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AGRICULTURAL MECHANIZATION IN GHANA: INSIGHTS FROM A RECENT FIELD STUDY

By

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ABSTRACT

Ghana is one of a few African countries where agricultural mechanization has recently undergone rapid development. Except for places in the forest zone where stumps are still an issue in fields, tractors used for plowing and maize shelling have been widely adopted even among small farmers. Medium- and large-scale farmers who own tractors provide the majority of mechanization services. Recognizing this fundamental fact is important for designing any effective mechanization policy, which should aim at the entire service market instead of targeting a selected group of service providers as beneficiaries. Tractor owners and operators are often discouraged from traveling long distances to plow only a few acres for individual small farmers, which becomes a considerable barrier for smallholders to access tractor services on time. This requires the government consider mechanisms to improve coordination among small farmers and to encourage Farmer Based Organizations (FBOs) to facilitate such coordination. The use of harrowing or second-plowing has been shown as a productivity-enhancing farming practice but it is currently under-demanded by farmers. A pilot program to address the coordination failures and to nudge small farmers to adopt harrowing services together can be considered.

TABLE OF CONTENTS

ABSTRACT.....	iv
LIST OF TABLES.....	vi
ACRONYMS.....	vii
1. INTRODUCTION.....	1
2. WHO ARE THE BENEFICIARIES OF THE BRAZILIAN FACILITY?	5
3. TRACTOR UTILIZATION AND HIRING-OUT SERVICES	12
4. CHALLENGES FOR SMALL FARMERS TO RECEIVE ON-TIME SERVICES.....	15
4.1. Lack of Aggregation among Small Farmers in a Community	15
4.2. Lack of Proper Land Development before Plowing	16
5. PLOWING VS. HARROWING.....	17
6. IMPORTED VS. LOCALLY FABRICATED IMPLEMENTS/ATTACHMENTS.....	20
7. POWER TILLERS AND SMALLER TRACTORS.....	22
8. CONCLUSIONS AND SUGGESTIONS.....	24
REFERENCES.....	27

LIST OF TABLES

TABLE	PAGE
1. Summary of the Information from Interviewed AMSEC Beneficiaries under Brazilian Facility.....	6
2. Summary of the Information from Interviewed Non-AMSEC Beneficiaries under Brazilian Facility.....	7
3. Numbers of Tractors and Tractor Owners among Medium- And Large-Scale Farmers in 2012 IFPRI-SARI Survey	8
4. Summary of the Information from Interviewed Tractor Owners Who Are not Brazilian Facility Beneficiaries	10
5. Numbers of Small and Medium/Large Farmers with and without Hiring in Tractor Services for Plowing by Agroecological Zones in 2012 IFPRI-SARI Survey	17
6. Plowing vs. Harrowing among Tractor Owners and Non-Owners in 2012 IFPRI-SARI Survey.....	18

ACRONYMS

AESD	Agricultural Engineering Service Directorate (AESD) of MOFA
AMSEC	Agricultural Mechanization Service Enterprise Center
Cedi	Ghana currency
CIF	Cost, Insurance, and Freight
CIMMYT	International Maize and Wheat Improvement Center
FBO	Farmer Based Organizations
IFPRI	International Food Policy Research Institute
JICA	Japan International Cooperation Agency
MOFA	Ministry of Food and Agriculture
NGO	Non-governmental Organization
PTO	power take-off
SARI	Savannah Agricultural Research Institute

1. INTRODUCTION

As African countries strive to increase agricultural production, mechanization has been playing an increasingly important role. Mechanization is a labor saving technology, that often enables to expand their farms where land is available as well as free up labor for other agricultural functions or off-farm income generation. While early efforts to promote mechanization in Africa failed due to minimal incentives for farmers to intensify production (Pingali, Bigot, and Binswanger 1987), many indications suggest farming systems have evolved sufficiently for farmers to demand mechanization (Mrema, Baker, and Kahan 2008; Diao, Silver, and Takeshima, 2016; Binswanger-Mkhize 2017). Ghana, with relatively large farm sizes, especially in the north (Jayne et al. 2016), and labor rapidly exiting from agriculture (Diao et al. 2017), appears to be a prime candidate for mechanization in Africa. In Ghana, increasing access to agricultural machinery could help accelerate farm expansion while also helping farmers to overcome their labor constraints, which deter the adoption of yield-enhancing technologies such as fertilizer (Nin-Pratt and McBride 2014). Thus, increasing access to machinery and mechanization services has become an important issue for policymakers in Ghana.

Recent experiences in both Asian and African countries suggests that machinery hiring services are required to meet the emerging demand for mechanization among farmers, of which many are small-scale and are unlikely to become machinery owners. In this process, the government can play an important role in addressing key market failures by promoting private ownership of agricultural machinery and spurring the development of service hiring markets to meet the growing demand from small farmers.

Against this background, the government of Ghana introduced the Agricultural Mechanization Service Enterprise Center (AMSEC) concept as one of the four initiatives included in the country's agricultural development strategy in 2007 (Ghana, MOFA 2007). The first group of 17 AMSECs were established in 2007/08, the second group of 52 were established in 2009, while the remaining 20 were established in 2010-2011.

The early AMSEC programs were not very successful. While each of the 69 AMSECs established in 2007-2009 was provided 5 to 7 tractors (with plow, harrow and trailer) by paying only 10 – 20 percent of the subsidized price (by 30 percent) as a down payment for a 5-year zero interest loan, the repayment rate for the loan was low. According to a report published by Japan International Cooperation Agency (JICA) in 2015, the loan repayment rate for AMSECs established in 2007/2008 was only 17.2 percent and 44.9 percent for those established in 2009. Almost one-third of AMSECs have not made any repayment at all after the down payment (JICA 2015). A survey of 29 AMSECs conducted by the authors of the JICA report indicated that 30 percent of the 157 new tractors distributed to these AMSECs had broken down and had a short lifespan (with an average lifespan of less than 6 years compared to the usual lifespan of 10 years).

Tractors and their attached implements can be easily damaged by obstacles such as stumps and stones in fields. These obstacles are common in Ghana's forest zone areas as well as many places in the transition zone. When tractor operators do not have the appropriate operational and tillage skills, these obstacles can frequently cause tractors to break down. When these obstacles damage some crucial parts of a tractor such as the transmission or hydraulic system, repairs and spare parts are often too expensive for tractor owners or are not readily available, particularly for the brands and models of tractors brought in by the government, which are less common in the country. All these factors can significantly shorten the working life of a tractor. One of the most important reasons that many AMSECs were unable to repay their government loans was that AMSECs' new tractors

ended up out of service in the early stages of their lifespans (JICA 2015). The second reason is the high costs of maintenance, repairs and spare parts, which made the purchase of a new tractor less profitable even with highly subsidized prices. This again relates to the improper operation of the equipment and lack of spare parts locally. Generally, older AMSECs tend to indicate a higher cost of maintenance and repair, while the 2015 JICA report found that the second group of AMSECs established in 2009 had the highest average maintenance cost. This appears to be associated in the rush to establish the second group of AMSECs in 2009 without a proper study of the first group established in 2007/08. It is obvious that many new tractor owners and their operators did not have an adequate level of skills to manage a fleet of five or more tractors. The third reason for nonrepayment of loans is the low annual plowing service acreage. The 2015 JICA report shows that among the 24 surveyed AMSECs that reported service acreage, 19 provided services for less than 300 hectares per year with 5 tractors, meaning each tractor on average provided services for less than 60 ha per year, far below the acreage level required to reach the breakeven point on the investment in tractors, even with the subsidized price (Houssou et al. 2013). At such a low level of service provision, an AMSEC is unlikely to make the profit necessary to repay its loan (JICA 2015).

