mechanization,* edited by G. P. Hettel and G. S. Argosino, 39-49. Los Baños, Philippines: International Rice Research Institute.

Wilcoxon, F. 1945. “Individual Comparisons by Ranking Methods.” *Biometrics* 1: 80–83.

World Bank. 2007. *World Development Report 2008: Agriculture for Development*. Washington, DC: World Bank.

———. 2013. *Living Standards Measurement Study datasets for Nigeria.* Accessed March 25, 2014. http://go.worldbank.org/NWWC6V42R0.

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