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Growth of Modern Service Providers for the African Agricultural Sector

An Insight from a Public Irrigation Scheme in Ghana

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ABSTRACT

This paper describes how modern service providers have emerged in the African agricultural sector, a subject that has been vastly understudied. The paper looks at providers of modern rice mills, power tillers, combine harvesters, and production services at a highly productive rice irrigation scheme in Ghana. These service providers earn net profits that are greater than the profits they would likely achieve from simply expanding rice production without investing in respective machines, suggesting that higher returns primarily induce the emergence of these modern providers. Surpluses and experiences from their years of rice production are likely to have provided the primary finance and knowledge required for entry. The service providers emerged by exploiting both the economies of scale and the economies of scope, keeping rice production as the primary source of income, instead of specializing only in service provisions. Key policy implications are also discussed.

Keywords: modern service providers, entry costs, rice, irrigation scheme, Ghana

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1. INTRODUCTION

Agricultural transformation is key to reducing poverty and improving food security in Africa south of the Sahara (SSA) (Dorward et al. 2004; Gabre-Madhin and Haggblade 2004). Agricultural productivity in SSA has largely remained low, despite a growing nonfarm sector and urban food consumption (African Center for Economic Transformation 2014). The slow modernization of the agricultural sector raises concerns that rural-urban inequality remains deep and poverty remains widespread, despite the structural transformation.

An important component of agricultural transformation is the growth of private-sector service providers (SPs) for various modern agricultural operations, including mechanization, processing, trading, and general production services.[1] This component also deepens agricultural industrialization.[2] The recent literature from SSA provides insights into the characteristics of some relatively indigenous SPs, such as traders (Fafchamps, Gabre-Madhin, and Minten 2005; Kikuchi et al. 2016). However, little has been documented in SSA about the emergence of more modern SPs, including semimodern milling, mechanization, and production services.

We partly fill this knowledge gap through our descriptions of various modern SPs, including rice mills, power tillers, traders, combine harvesters, and production service providers, for rice production in Ghana's Kpong Irrigation Scheme (KIS), one of the nation's largest irrigation schemes. Not only has rice become an important food security crop in West Africa, including Ghana (Ragasa et al. 2015; Gyimah-Brempong, Johnson, and Takeshima 2016), but it also receives intensive, relatively modern production and processing operations that can potentially be outsourced to SPs. We focus on these SPs because, except for rice traders, they are still relatively rare in much of SSA, including in the public irrigation schemes, even though they are more active elsewhere in the world. We also focus on rice traders because,

[1]In this paper, the term *production service* refers to production on subleasing in which fixed fees are paid to the lessors. Unlike in sharecropping, service providers bear all the production and income risks. Such practices are rare in SSA relative to Asia, particularly in public irrigation schemes.

[2]For example, Takeshima (2017) showed that increased tractor uses can transform farming from an activity with decreasing returns to scale to one with constant returns to scale, an important process of agricultural development (Hayami and Ruttan 1985).

despite their relative prevalence and roles in linking farmers to markets, patterns of their emergence have not been widely studied in SSA. We therefore focus on both upstream and downstream SPs for rice production.

KIS offers a particularly useful setting to study the development of modern SPs, because it is one of the few sites in SSA that has seen growth in this area (Takeshima et al. 2013). KIS is the second largest of 22 functional irrigation projects managed by the Ghana Irrigation Development Authority and the Irrigation Company of Upper Region. It irrigates 1,860 hectares (ha) of rice and 1,700 ha of commercial banana areas. The scheme was originally established in 1967 and was later expanded. Between 1997 and 2004, 860 ha that had been developed earlier were rehabilitated, and 1,000 ha were newly developed through loans from donors such as the African Development Bank (Takeshima et al. 2013). Approximately 2,600 farmers are registered as cultivators for the 1,860 ha of rice area. KIS farmers largely grow aromatic varieties of rice that are popularly consumed in Ghana, particularly by urban consumers; these varieties attract high market prices (Takeshima et al. 2013). KIS is characterized by high rice yield in SSA standard (approximately 5–6 tons/ha), as well as high adoptions of power tillers, combine harvesters, semimodern rice mills, and production services, all of which are largely provided by the private sector. KIS has received significant public support in the development and provision of improved varieties of rice and of the irrigation infrastructure. In Ghana, all rice varieties promoted in irrigated schemes are screened and tested at the Kpong Agricultural Research Station of the University of Ghana, located near KIS; thus, the varieties are more suited to KIS than to schemes in other parts of the country. In addition, because KIS irrigation facilities are set up as a run-of-the-river system, irrigation water is generally available throughout the year, unlike in some of the other schemes, where irrigation water is available only after land preparation such as tilling.