In 2010 and 2011, fewer AMSECs were established (15 in 2010 and 5 in 2011), mainly because of the government's inability to secure a new concessional facility for additional tractor importation and partially because of a change in the government's payment policy (the down payment was increased to 70 percent or as a single full payment and a bank guarantee for the remaining 30 percent of loan was required). There were no additional AMSECs established until 2016.

In 2016, under a South-South Cooperation Program, the Ghanaian government secured a concessional loan facility from the government of Brazil to import agricultural machinery from Brazil. While some officials of Ministry of Food and Agriculture (MOFA) generally agree with the International Food Policy Research Institute's (IFPRI) early findings on mechanization in Ghana, which show farmer-to-farmer hiring services as the primary mode of mechanization service provision in the country, the concern among the government officials that medium-scale farmers as hiring service providers tend to patronize extended family members still exists. They believe that this arrangement leaves small farmers, who have no connection to these hiring service providers, with difficulty getting on-time services. Thus, under the recent Brazilian Facility arrangement, the government has decided to continue the promotion of AMSECs, believing that providing subsidized machinery to private enterprises, for which service provision is their main business, can effectively mitigate the market failures associated with the farmer-to-farmer service provision model. However, drawing lessons from the early AMSECs, significant modification has been made by the government for the new phase of the AMSEC program.

Based on some recommendations made by researchers from IFPRI and JICA, the following new policies were introduced under the Brazilian Facility for the first tranche of machinery importation and distribution:

- (1) A single full payment instead of a down payment for the loan or a partial payment backed by a bank guarantee on the balance of the payment due is required. However, the purchase price of the machinery continues to be highly subsidized by about 60 percent. The cash received from machinery buyers is put into a special government (escrow) account to generate interest, so that the money can be used to pay back more than 40 percent of the loan starting in the sixth year.
- (2) The offer to purchase machinery imported by the government is opened to all would-be buyers (either AMSECs or individual farmers) at the same price and there is no minimum

requirement for the number of tractors to be purchased. However, individuals or companies who have not fully repaid their loans under the previous AMSEC arrangements are not eligible for the offer. Individual buyers can decide to buy any additional equipment separately or as a full package. Of the total 549 tractors imported from Brazil, 379 (69 percent) were purchased by individuals who only bought one tractor.

(3) The minimum requirement for tractor (or other equipment) purchases to be qualified as an AMSEC was lowered to two (instead of five as in the previous AMSEC programs). There were 79 individuals or companies who bought two or more tractors (or other equipment), of which only 14 bought more than three tractors. These 79 new AMSECs bought a total of 170 tractors.

(4) A free scheduled 1,000-hour technical tractor maintenance service is included in the package in the first year for all beneficiaries including both AMSECs and non-AMSECs. 12 mobile workshops were set up with the government subsidy for the provision of maintenance services and are run by private individuals. The manufacturers in Brazil from which the machinery was imported from are required to provide spare parts for two years.

(5) Training was provided by the MOFA engineering staff for all new buyers and/or their machinery operators, and participation of the training is mandatory for a first-time buyer. Tractor owners were encouraged to record daily operational hours as better management practices and to avoid overuse of the tractors by their operators, and electronic meters were installed on the new tractors to allow owners to monitor their tractor's overall operation time.

(6) Various implements and equipment such as maize shellers, multi-crop threshers, pneumatic or mechanical planters, cassava planters and harvesters, seed drills, boom sprayers, and maize/soya/rice harvesters that can be attached or mounted to tractors were imported. Some of these implements (e.g., planters and harvesters) were imported for promotional purposes to broaden the mechanized services beyond land preparation. Many such imported implements aim to reduce the tractor's idle time after the plowing season and to promote mechanization along the crop production value chain. Three different brands of tractors were imported, including Massey Ferguson, the most popular brand in Ghana's secondhand tractor market. While the government was also looking for lower horsepower tractors at lower prices to test their potential market in Ghana, Brazil unfortunately did not produce such tractors. Three private companies were selected as the local agents of the tractor suppliers for handling after sales support for three different brands of tractors.

While the Agricultural Engineering Service Directorate (AESD) of MOFA estimates a target use of 800 – 1,000 hours per tractor per year and not more than 12 hours per day, there does not exist an explicit monitoring system to help achieve this target. For this reason, MOFA encouraged IFPRI to conduct an assessment for the second phase AMSEC program as well as non-AMSEC beneficiaries under the Brazilian Facility. Given that MOFA will continue the importation of second tranche of machinery under the same Brazilian Facility and is negotiating a new \$150 million Indian concessional loan agreement, this assessment is timely and should be done as soon as possible.

With official support from AESD of MOFA, a team of six researchers from IFPRI and International Maize and Wheat Improvement Center (CIMMYT) and two government officials from AESD was formed for conducting an intensive field study. Between January 29 and February 13, 2018, the team visited nine districts across six regions in the south and north and interviewed 33 tractor owners or their farm managers and/or tractor operators as mechanized service providers and more than 40 farmers (mainly small-scale farmers) as the consumers of mechanized services. Some

tractor owners are the beneficiaries of the recent Brazilian Facility while others are not. Some beneficiaries purchased more than one set of agricultural machinery (mainly tractors) and therefore are identified as the new AMSECs according to AESD's definition, while some bought only one tractor and are non-AMSEC beneficiaries. Most tractor owners interviewed are mechanized service providers. Tractors owners (as well as their farm managers) were often interviewed individually, while small farmers were interviewed in a total of five groups.

This paper is written based on the interview transcriptions, authors' own field observations and frequent discussions among the team members during the trips. The hypotheses/questions that emerged from the team discussions based on earlier interviews were then tested by asking relevant questions to interviewees in the later interviews. Thus, some of the findings and suggestions in the paper were confirmed by the questions repeatedly asked in the later interviews of the field study.

The remainder of the paper is structured as follows: Section 2 describes some characteristics of the beneficiaries of the new Brazilian Facility. Section 3 describes the tractor hiring market in which they provide services, while Section 4 describes how imperfections in this market make it difficult for smallholders to obtain timely mechanization services. Section 5 then addresses the differences in farmer demand for plowing and harrowing services. Turning to the supply side, Section 6 discusses the differences in the adoption and usage of locally-made vs. imported machinery while Section 7 discusses the adoption of and conditions for power tillers and small tractors. Section 8 concludes and provides an extensive set of policy recommendations.

2. WHO ARE THE BENEFICIARIES OF THE BRAZILIAN FACILITY?

According to the AESD records, there are 458 individuals and enterprises that are beneficiaries of the Brazilian Facility, including 379 individuals as non-AMSEC beneficiaries, who bought only one tractor, and 79 AMSEC beneficiaries. Sixty-three AMSECs bought 2-3 tractors, 14 bought more than three tractors, and two only bought implements without purchasing a tractor (as they have their old tractors).

Eighteen beneficiaries of the Brazilian Facility who bought tractors were interviewed, including 10 AMSEC beneficiaries (of which eight are farmers, one is a non-governmental organization (NGO) and one is a private company) and eight non-AMSEC beneficiaries. Excluding the NGO and the company, all beneficiaries interviewed are medium- and large-scale farmers. The eight interviewed AMSEC-beneficiary farmers are all large-scale farmers, including five with farmland (including uncultivated land) between 600 acres (240 ha) and 1,240 acres (496 ha) and three with land 50 – 180 acres (about 20 – 72 hectares, see Table 1, row 1). Similarly, seven of the eight interviewed non-AMSEC beneficiaries are large-scale farmers with land between 150 acres (60 ha) and 1,000 acres (400 ha); the other is a medium-scale farmer with farmland of 20 acres (8 ha). (See Table 2, row 1).

We further compare farm sizes of the beneficiaries under the recent Brazilian Facility with medium- or large-scale farmers reporting owning tractors in a 2012 survey conducted by IFPRI and the Savannah Agricultural Research Institute (SARI). While the 2012 survey did not identify the beneficiaries of the early phases of AMSEC programs explicitly, many medium- and large-scale farmers in the survey did report buying new tractors from MOFA, indicating that they are possible beneficiaries of the early AMSEC programs. In the 2012 survey, 29 farmers bought new tractors from the government between 2006 and 2012. Among them, 23 are large-scale farmers with more than 50 acres (20 ha) of land. (See Table 3) Also, according to the 2015 JICA report in which 29 early AMSECs were interviewed, the majority of AMSECs were large-scale farmers and a few were private companies, similar to what we observed for the new AMSECs.

Not only the beneficiaries of Brazilian Facility are predominantly large-scale farmers, but also many (eight) have recently acquired or rented in additional land. More importantly, we found that many large-scale farmer beneficiaries have nonfarm incomes either from public sector jobs/retirement pensions, or from their own large nonfarm businesses. Most such owners live in cities or district towns and have hired farm managers. All eight beneficiaries who have acquired or rented in land in the recent years have urban jobs/pensions or have nonfarm business incomes (Tables 1 and 2, rows 3 – 5).

For both AMSEC and non-AMSEC beneficiaries of Brazilian Facility, the main motivation for purchasing tractors was use on their own farms. In some cases, this was also the reason for purchasing maize shellers or multi-crop threshers, as well as other implements. This seems to be contradict to the intention of the government using public funds to support the AMSEC program. Moreover, when deciding on the number of tractors purchased, own farming is not necessarily the only consideration when the subsidy rate is high. A buyer, who bought two new tractors under the Brazilian Facility and did not have farming experience but just planned to start farming on his 100 acres of land, cited the devaluation risk of local currency as a reason for him to buy two tractors using his retirement savings.

Table 1. Summary of the Information from Interviewed AMSEC Beneficiaries under Brazilian Facility

Interviewee's ID		01	02	03	04	05	06	07	08
Farm Locations		Winneba, Central/Nasia, Northern	Kasoa, Central	Torgome, Volta	Dobonso, Ashanti	Ejura, Ashanti	Nkoranza, Brong- Ahafo	Tamale, Northern	Tamale, Northern
Total land holding (acres)	(1)	746	100	1,236	640	1,000	640	50	180
Cultivated land for food crops in 2017 (acre)	(2)	450	No	247	20	1,000	100	20	180
Whether acquired land in recent 8-10 years	(3)	No	Yes	Yes	No	Yes	No	No	No
Whether hired a farm manager	(4)	Yes	No	Yes	Yes	Yes	Yes	Yes	No
Whether has urban income	(5)	N/A	Yes	Yes	Yes	Yes	No	Yes	Yes
Whether has out-growers	(6)	No	No	Plan to have	No	Yes	No	No	Plan to have
No. of all tractors currently owned	(7)	3	2	4	6	5	5	4	12
No. of tractors from Brazilian Facility	(8)	3	4	3	6	5	4	1	5
Year of purchasing the first tractor	(9)	2004	2016	2017	10+ years ago	10+ years ago	10+ years ago	1980s	2003
Whether currently own 2 nd hand tractors	(10)	No	No	No	No	No	Yes	Yes	Yes
Whether sold or with un-operational tractor	(11)	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Whether provide mechanization services	(12)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Acreage of service provision in 2017 (acres)	(13)	150	N/A		480	1,600 plus	N/A	190	N/A
Whether owner himself is an operator	(14)	Yes	No	No	No	No	No	No	No
Whether hired operator(s)	(15)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors' own interview notes.

Table 2. Summary of the Information from Interviewed Non-AMSEC Beneficiaries under Brazilian Facility

Interviewee's ID	09	10	11	12	13	14	15	16
Farm Locations	Ejura, Ashanti	Ejura, Ashanti	Ejura, Ashanti	Kintampo, Brong- Ahafo	Kintampo, Brong- Ahafo	Tamale, Northern	Tamale, Northern	Tamale, Northern
Total land holding (acres)	(1) 500	200	150	195	600	295	20	1,000
Cultivated land for food crops in 2017 (acre)	(2) 100	200	30	10	300	295	20	20
Whether acquired land in recent 8-10 years	(3) Yes	Yes	Yes	Yes	Yes	No	No	No
Whether hired a farm manager	(4) Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Whether has urban income	(5) Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Whether has out-growers	(6) No	No	No	No	Yes	Yes	No	No
No. of all tractors currently owned	(7) 1	1	1	1	2	3	2	1
No. of tractors from Brazilian Facility	(8) 1	1	1	1	1	1	1	1
Year of purchasing the first tractor	(9) 2016	2016	2017	2008	2014	2009	1996	1979
Whether currently own 2 nd hand tractors	(10) No	No	No	No	Yes	Yes	No	No
Whether sold or with un-operational tractor	(11) No	No	No	No	No	Yes	Yes	Yes
Whether provide mechanization services	(12) Yes	No	No	Yes	Yes	Yes	Yes	Yes
Acreage of service provision in 2017 (acres)	(13) 100	No	No	N/A	N/A	N/A	200	200
Whether owner himself is an operator	(14) No	No	No	No	No	No	No	No
Whether hired operator(s)	(15) Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors' own interview notes.

Table 3. Numbers of Tractors and Tractor Owners among Medium- And Large-Scale Farmers in 2012 IFPRI-SARI Survey

	New tractors bought from the government				New tractors bought from the private sector				2 nd Hand Massey Ferguson (MF)		2 nd Hand other brands		Total	
	Bought in 2006-2012		Bought in 2003-2005		Bought in 2006-2012		Bought in 2003-2005		No. of tractors	No. of owners	No. of tractors	No. of owners	No. of tractors	No. of owners
	No. of tractors	No. of owners	No. of tractors	No. of owners	No. of tractors	No. of owners	No. of tractors	No. of owners						
Medium-scale farmers (5 to 49 acres)	6	6	3	3	10	10	1	1	108	97	38	38	166	155
Large-scale farmers, group 1 (50 to 99 acres)	9	9			14	13	2	2	82	70	45	44	152	138
Large-scale farmers, group 2 (100 to 199 acres)	12	9			13	11	2	2	41	30	22	19	90	71
Large-scale farmers, group 3 (>=200 acres)	5	5	1	1	14	11	1	1	25	19	15	14	61	51
Total	32	29	4	4	51	45	6	6	256	216	120	115	469	415

Source: Authors' calculation using data from the medium- and large-scale farmers and mechanization survey conducted by IFPRI-SARI in 2012 (IFPRI-SARI 2016).

Note 1: In the group with farm size 5-49 acres, one farmers bought two new tractors from the private sector, nine bought two 2nd hand, and one bought three 2nd hand.

Note 2: In the group with farm size 50-99 acres, eight farmers bought two 2nd hand, and three bought three 2nd hand.

Note 3: In the group with farm size 100-199 acres, one farmer bought two new tractors from the government, one bought three from the government, one bought two from the private sector, seven bought two 2nd hand, one bought three 2nd hand, and one bought six 2nd hand.

Note 4: In the group with farm size more than 200 acres, three farmers bought two 2nd hand, and one bought five 2nd hand.

Note 5: The private sector includes NGO.

Note 6: Tractors owned before 2003 are all treated as used ones. There are three such cases for MF and a few for other brands.

Note 7: There are seven owners who didn't provide information about their tractor, and they are excluded from the table.

Note 8: There is a double counting issue in the number of owners in the table, as some owners bought tractors from different sources. Totally, there are 25 such cases, including four farmers who bought new tractors from both the government and the private sources, two who bought new tractors from the government and also bought 2nd hand from the private traders, six who bought both new and 2nd hand tractors from the private sector, and 11 who bought 2nd hand MF and other brands. In the survey the total tractor owners who are medium- and large-scale farmers are 397.