We shed light on three main aspects regarding SPs. First, we show that most of them are privately profitable, even without government support, and that higher returns from service provisions have induced these SPs to start additional provisions rather than continuing rice production only. Second, we offer insights into the entry barriers for becoming each type of SPs, in terms of both financial and

knowledge requirements, and how SPs have overcome these barriers. Third, we offer some indications of how these SPs have emerged. They did so not purely by specializing in service provisions but rather by expanding their scopes of activities while keeping rice farming as their primary income source. Where external markets for such services are largely absent, such as in KIS, the SP market initially operates in a closed economy, and its growth process is endogenous rather than exogenous. We also show that rice production within KIS has provided both the demand for services and the resources for SPs to grow.

One reason this study focuses on a specific area is that these relatively modern SPs have emerged in only a handful of locations in SSA. However, unlike in many other studies, which tend to focus on specific SPs, we offer insights into multiple types of SPs and address some commonalities across them. Our evidence is largely descriptive, partly because the number of agents is quite small for deriving rigorous statistical evidence on hypotheses regarding SP behaviors. However, our findings still reveal key patterns of relatively modern SPs in the agricultural sector, which, as mentioned earlier, have been understudied in SSA.

This study is based on a small survey of modern SPs operating around KIS, as well as informal follow-up meetings with local experts. It also uses information on rice production gathered by Takeshima et al. (2013). Throughout this paper, figures are expressed in constant 2010 US dollars (US$) unless otherwise noted.

Section 2 of this paper discusses the simple theoretical framework. Section 3 describes the competitiveness of these modern SPs in KIS, the entry costs and how they were overcome, and the economic returns. Section 4 discusses key hypotheses regarding the effects of SPs on rice productivity and income distributions. Section 5 discusses briefly the potential effects of the growth of these modern SPs. Finally, Section 6 concludes.

2. THEORETICAL FRAMEWORK

Standard microeconomic theories suggest that the higher returns achievable by SPs, as compared with other activities such as paddy production, induce private-sector agents to start engaging in service provisions. Returns depend on the expected revenues and costs. The costs include the entry costs (fixed costs) into the SP businesses and operational costs (marginal costs) required upon entry, both of which include financial and informational costs. Financial entry costs include not only the working capital required[3] but also the financial investments into various capital assets, which are paid from an SP's own savings, excluding any investments made on credit. Amounts of credit taken and interests are included in the operational costs. Informational entry costs are the minimum knowledge required to earn profits for some period after entry that is relevant to the SP. Of course, SPs can continue acquiring further knowledge that improves their efficiency over time, but the costs of acquiring such knowledge are included in the operational costs. Standard microeconomic theories also suggest that if returns from engaging in service provisions are sufficiently high, returns on innovations to further reduce entry costs are also high, leading to greater investment to produce such innovations. Entry costs are often lowered due to the availability of rental markets for required capital assets.

Key aspects relevant to our study are (1) factors affecting the marginal profit of SPs, (2) factors affecting entry costs into the SP business, and (3) factors affecting certain institutional forms of SPs.

Factors Affecting the Marginal Profits

Revenues from service provisions are greater if market sizes are greater. Market sizes are increased by the popularity of commodities among consumers, as well as by the availability of technologies (such as superior rice varieties) that help raise financial returns for farmers' intensive uses of these services, and thus raising the farmers' willingness-to-pay for these services (Otsuka and Larson 2012, 2016). Lu, Reardon, and Zilberman (2016) theoretically showed that, even for indivisible technologies like machineries, the increase in the demand for output leads to an increase in equilibrium rental fees and in

[3]Working capital required upon entry includes up-front payments for hiring workers and renting some assets.

equilibrium machine uses. Growing demand for aromatic rice in Ghana and the introduction of aromatic varieties that grow well in the Kpong environment help ensure these conditions.