Acquiring land that has been under cultivation for a while is difficult in Ghana; therefore those who have purchased land recently acquired mostly virgin land. Virgin land development is a gradual process that requires a significant amount of investment, mainly associated with the high cost of de-stumping. Such land development investment could make it difficult for investors to simultaneously invest in land and tractors. Thus, at the early stage of land development and when only a small piece of virgin land is developed and cultivated, these new farmers commonly hire tractor services for land preparation. When more virgin land has been developed and when the farm size is increasing, investing in tractors becomes necessary and more reliable than hiring, and also becomes financially feasible for these new large-scale farmers. This phenomenon seems to indicate a strong correlation between land expansion in Ghana and increased demand for owning tractors among large-scale farmers.

Not all large-scale farmers are new farmers; those who have been farming for a long time often already owned tractor for many years. For such large-scale farmers, replacing their old tractors is often a major motivation for purchasing new tractors. They have better knowledge of tractors and know how to take advantage of the government programs to purchase the highly subsidized new tractors. Six interviewed beneficiaries sold some of their old tractors, often after purchasing the new tractors under the Brazilian Facility. It is plausible to believe that many beneficiaries, particularly large-scale *new farmers*, would have eventually been able to buy tractors regardless of this government program, possibly from the second-hand market. The government program seems to help them acquire tractors earlier than they could have otherwise, and to acquire new tractors instead of second-hand ones.

Owning a tractor for use on their own farm as the primary motivation is an understandable behavior for medium- and large-scale farmers, and this is also found among many second-hand tractor owners (Chapoto et al. 2014). Still, many medium- or large-scale farmers did not purchase the new tractors with the highly subsidized prices under Brazilian Facility. We brought this question to those second-hand tractor owners or would-be buyers who are not beneficiaries in the interviews. While there are four interviewees who cited lack of information and a proper channel for the application as the reason for them not being able to buy the new tractors, nine out of 15 non-beneficiary tractor owners or would-be buyers agreed that the large one-time cash payment was their major reason for not acquiring a tractor under the Brazilian Facility. Unlike the beneficiaries, farming is the main or only income source for most non-beneficiary tractor owners and few of them have an urban income source. We also noticed that many non-beneficiary tractor owners interviewed are medium-scale farmers: five with farmland below 50 acres (20 ha), five with between 50 acres and 70 acres (28 ha), and only three with more than 100 acres (40 ha), including one who inherited more than 3,000 acres (1,200 ha) but has only cultivated 70 acres (see Table 4, rows 1 and 5).

While new machinery imported under the Brazilian Facility has been subsidized by the government for 60 percent of the Cargo, Insurance, Freight (CIF) prices, the one-time payment for a full package (a tractor with a plow, a harrow, and a trailer) is still about 70,000 to 80,000 Ghana cedi or \$17,500 to \$20,000 USD. Even relatively large farmers without cash income inflows from other sources such as urban jobs or large nonfarm businesses face liquidity constraints for such a significant lump-sum investment. While individuals are allowed to make a partial payment for the first installation of the purchase, it requires a bank guarantee from a commercial bank for the remaining balance. This is almost impossible for many farmers, whose main business is farming and hence are often excluded from formal banking systems. This might explain why many beneficiaries have urban jobs or other nonfarm income. It also points out the difficulty of financing investment in mechanization under the existent banking systems, even for large scale farmers.

Table 4. Summary of the Information from Interviewed Tractor Owners Who Are not Brazilian Facility Beneficiaries

Interviewee's ID	17	18	19	20	21	22	23
Farm Locations	Ejura, Ashanti	Ejura, Ashanti	Ejura, Ashanti	Ejura, Ashanti	Ejura, Ashanti	Tamale, Northern	Tamale, Northern
Total land holding (acres)	(1) 59	60	16	30	50	35	25
Cultivated land for food crops in 2017 (acres)	(2) 59	60	16	30	50	35	25
Whether hired a farm manager	(4) No	No	No	No	No	No	No
Whether has urban income	(5) No	No	No	No	No	Yes (running a repairing shop)	No
Whether has out-growers	(6) No	No	No	No	No	No	No
No. of all tractors currently owned	(7) 5	1	3	3	3	2	1
Year of purchasing the first tractor	(9) 1990	N/A	N/A	N/A	N/A	1998	2008
Whether currently own 2 nd hand tractors	(10) Yes	Yes	Yes	Yes	Yes	Yes	No
Whether sold or with un-operational tractor	(11) N/A	N/A	N/A	N/A	N/A	Yes	Yes
Whether provide mechanization services	(12) Yes	Yes	Yes	Yes	Yes	Yes	No
Acreage of service provision in 2017 (acres)	(13) 1,000	600 - 700	1,000	1,500	350	250	N/A
Whether owner himself is an operator	(14) Yes	Yes	Yes	Yes	N/A	N/A	N/A
Whether hired operator(s)	(15) Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interviewee's ID	24	25	26	27	28	29	
Farm Locations	Tamale, Northern	Tamale, Northern	Kumbungu Northern	Tamale, Northern	Tamale, Northern	Tamale, Northern	Tamale, Northern
Total land holding (acres)	(1) 70	68	214	3178	60	102	
Cultivated land for food crops in 2017 (acre)	(2) 70	68	90	70	60	102	
Whether hired a farm manager	(4) No	No	No	No	No	No	No
Whether has urban income	(5) No	No	No	No	No	No	No
Whether has out-growers	(6) No	No	No	Yes	No	Yes	
No. of all tractors currently owned	(7) 1	1	2	2	1	2	

Table 4 cont.

Interviewee's ID		24	25	26	27	28	29
Farm Locations		Tamale, Northern	Tamale, Northern	Kumbungu Northern	Tamale, Northern	Tamale, Northern	Tamale, Northern
Year of purchasing the first tractor	(9)	2013	2014	2011	2003	2010	1997
Whether currently own 2 nd hand tractors	(10)	Yes	Yes	Yes	Yes	Yes	Yes
Whether sold or with un-operational tractor	(11)	N/A	No	No	Yes	No	Yes
Whether provide mechanization services	(12)	Yes	Yes	Yes	Yes	Yes	Yes
Acreage of service provision in 2017 (acres)	(13)	172	50	296	370	400	2000
Whether owner himself is an operator	(14)	N/A	N/A	N/A	N/A	Yes	N/A
Whether hired operator(s)	(15)	Yes	Yes	Yes	Yes	No	Yes

Source: Authors' own interview notes.

3. TRACTOR UTILIZATION AND HIRING-OUT SERVICES

While the primary motivation for most medium- and large-scale farmers to own tractors is use on their own farm, hiring-out services is common practice for most tractor owners, including many beneficiaries. This is particularly true for the beneficiaries who owned tractors prior to purchasing new tractors from the Brazilian Facility. Of the eight interviewed AMSEC beneficiaries who are farmers, five were experienced farmers and service providers before they bought new Brazilian tractors. With many years of experience in the business for mechanized service provision, these previous owner beneficiaries' new tractors are barely idle and have all reached or close to the MOFA's target for their tractor use about 800-1,000 hour per year per tractor. The high utilization of their tractors is either due to migration between two agroecological zones (from south to north, e.g.) providing services in three different seasons a year (two in the south and one in north), or by combining the use of tractor for plowing with transportation and maize shelling. In the case of migration for service provision, having a reliable network in different agroecological zones is key. In the mechanized service market, service providers still mainly depend on phone calls or text messages received directly from customers. Without knowing customers in different locations, tractor owners are unlikely to migrate for service provision from the south to the north and vice versa.