Even when average market size is large, however, fluctuations in demand can negatively affect the expected revenues, discouraging risk-averse agents from engaging in service provisions. However, sufficient irrigation in Kpong, which allows relatively flexible production schedules, reduces seasonality of demand, while also reducing demand fluctuations due to water-related production risks (such as rainfall and flooding).

Favorable local-factor endowments and price structures (such as the cost of renting capital, labor, other materials such as fuel, and public services such as electricity) could lower the marginal cost of capital-intensive service provisions (such as for larger machines and relatively fewer labor uses), as compared with more labor-intensive service provisions. Production in relatively concentrated areas like KIS bring agglomeration effects with economies of scale, reducing travel costs per unit of service provided.

Factors Affecting Entry Costs

Requirements for initial capital investments depend on which scales of machines are profitable, as well as on local-factor endowments, conditions of machinery markets, and credit and service markets in the area. For example, if SPs bring positive profits only with large machines at substantial operational scale, with no smaller machines bringing positive profits, and if affordable credit is unavailable and machines cannot be rented, then required initial capital investments are higher. If, on the other hand, smaller machines can be used to realize positive profits, then required initial capital investments are lower.

The presence of rental markets for certain capitals or land further reduces the entry costs by sparing SPs the need to make up-front investments to acquire these assets. Truck and transportation services, which are widely used in the nonfarm sector, are some examples of such markets. Similarly, informal arrangements with suppliers of other inputs (such as labor) to allow delayed payments often

reduce working capital requirements upon entry. Similarly, greater availability of affordable credit lowers the entry costs.

Personal wealth also generally reduces the entry costs by reducing the costs of obtaining additional resources required for entry, such as interests associated with credits. In addition, where credit market imperfection is particularly severe, greater potential returns from an entry in the future induce the accumulation of personal savings (Ghatak, Morelli, and Sjostrom 2001). Personal wealth may be accumulated by nonfarm incomes, but in areas like Kpong, it may be accumulated through years of rice farming.

Costs of acquiring entry-level knowledge may be reduced by various factors. The experiences of local rice farming on own-farm and through interactions on neighbors' farms may reduce some informational costs about potential market size and plot conditions within serviceable areas. Social networks also reduce the costs of acquiring knowledge on machine suppliers, operations, and repairs. Growing migration and kin contacts abroad may often become the most efficient mode of reducing informational costs for acquiring knowledge about technologies abroad (Lewis 1996). Furthermore, if expected returns from knowledge are high, this may induce private investments in acquiring such knowledge.

Factors Affecting Institutional Forms of SPs

Different institutional forms often emerge in response to the characteristics of available technologies, further raising overall efficiency of rice production and service provisions. Where economies of scale can be exploited, service provisions often involve specialization and division of labor. For example, studies on a large tractor-hiring service in African countries, including Ghana, show that revenues from custom-hiring service are important determinants of investment in machineries (Diao et al. 2014; Takeshima et al. 2015).

Similarly, where economies of scale can be exploited, service provisions often involve vertical integration (Delgado 1999). In particular, where service provision is done with large-scale machines such

as combine harvesters or rice mills, some SPs enter into paddy-production services by leasing the farm, partly to reduce the cost of raw materials (paddy). Because of economies of scale associated with the large capital, benefits from the reduced costs of raw materials are greater.[4]

However, where economies of scale are relatively absent in each activity (that is, diversification is not due to risk mitigation), SPs take the form of diversification rather than specialization. For example, for power tiller service provisions and trading, entry costs are somewhat low. Many power tiller SPs and traders emerge; thus, the potential for exploiting economies of scale is limited.[5] Many of these SPs therefore continue rice production, instead of leasing out their farms to larger-scale producers.

Concerns among some policymakers and donor communities are that, in much of the African agricultural sector, the private sector's entry into modern service provision is constrained largely because the entry costs (both financial and informational) are too high. In addition, the operational costs (in particular, informational costs) are high because the private sector is inefficient in acquiring further knowledge in business operations. In this paper, however, we show examples of a growing competitiveness among modern private-sector SPs in the Kpong area, with a majority of them receiving relatively little direct government support in overcoming these entry costs and informational costs. (Instead, the government provided important technologies, such as successful varieties of rice, and infrastructure, such as irrigation facilities and farm extension.)