There are two non-farmer AMSEC beneficiaries in our interviews, one large NGO that has recently expanded its business into agricultural value chain development and one large agribusiness company. Our interview with the NGO's agriculture project manager was done at Kpong Irrigation Scheme in Asutsuare, Eastern Region where the NGO provides mechanized services to small farmers who are members of Farmer Based Organizations (FBOs) established by the NGO in the irrigation scheme for paddy production as well as other services (e.g., marketing and rice milling). As an AMSEC beneficiary, the NGO purchased five new tractors and a seed drill from the Brazilian Facility. It also owns three combine harvesters, five rotavators, one seed drill and some other equipment, which were all purchased new abroad by the NGO itself. The agribusiness company interviewed in the north purchased two tractors from the Brazilian Facility and qualified as an AMSEC. The company rents in more than 1,000 acres of land and has more than 5,000 small farmers as out-growers. While the company currently owns five tractors, it also rented in 10 more tractors in 2017 for their operations. The CEO of the company, whom we interviewed, said his goal is to have a fleet of 20 tractors in the future. Although the NGO and the large agribusiness company are beneficiaries that provide mechanized services to small farmers who are either their out-growers or members of their value chains, they appear able to do so without the government program, at the very least at a smaller scale.

All interviewed non-beneficiary tractor owners are service providers, given their relatively smaller farm sizes. Moreover, all of them have owned tractors and have been providing services for many years. Most are knowledgeable tractor operators that started with one tractor themselves. Although they prioritize the land preparation of their own farms before providing hiring out services, given their relatively smaller farm sizes, they have plenty of time to offer services during a season, especially if they have been in the migratory service business for many years. The five non-beneficiary tractor owners who provided migratory services interviewed claimed that they can plow 600 – 2,000 acres a year for other farmers. Customers often contact them or their operators directly and finding customers is never an issue.

For beneficiaries who have experience providing services, finding customers is also not an issue. Many of them are confident that they can recover their tractor investment cost in two to four years.

Non-beneficiary second-hand tractor owners are also confident about their ability to recover their tractor investment.

The experience of tractor owners in farming and the service provision business and their knowledge for tractors are the most important factors to determine the efficiency of tractor utilization. On the other hand, for the new tractor owners whom purchased their tractors from the Brazilian Facility, there is a steep learning curve. There is no formal mechanism for providers to search for customers or vice versa. Newcomers into the business have a big challenge of finding customers and establishing a service provision network. Farmers were less likely to know these newcomers and the newcomers were struggling to find customers, especially in the first year. An interviewed AMSEC beneficiary who is a first-time tractor owner said that he had great difficulty finding any business in the first two weeks.

Moreover, new farmers relying on farm managers and operators to manage their farms and marketing, found difficulty in finding trustworthy and experienced operators who wouldn't damage their tractors. There was also the risk that the operator wouldn't properly report income. As a result, some beneficiaries were reluctant to allow farm managers/operators to provide services due to concerns of damage to their tractors from improper operation.

While it is a common practice for experienced owners and operators to do a field pre-inspection to check for tree stumps before plowing, first-time tractor owners and their farm managers and operators seem to lack such knowledge. Among interviewed beneficiaries, there are five cases in which the new tractors from the Brazilian Facility were damaged and in two cases serious damage was caused by running into stumps because the operators did not pre-inspect the field. Both cases occurred within the first few weeks of ownership. The concern of the possibility of future damage to their tractors led some owners to move away from service provision. Operational hours are often low for these beneficiaries' tractors, while few seem very concerned about the recovery of investment cost nor regret the tractor purchase. Some new owners report that they are content with owning a new tractor just for their own farm and feel confident that their farm income together with some other small businesses in agriculture could eventually cover their tractor investment cost. Additionally, new tractors with low use intensity and low risk of damage can have a long lifespan. Owners believe that the value of a new tractor with good maintenance is unlikely to depreciate over time in comparison with the local currency.

Occasionally, relatives and close friends of tractor owners ask for services at discount prices (e.g., just to cover the fuel cost), especially for the owners who own only one tractor. This situation exists both for beneficiaries and non-beneficiaries. One interviewed beneficiary told us that this was one of the reasons he stopped providing services to anyone. Besides this case, we did not hear other complaints from the interviews to cite such non-profitable services related to relatives and friends as a factor that affects their market-based service provision.

Performance of second-hand tractors seems to be comparable to the performance of brand-new tractors. However, this may partly be because second-hand tractors are used by more experienced owners and operators than the brand-new tractors. This suggests that the government does not need to limit its support to brand new tractors. Most non-beneficiary tractor owners own second-hand tractors. Tractors, for those who own more than one tractor, are often in different mechanical conditions and not all of them are suitable for plowing. Second-hand tractors are often resold when they are no longer in good condition for plowing or are retired from plowing and are used for other

means such as transportation or powering maize shellers. The application of different uses based on the tractors' mechanical condition has significantly increased the lifespan of a second-hand tractor, which is the reason why most owners prefer tractor such as old models of Massey Ferguson (MF). Among interviewed 13 non-beneficiary tractor owners, 12 of them own second-hand tractors and all of them own MF. There are only three owners who own other brands of tractors in addition to MF. With the well-developed supply chains for MF spare parts and repair services in many locations across country, owning an MF is a more secure option for increasing the tractors' service life than owning other brands. Less popular brands, such as those brought in by the government under various concessional loans or through other bilateral arrangements, often do not come with the backing of enough spare parts and repairs and their service life is reported to be much shorter. Between 2003 and 2015 before the Brazilian Facility, there were about 2,500 new tractors brought in by the government with various brands, but few can be found in operational condition. Six of the 11 interviewed tractor owners, including both beneficiaries and non-beneficiaries of the Brazilian Facility, who reported the purchase of a new tractor before the Brazilian Facility still use these tractors, including three who just purchased one recently between 2013 – 2015. For the others, these tractors were either sold or are not in operational condition. Though more research needs to be done, it appears that the lack of a well-established supply chain for spare parts and repair services could be a reason for less popular brand tractors to be out of service earlier than the more popular brand ones.

4. CHALLENGES FOR SMALL FARMERS TO RECEIVE ON-TIME SERVICES

We also interviewed about 40 farmers in five groups in their communities in both southern and northern Ghana about mechanized services the farmers received. Most of these farmers are small scale with 2 – 5 acres (0.8 – 2 ha) farms in the south, and relatively large farms in the north ranging between 10 – 25 acres (4 – 10 ha). While there are no tractor owners in almost all the communities where smaller farmers were interviewed, almost all interviewed farmers did hire tractor services for land preparation, mainly for plowing as well as for maize shelling. In two groups, some farmers also hired tractors for carting. There is only one farmer interviewed did not hire tractor services for land preparation because of stumps in his field. In the two groups interviewed in the north, some farmers used animal traction (mainly for harrowing) in addition to hiring in tractors for plowing. In one case, a relatively larger farmer with farmland 24 acres (about 10 ha) who owns about 50 head of cattle, used both animal traction and tractor services and also rented out animal traction services for plowing to other smaller farmers. Demand for mechanized plowing services exists among small farmers for various crops and cropping systems and plowing is done not only for rice and maize, but also for cassava. In one case for cassava, a tractor with a ridger was used. However, it is not clear whether the ridger is widely available in the market, as it was only mentioned by one service provider interviewed.

There is no formal mechanism or network for small farmers to get access to tractor services. Farmers typically call their known service providers (in most cases their operators) individually to ask for services from nearby towns. Others receive contact information from other farmers who hired-in services previously, while many simply approach the tractor's operator when they see a tractor operating in their neighbors' farms or traveling on the road. Only in one group interviewed did farmers contact service providers together because the provider was reluctant to come if they did not act as a group.

While the charge for the same service (e.g., plowing) varies across different locations, the rate seems to be uniform in the same community regardless of the farm size plowed. Farmers can easily recall the service charge per acre in 2017 as well as in previous years, and the charge is more or less the same among interviewed farmers in the same group. While service charges had increased over time, few complained about it. Instead, when asked about the main challenges regarding mechanization, many complained about difficulty of receiving services on time. The following two factors seem to be the main reasons for the difficulty small farmers have getting plowing services or getting services on time.