[4]Importantly, however, economies of scale in KIS may not be as high as in China, where many SPs fully specialize in combine harvester service provisions without involvement in farming, due to much greater market and better infrastructure (Yang et al. 2013). Combine harvester SPs in Kpong may therefore continue local rice production.

[5]Fafchamps, Gabre-Madhin, and Minten (2005) showed that agricultural trade in African countries does not exhibit increasing returns to scale. Similarly, Kikuchi et al. (2016) found that barriers to entry in Uganda's rice trading business are low.

3. DATA AND METHODOLOGIES

Data on SPs were collected in June–July 2016 through a survey of modern SPs around KIS that included structured questionnaires. As described below, because the seasonality of operations is relatively modest in the KIS area, the timing of the survey was not expected to significantly affect the findings. For rice mills, power tillers, and combine harvesters, almost all SPs in KIS were identified based on informal communication with the scheme office, as well as through local SPs who could identify other SPs. Specifically, 14 rice mill, 80 power tiller, and 14 combine harvester SPs were identified and interviewed. Each SP's reported transaction scales and the overall production scale of KIS corroborate that interviewed SPs did, in fact, constitute almost the entire population of SPs in the area.

For traders and production service SPs, no complete lists were available given their informal nature and the large population; thus, their subpopulation was sampled. We estimate that there are a few hundred traders in KIS,[6] including rice mill owners who trade 30 percent of paddies in KIS. Among traders who do not own rice mills, we identified 35 traders through the snowballing method; thus, the interviewed traders may not be purely representative of traders in KIS. However, because the survey suggests that together these traders trade about 25 percent of KIS paddy, their information can offer insights applicable to considerable segments of the trader population. Similarly, 32 production service SPs were also identified through the snowballing method. Although their information may not be representative of production services in KIS, it still offers useful insights into the nature of the emergence of production service SPs in the area.

Interviews were conducted by locally recruited enumerators who were familiar with the region and with rice farming in general and who were conversant in local languages. It should be noted that most SPs were relatively more educated than other farmers and fluent in English. Survey questionnaires were programmed using the Census and Survey Processing System (CSPro), and tablet PCs were used for the interview.

[6]This estimate is based on a back-of-the-envelope calculation using the average quantities of rice traded by traders; it may differ considerably from the actual figures.

Much of the discussion that follows is based on average statistics compiled from interviewed SPs, given the considerably small sample size of each type of SP. As such, relatively less focus is placed on the heterogeneity among interviewed SPs, except where rough comparisons across different groups of specific SPs offer useful insights.

4. GROWTH OF MODERN SERVICE PROVIDERS IN THE KPONG IRRIGATION SCHEME

All of the 4,000 ha of annual land preparation in KIS is done by power tiller SPs, and half or more of paddy in the region is harvested by combine harvester SPs; both are considerably high according to African standards. As of 2012, one-third of the area within KIS was cultivated by production service SPs, who sublease plots from registered farmers, rather than by registered farmers themselves. Production service SPs are still fairly rare in SSA public irrigation schemes (Takeshima et al. 2013).

Observed patterns of the growth of modern SPs in KIS are generally consistent with the theoretical framework described in Section 3. This section first describes the general characteristics of modern SPs. It then highlights the following points: (1) Modern SPs in KIS offer services that are as competitive as in Asia. (2) Entry barriers for some SPs are often low; even when the barriers are high, they have been largely overcome by the resources and knowledge accumulated through rice production in the area over time. (3) Higher profitability and returns from owning key capital assets and providing services, rather than from expanding rice farming alone, are likely to have induced entry into these SP businesses.