4.1. Lack of Aggregation among Small Farmers in a Community

This is not only because small farmers often contacted service providers (mainly their operators) individually, but also because of lack a of coordination in land preparation or other farming operations. Farmers in the same community seem to make decisions on when they will do land preparation, planting and harvesting individually, according to their own schedules. This is not solely the case for rainfed agriculture, but also within irrigation schemes. It is common practice for different farmers to grow different crops on their land that have different lengths of growing period within a single season, which could make coordination difficult in some mechanized services (e.g., harvesting) even in some Asian countries. However, we observed that within a large piece of land owned by different farmers growing the same crop in the same season, the growth of those crops

appeared to be in very different stages, indicating that both land preparation and planting were likely done at different times by individual farmers. In locations where few farmers demand tractor services for just 2-3 acres of land, tractor owners and operators are reluctant to come because of the additional fuel and time consumed by travel to those locations. When the plot is extremely small, efficiency in services goes down for each acre of land (the tractor needs to turn around more), which uses more fuel and requires more of the service provider's time.

4.2. Lack of Proper Land Development before Plowing

In the forest zone and some areas of the transition zone, additional efforts for land development are necessary before plowing. High weeds need to be cleaned such that stumps are visible to operators. Hidden stumps need to be removed to reduce the risk of the tractor and implements running into them, which can easily damage the tractor. Unless the plot has been plowed for many years and hence stumps have been removed, service providers are reluctant to provide services for less prepared land with high weeds. For farmers, it requires additional efforts for land preparation and hence additional cost, which they sometimes cannot afford.

5. PLOWING VS. HARROWING

Both plowing and maize shelling have become highly demanded and widely adopted by many farmers (plowing is still uncommon in the forest zone because of the stumping issue).¹ In rice growing areas, particularly within irrigated schemes and inland/bottom valleys, demand for combine harvesters is growing. Deep plowing (by disc plows that are commonly used in Ghana) is used for killing weeds and bringing nutrients up to the surface of soil for the plants. On the other hand, demand for second-plowing and harrowing that helps break clods and level the soil after deep plowing is still low, except for rice fields where second plowing and sometimes harrowing have become common under rainfed conditions in the north and in irrigated fields where a rotavator (which combines plowing and harrowing) is used. For rice, water would be more obstructed and unable to move evenly across the field unless clods are broken down and the field is leveled. Second plowing/harrowing after seeding is also necessary for covering up rice seeds with soil when seeds are broadcasted. During our interviews, according to a few service providers' own assessments, only 10 – 20 percent of farmers request second plowing or harrowing. Interviews among farm groups also confirmed this. In the south, none of interviewed small farmers requested harrowing services. In the north, while farmers paid for both first and second plowing services for their rice fields, they only requested one primary plowing service for their maize fields.

On the other hand, almost all interviewed service providers practiced both primary plowing and harrowing or second plowing on their own land. The service providers are aware of the benefits of breaking large clods and finely leveling the land using harrowing or second plowing and believe that this can help increase yields. Some of them provided us with the estimated yield gaps between plowing only and plowing plus harrowing. The fact that more tractor owners tended to do both primary plowing and second-plowing/harrowing than non-tractor owners is also seen in the 2012 IFPRI-SARI survey, in which 42 percent of tractor owners did second plowing or harrowing while only less than 9 percent of non-tractor owners who hired in plowing services did so (see Table 6).

Table 5. Numbers of Small and Medium/Large Farmers with and without Hiring in Tractor Services for Plowing by Agroecological Zones in 2012 IFPRI-SARI Survey

	Hiring in tractor services for plowing	Not hiring in tractor services	Total
Without plot in the forest zone	562 65.1%	301 34.9%	863 100.0%
With plot in the forest zone	227 39.1%	354 60.9%	581 100.0%
Total	789 54.6%	655 45.4%	1,444 100.0%

Source: Authors' calculation using data from the medium- and large-scale farmers and mechanization survey conducted by IFPRI-SARI in 2012 (IFPRI-SARI 2016).

Notes: The table covers only farmers who do not own tractors. The total number of such farmers is 1,444.

¹ The IFPRI-SARI survey conducted in 2012 also confirms this. As displayed in Table 5 above, and when farmers who do not own tractors are broken down by agroecological zones, it shows that two-third farmers who do not have plots in the forest zone hired in services, while only one-third farmers who have plots in forest zone hired in services.

Table 6. Plowing vs. Harrowing among Tractor Owners and Non-Owners in 2012 IFPRI-SARI Survey

	Primary plowing only		Primary plowing plus second plowing or harrowing	
	# of farmers	% in each group	# of farmers	% in each group
Tractor owners	223	58.2	160	41.8
with rice field	90	52.0	83	48.0
without rice field	133	63.3	77	36.7
Non-tractor owners who hired in services	656	91.1	64	8.9
with rice field	214	83.6	42	16.4
without rice field	442	95.3	22	4.7

Source: Authors' calculation using data from the medium- and large-scale farmers and mechanization survey conducted by IFPRI-SARI in 2012 (IRPRI-SARI 2016).

Notes: The table covers only medium- and large-scale farmers who used mechanized service for plowing. The total number of such farmers is 1,103.

In the farmer group discussions, we asked small farmers who received plowing services whether they knew of the potential yield increase from harrowing. Many of them indicated that they know of such a benefit from harrowing, but few were willing to pay for the service of harrowing citing cash constraints (in many locations, harrowing is about half the price of plowing), risk of bad weather preventing the potential yield gain, and market price risk when the harvest is good as the reasons for not paying for this service.

While liquidity constraints, weather risk and market uncertainty are often used to justify why smallholders lack incentives to adopt modern technology, in the case of mechanization, they don't solely explain why demand for harrowing is so low given that plowing also requires a cash payment (even more than harrowing in many cases), and faces similar risk from weather or market uncertainty. In the case of plowing, none of the interviewed farmers mentioned either the cash constraint or weather uncertainty and instead complained about the difficulty of accessing plowing services on time. The different attitudes among farmers towards hiring services in plowing and harrowing seem to indicate some factors overlooked by the conventional economic theory. The inconsistent behavior, a notion proposed by behavioral economists, seems to be very relevant in this case. First, farmers seem to value the level of spending differentially from changes in spending. Plowing has long been recognized as a necessity for most farmers, which can be treated as status quo level of spending on land preparation. Then, harrowing is an additional cost after plowing, which is seen as incremental spending. People are generally reluctant to spend incrementally when a status quo has been established. Second, based on the famous loss aversion notion developed by Kahneman and Tversky (1984), people often value loss and gain differently. In our case for mechanization, farmers seem to value the cash (e.g., 100 cedi) spent on hiring services for harrowing as a loss, which they value much higher than an equal hypothetical (e.g., 100 cedi) gain from increased yields. Kahneman and Tversky predict that in most cases, people value the loss of the same amount of cash twice more than the value of the gain. Unless gains from harrowing are significantly high, few farmers are likely to be willing to pay for harrowing.

On the other hand, why do tractor owners plow and harrow their own land? Again, according to the explanation of the behavioral economics, it is the actual cash cost for harrowing instead of its *opportunity cost* that determines the tractor owners' decision-making. Although the opportunity cost for a service provider to do harrowing on their own land is worth 100 cedi (i.e., the price of harrowing services), the actual cash cost of harrowing their own land is much lower and it is just the fuel cost in most cases (e.g., 20 cedi). Therefore, if the gain from increased yield after harrowing is more than 40 cedi (i.e., more than doubling the fuel cost of 20 cedi), it is worthwhile for the tractor owners to harrow their own land. For other farmers to hire harrowing services, the potential gains would have to heavily outweigh the costs (by a factor of 2 according to Kahneman and Tversky's prediction) for them to be willing to pay for it. While most farmers know harrowing is associated with yield gains, few believe they can be double the service charge of harrowing.

The different attitudes for different mechanization services (e.g., plowing vs. harrowing in this case) can also be observed for other services such as planting. For example, in the interviews, many tractor owners showed their interests in purchasing a planter, if its price is reasonable and quality is reliable. They considered buying it mainly for their own land, knowing that demand for the hiring services of a planter is unlikely high. When a similar question was asked to small farmers, many of whom currently hire manual labor for planting, few want to pay for planter services, unless the service charge is as same as the cost they paid for manual labor for planting, even after we pointed out that yield could be higher when a planter is used rather than manual planting.

6. IMPORTED VS. LOCALLY FABRICATED IMPLEMENTS/ATTACHMENTS

Two hundred and twenty-four maize shellers were imported through the Brazilian Facility and about 200 were sold at a price of 4,000 cedi (\$1,000) per piece with a government subsidy of 60 percent on the imported price. Imported maize shellers can be attached to tractors or powered by a self-engine and it seems to work well. The fee for shelling is paid according to the numbers of bags of maize and price per bag is similar in the south and the north. Farmers face little difficulty paying for shelling services, which can be either in cash or in maize, as the services occur immediately after harvesting. Therefore, demand for shelling is very high, and it is probably the mostly broadly adopted mechanized service in Ghana. Because of the high demand for such services and the relatively simple design of the machine, local maize shellers have been fabricated in Ghana for many years by many small manufacturers. Moreover, locally manufactured products are generally much cheaper than the subsidized price of imported ones. While imported shellers are superior in quality to the local varieties, subsidizing imported shellers directly competes with local manufacturers rather than supporting them to upgrade their product quality. We will revisit this issue later in the policy suggestion section.

Six hundred and fifty-one tractor trailers were imported and sold either individually or as part of the full package with a tractor (and plow and harrow) at the subsidized price. After the 60 percent subsidy, the price paid was 9,000 cedi (\$2,250) per trailer. Tractor trailers are also fabricated by small local manufacturers. While imported trailers have more functions than local varieties (e.g., imported ones normally tip while local varieties cannot), prices for local varieties are generally lower than the subsidized price for the imported one. In the interviews, many farmers stated that they prefer to hire tractors with one type of local trailer for carting their produce, because it has a higher side-wall and can be filled with more produce while the price for transportation is based on trips instead of weight. Similar to the case of maize shellers, the government is subsidizing imported machinery that directly competes with locally manufactured ones.

Imported multi-crop threshers either powered by tractor power take-offs (PTOs) or self-engines can be used for three crops: maize, soybean and rice. One hundred twelve pieces of such equipment were imported and sold with a 60 percent subsidy. However, a technical issue with the machine was identified soon after buyers started using it. While the thresher can be powered by a tractor, its own attached engine coming from the manufacturer is not powerful enough for maize threshing in a way Ghanaians commonly prefer.

The imported Brazilian planters cost almost \$30,000 for a pneumatic planter and \$15,000 for a mechanical planter at CIF imported prices. Fifteen pneumatic planters and 60 mechanical planters were imported, most of which were sold. Even with the 60 percent subsidy, a buyer has to pay about 45,000 Ghana cedi (\$11,250) for a pneumatic planter and 24,000 cedi (\$6,000) for a mechanical planter. In the interviews with both tractor owners and small farmers, we only heard one case in which a Brazilian Facility beneficiary hired a planter for services. The farmer who hired the planter services, however, complained that the planting quality was poor, as seeds did not drop regularly because the operator lacked the ability to effectively calibrate the planter. As a result, the farmer had to re-hire manual labor to redo the planting. A modern planter that works perfectly in the country that manufactured it, can perform poorly elsewhere, as its working efficiency and quality are determined by many conditions, e.g., the inconsistency in seed size when seeds are unsorted (almost all interviewed small and larger farmers use their own maize as seeds and few purchased seeds from market, which implies seeds are unlikely to meet the standard conditions and uniformity that a

modern planter was designed for). The soil conditions and whether the field was well prepared before planting also may affect the planter's working quality.

Twenty-one cereal harvesters that can be attached to a tractor were imported for promotion purposes. This equipment is designed for harvesting maize, rice, soya, and cowpea. Buyers of such equipment mainly use them for harvesting rice. The CIF price is \$35,000 per machine and the subsidized price paid by buyers is about 56,000 cedi (\$14,000). However, the current design of the harvester did not work properly for rice in Ghana with extremely high waste in operation, while it was able to harvest maize and soya efficiently. Rice farmers had to stop using it.

These three typical examples indicate that an implement that works perfectly in the manufacturing country could be a failure in Ghana due to many unexpected factors. Local adaption for such equipment is a necessity, which requires knowledge from local manufacturers and farmers as users. Similar to many other types of complex agricultural machinery, multi-crop threshers, pneumatic planters and multi-purpose harvesters attached to tractors are unlikely to be manufactured in Ghana in the foreseeable future. In some of these cases, however, when simpler machines are suitable and can be partially substitutable with more complicated ones, the government should consider encouraging local manufacturing or bringing in much simpler equipment that is often cheaper and can be quickly adapted for manufacturing locally, without a subsidy. In such cases, government support is needed, which will be further discussed later in the policy suggestion section. Low cost imports may be a sustainable strategy to promote many complex agricultural machines that cannot be manufactured locally and for which demand for services is growing. For example, combine harvesters have become increasingly used by rice farmers, especially larger farmers in rainfed areas and small farmers in irrigation schemes. The high demand increases the efficient use of such machinery, which gives the private sector incentives to import low-cost, unsubsidized machines. We will revisit this issue later in the policy suggestion section.

7. POWER TILLERS AND SMALLER TRACTORS

The government decided to import 1,000 power tillers in the second tranche of Brazilian Facility loans and are also considering importing more under the possible new concessional loan agreement with the Indian government. Therefore, we asked both tractor owners and small farmers a few questions to assess their attitude and knowledge about power tillers. Besides the trip to Kpong Irrigation Scheme, where many power tillers can be found in repair shops alongside the road, we did not see any in the rainfed areas in both the south and the north.

When tractor owners were asked for their attitude towards power tillers, it was almost uniformly negative. With their large farm sizes, few want to invest in power tillers regardless of its price. As tractor service providers, they also believed that power tillers are not suitable for Ghana's heavy soil under rainfed conditions. In the forest zone among tree crop growing farmers, it is possible for them to consider the use of power tillers when they plant food crops in between tree crops before trees start to bear fruits (e.g., in cashew plantations), given that large tractors are unlikely to be able to plow in such conditions. One interviewed cashew grower did purchase a power tiller a few years ago, but he gave up using it as he found that soil is too heavy for the machine to work. The machine was abandoned as there was no buyer for it. For small farmers who depend on hiring-in services, few showed interest in owning a power tiller, given that they often depend on either hiring a tractor or labor for land preparation, planting and carting, and did not see the reason to own a power tiller. Indeed, even in Asian countries where power tillers are broadly adopted for land preparation and other functions including rural transportation and powering water pumps in shallow water irrigation, only a small number of farmers own power tillers (less than 6-7 percent in Bangladesh, (Diao et al. 2014)) and most small farmers hire its services. While the government intends to highly subsidize the power tillers to be imported from Brazil to boost the number of small farmers as buyers, maintenance and repairs are at the owners' cost. Few small farmers are likely to have either the financial or technical capability to do so.

The current model to be imported under the Brazilian facility is the Japanese Yanmar made and sold in Brazil (Yanmar Agritech). Japanese products like this one are well known for their quality, but also their high price. In South and Southeast Asia, Japanese brands can be sold only with subsidies, while the Chinese and Thai (in the case of Southeast Asia) made power tillers have the lion's share of the market without a subsidy, as their prices are usually at 50-60 percent of the Japanese models (including Kubota, Mitsubishi and others). Again, price sensitivity outside of any subsidy program could play a big role in success or failure of these machines.