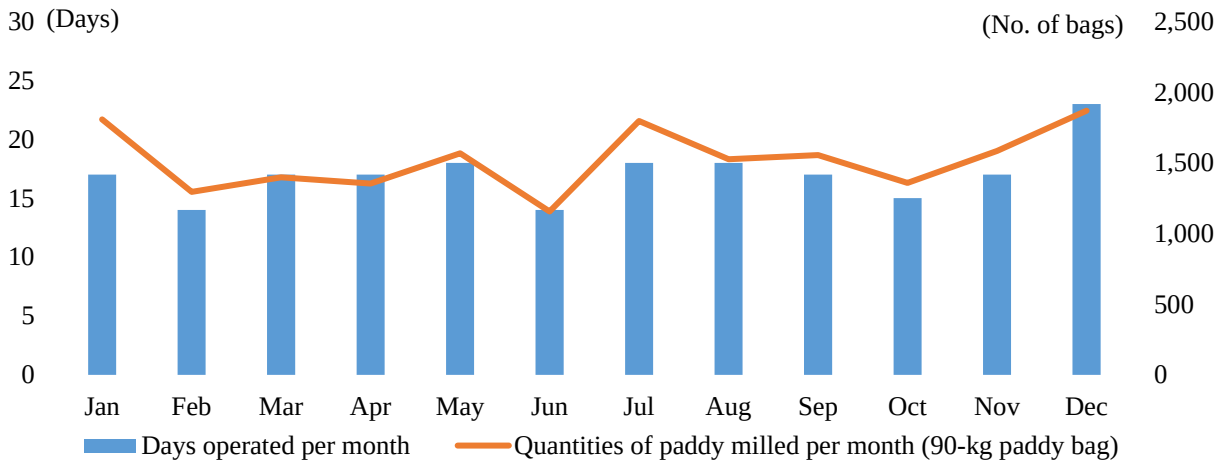
General Characteristics of Modern Service Providers in KIS

Rice Miller Service Providers

Most rice mill services around KIS are provided by 14 private millers, all of whom were interviewed for this survey. Most millers also own the buildings that contain rice mills, warehouses (typically worth $10,000–$15,000), and drying spaces (worth about $5,000). About half also own the land where the milling facilities sit. On average, they mill approximately 1,600 tons of paddy (1,040 tons in milled rice) per year. They mill roughly two-thirds of paddy for fees only (milled for fee); they also mill a third of paddy for their own sales. Capacity use rates are generally low (around 25 percent) but are comparable to the 20–30 percent in China and India (see Table 4.2 in Reardon et al. 2012). These rates are also sufficient

to earn profits. Millers obtain sufficient paddy from the KIS area alone—not only is yield high, but also operations are relatively stable year around (Figure 4.1) thanks to relatively stable harvests in KIS.

Figure 4.1 Seasonality of milling operations (average per miller)



Source: Field survey in 2016.

Power Tiller Service Providers

About 80 power tiller owners provide services to almost all of the 4,000 ha (or 2,000 ha per season) of rice areas in KIS. We interviewed all 80 power tiller owners. More than 90 percent are registered with KIS and grow rice. Many of them entered the power tiller–hiring business after the mid-1990s, and half entered after 2005; their behaviors are somewhat different from those power tiller SPs who relied on subsidies. We provide a comparative analysis of these two groups where appropriate.

The current stock of operating power tillers in KIS area consists mostly of four brands (see Table 4.1): Daedong (South Korea), Shakti (India), Kubota (Japan), and Yanmar (Japan). Most power tillers were obtained before 2010; the Yanmar power tillers were introduced around 2013. Kubota and Yanmar power tillers are more likely to have been subsidized (that is, obtained from the government, nongovernmental organizations, or cooperatives), while 40 percent of Daedong and Shakti were unsubsidized. Subsidy rates were typically 50 percent.

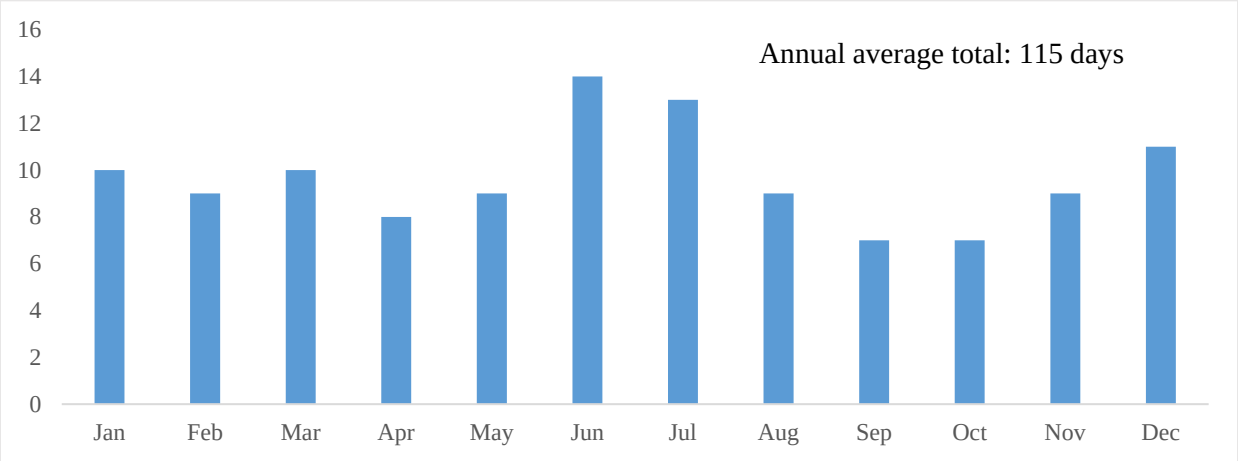
Table 4.1 Characteristics of power tillers owned in KIS