Another major difference is that the Japanese brands' rotovator attachment or plow does not come with a seat while the Chinese ones do. This is not only important for ease of use in the field but of supreme importance when power tillers are to be used by operators to provide services to other farmers. In such situations it is important for moving quickly from one field to another and to reduce the time of transport (walking speeds of 2nd or 3rd gear vs. to speeds approaching 30 kilometers per hour in 6th gear).

In the interviews, we noticed that farmers are very sensitive to the price of tractors and this is especially true for those depending on hiring out tractor services for income generation. This is one of the main reasons why most tractor owners who do not have regular urban income prefer to buy second-hand tractors of which prices vary widely. We proposed a few hypothetical situations to the interviewed tractor owners to assess potential demand for low-horsepower and low-price four-wheel

tractors. Most tractor owners indicated that the high horsepower is not the main factor deciding which tractor to purchase, as they know higher horsepower is often associated with higher fuel consumption. However, they still prefer tractors between 60 and 75 horsepower, which are the ones currently popular in the country. When asked, many said that they would consider buying a tractor with 45-55 horsepower for a 20% lower price. However, few would consider 25-40 horsepower tractors even at prices much lower than the larger tractors, as they argued that such low horsepower tractors cannot deal with heavy soil and are much slower than the tractors they currently use in operation. Therefore, opportunities for promoting smaller tractors at a lower price may exist if their suitability in different locations and for different types of operations can be demonstrated.

8. CONCLUSIONS AND SUGGESTIONS

We estimate that there are about 10,000 tractors currently operating in Ghana, most of which were imported through the private sector as second-hand tractors. Despite government attempts to promote AMSECs, most new tractors imported by the government and most second-hand tractors are owned by individual farmers. The private hiring market that is primarily supplied by these individual farmers who own tractors is likely to remain the dominant mechanism for the development of mechanization. Since the scale of government intervention is dwarfed by private channels, the main concern over government involvement in mechanization is not crowding-out effects but in the equity effects of such programs and whether government funding and effort could be better utilized elsewhere.

Both the current and previous governments' AMSEC programs are a result of receiving money and machinery from various bilateral concessional loan arrangements with foreign governments. The challenge for the Ghanaian government is how to respond to this sort of bilateral foreign aid from a donor country's government that ties it to the type of tractors brought in under the program. While it is unrealistic to suggest that the government should decline such concessional loan arrangements, it is important to recognize their possibly unintended outcomes, such as those discussed in this paper. Since donor countries aim to promote mechanization for Ghanaian farmers, particularly smallholders, through these concessional loan arrangements, it is important for the Ghanaian government to openly discuss their challenges and trade-offs during negotiations with the donors. While it might be impossible to completely overcome the disadvantages of concessional loan arrangements, there is room to minimize the risk, which requires close collaboration between the two countries' governments.

The following suggestions are proposed to help refocus government efforts on how to improve the fairness and efficiency of mechanization policy.

1. Recognizing the fundamental fact that medium- and large-scale farmers are the dominant players in mechanization service provision is the important first step in order for the government to rethink the concept of AMSEC and support to mechanization in general. Because of this fundamental fact, *an effective mechanization policy should aim at the whole service market* as a primary principle instead of targeting a selected group of service providers as policy beneficiaries. Examples of such policies include removing taxes and duties on the imports of spare parts, non-discriminatory subsidized lending to farmers and machinery and spare part importers, and other policies that help buyers overcome liquidity constraints. These policies can benefit the full range of tractor owners and machinery service providers rather than arbitrarily selected groups of beneficiaries.
2. The number of tractors under any new subsidy program is always small compared with the number of tractors in the existing service provision market, and hence, the direct benefit of such program will always go towards a small group of would-be buyers, leaving the majority of tractor service providers outside the program. Because of this, *the subsidy rate should be as low as possible*. For example, introducing an auction-like smart subsidy mechanism can generate proper information to ensure that tractors go to those who are willing to pay higher prices, and the reduced subsidy could allow the government to use funds more efficiently and fairly in other areas. A reducing subsidy

rate on each tractor purchased by an owner can also make funds available to reach more would-be buyers. In addition, most commonly used implements (such as plows, harrows and trailers) should not be subsidized to minimize the price difference received by beneficiaries from the non-beneficiary owners, and to allow the development of local manufacturing where feasible. While subsidies are often necessary for currently less well-known implements that can bring productivity and soil improvements like no-till conservation agriculture seeders and planters, the pilot of such purchases and feedback from their users are important before spending too much public money on them. Given the high cost of de-stumping in land development and the high risk to tractor owners for tractor damage from the stump, subsidies could be considered for more practical and low costed de-stumping implements or techniques. There are plenty of innovations in developed countries for de-stumping using smaller tractors with relatively simple implements or manual devices and techniques. However, these need to be tested technically as well as in the market.

3. *The government can do more to help small farmers easily access timely mechanization services.* Lack of coordination among small farmers in farming practices is a considerable barrier for them to access services on time. Since tractor owners and operators are discouraged from traveling long distances to plow only a few acres, on which their machines cannot move efficiently, it is worth considering mechanisms to improve coordination. While part of the lack of coordination is due to different timing of production of the same crop in a season by different farmers, there must be enough farmers planting simultaneously to attract a service provider. Ghana's many Farmer Based Organizations (FBOs) could also be helpful in this regard, although it is not clear why they haven't organically pursued such avenues. There is also a major lag for new service providers and customers to link, to which apps such as Troto tractor could provide novel private solutions.
4. *Government can also do more in promoting the use of harrowing or second-plowing* such that mechanization can be more helpful for land productivity improvement. While even non-adopters are aware of the benefits in yield improvement from harrowing and second-plowing, the low willingness-to-pay for such services seems to be associated with *loss aversion* behavior. However, addressing the coordination failures discussed above could also nudge more farmers to hire in second plowing or harrowing services. A voucher system can be piloted among selected FBOs, where vouchers are given to all small farmers in a group in the FBO. The voucher is a subsidy for hiring harrow or second-plow and can only be redeemed as a group. This also encourages more tractors to come and provide simultaneous services of both plowing and harrowing to a group of small farmers. Lessons from many past and less successful subsidy programs (e.g., the recent fertilizer subsidy) need to be studied to minimize abuse at the local level of the public system.
5. *The demonstration of various smaller tractors* including power tillers is important for filling the knowledge gap about smaller tractors in the country as well as for understanding what types of smaller tractors are suitable for which locations in Ghana. Experience of some local tractor owners who have successfully managed smaller horsepower of Indian tractors would provide helpful lessons learned. The recent negotiation with the Indian government for a possible new concessional loan agreement provides a good opportunity for this, given that Indian manufacturers produce a broad range of

tractors with different horsepower as well as various less expensive and generally simpler implements.

6. Experiences with the *new implements* such as the recently imported planters and harvesters should be further studied. It is important to introduce planters and harvesters to the country, such that mechanization will not simply stay at the land preparation stage and could lead farmers to adopt better practices in land preparation. However, imported Western-made and knowledge-intensive planters and harvesters as attachments may not fit local conditions. Some attachments that work perfectly in the countries of manufacture, where conditions can be highly manipulated and controlled, may not perform well in Ghana without additional adaptations. As demonstrated by the importation of planters and harvesters discussed above, the effectiveness of an attachment such as a planter is related to many local factors such as the common practices in land preparation that may not lead to well leveled fields. In addition, variation in soil quality and lack of uniform-sorted size of seeds may require knowledge and skills that do not exist among the equipment's operators. Local R&D for simple implements either imported from elsewhere or manufactured locally should be encouraged.
7. Experience in Asia has shown that agricultural mechanization was preceded by small scale irrigation, much of it unsubsidized. More research and development on reducing the impediments for *investment in irrigation* in areas where such water resources exist is necessary. Cheaper and faster shallow and deep tube well boring technologies, inexpensive investments in diesel and petrol-powered irrigation pumps, and low cost flexible plastic hose pipes are some examples that should be explored in Ghana, given that they have been widely adopted in South Asia by smallholders.

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