Brands	Sample size	Year acquired	% subsidized
Daedong	19	2007	58
Shakti	14	2009	57
Kubota	21	2009	71
Yanmar	43	2013	93
Others	4	2012	50

Source: Field survey in 2016.

Typically, power tiller SPs operate for 115 days a year. Operation is somewhat seasonal but not extremely so; the average days of operation per month vary from 14 days in June to 7 days in September–October (Figure 4.2). On average, a power tiller is used on 34 ha for plowing and tilling and 28 ha for rotovating (further breaking up the soil with rotating blades), mostly through hiring out. In addition, they are used for about 10 days for transportation of farm products, including paddy and other goods, mostly SP's own-farm.

Figure 4.2 Number of days operated by power tiller owners in each month

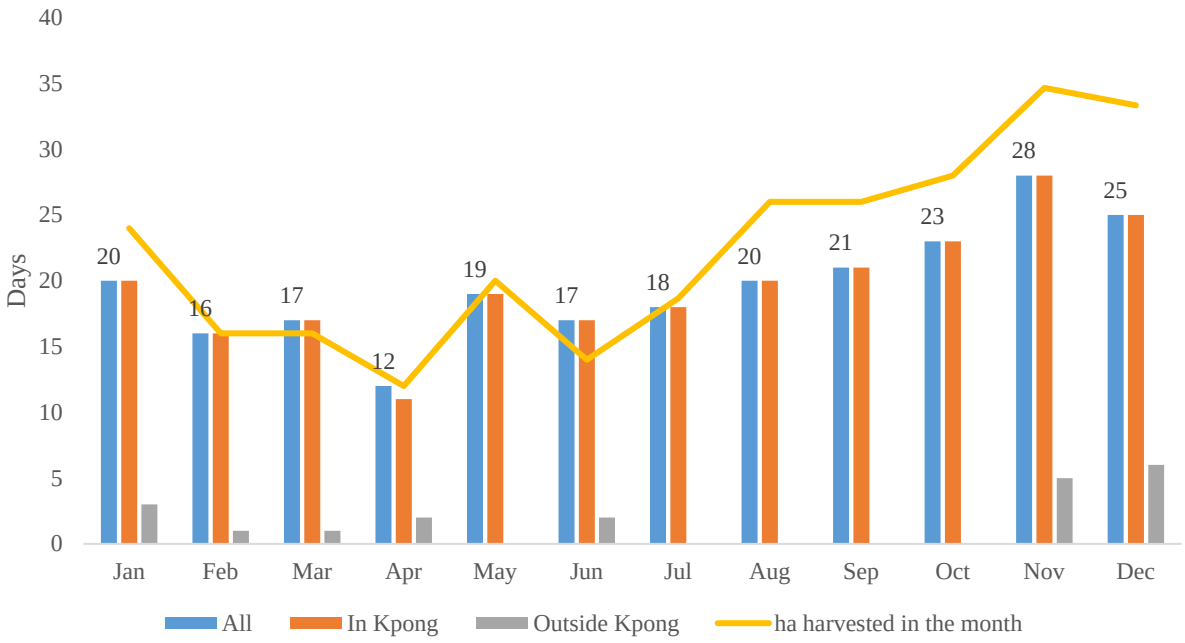


Source: Field survey in 2016.

Combine Harvester Service Providers

Fifteen combine harvester owners currently provide services, harvesting more than half of the paddy in KIS. All combine harvester SPs started their business after 2009 (on average, in 2012). Combine harvesters typically operate in KIS only, and seasonality in operations is relatively modest between the peak periods of November–December (25–28 days per month) and the slack periods of February–April (12–17 days per month), as Figure 4.3 shows.

Figure 4.3 Seasonality of operations (number of days operating combine harvester in each month; sample average is N = 15)



Source: Field survey in 2016.

Traders

It is important to note that most traders interviewed mill paddy to rice; few of them focus solely on gathering paddies for larger traders. This is because rice production is geographically concentrated around KIS, and few itinerant traders exist who gather paddy from remote locations.

Those interviewed trade about 25 tons of milled rice per year. The typical quantities traded are similar to those in other SSA countries, including Uganda (Kikuchi et al. 2016). Quantities, however,

vary considerably across traders; thus, we group traders into large traders (selling more than 25 tons a year) and small traders (selling fewer than 25 tons a year).

Each year, traders are typically engaged in trading for only 42 days for buying paddy and 24 days for selling milled rice. For small traders, the time is only 15 and 5 days of the year, respectively, while large traders are engaged in trading 65 and 40 days, respectively. For the rest of the year, traders may be engaged in rice production or other household chores. Trading business is done periodically, rather than continuously—a pattern that is similar to rice traders in Uganda, where traders typically procure paddy every 1.1 months and sell all in a few days (Kikuchi et al. 2016). For most traders, trading (including own-paddy production) is still the largest source of income.

During the trading periods, traders transact about 2.7 tons of paddy (roughly the harvest from 0.5 ha) and 2.5 tons of milled rice per day. These scales are somewhat smaller than typical village or rural traders in Bangladesh or India (Reardon et al. 2012).

Production Service Providers

Many production service SPs are indigenes of the area, whose parents or grandparents had been evicted by the Ghanaian government when KIS was constructed in areas where these indigenes used to farm. This pattern is similar to other irrigation schemes in SSA, including the Mwea Irrigation Scheme in Kenya (Njeru, Mano, and Otsuka 2016). On average, interviewed production service SPs lease in 2.6 ha per season, which is slightly larger than the 1.8 ha they leased in upon entry into the production service business.

As mentioned below, many millers, power tiller owners, and combine harvesters also provide production services, benefiting from access to cheaper paddy. Millers may typically cultivate as much as 13 ha per season (own-farm and leased in combined). About half of power tiller owners also provide production services. This share is rising gradually and is higher among those who obtained power tillers without subsidies (70 percent of them are production service providers). On average, they lease in 1.5 ha

per season. Finally, 14 (including 6 who are nonregistered) out of 15 combine harvester owners also provide production services, typically leasing in 4.5 ha per season.

Competitive Services Provided by Modern Service Providers in KIS

Milling in KIS is competitive, with premiums that are comparable to those in Asia. Premiums are $0.03/kg of milled rice for aromatic rice and $0.025/kg for nonaromatic rice; this is similar to $0.02/kg in the Philippines (Hayami, Kikuchi, and Marciano 1999) and lower than in other SSA countries—for example, $0.04–$0.08/kg in Uganda in 2012 (Tokida et al. 2014; Kikuchi et al. 2016). Importantly, paddy yield in KIS, which is around 5–6 tons/ha, is also comparable to many Asian countries, including the Philippines, where the yield is around 5 tons/ha (FAO 2017). This indicates that in KIS, total milling premiums per hectare of rice area are also similar to those in Asian countries.

Combine harvester service is typically charged at $200/ha, which is slightly higher than common rates in Asia— for example, $90–$140/ha in Thailand (Poungchompu and Chantanop 2016) and $171/ha in China (Yang et al. 2013). Power tiller service is provided at $160/ha, typically for two rounds of tilling, which is higher than in Bangladesh, where the fee for tilling is about $30/ha, or $60/ha for tilling twice (Mottaleb et al. 2017). In real terms, however, these rates are not necessarily high, because the farmgate price of paddy in Ghana is typically much higher than in Asia. For example, in 2011, the farmgate price of paddy (in US$/kg) was about 0.5 in Ghana, and in KIS, it was about 0.46 (Takeshima et al. 2013); this is considerably higher than in Bangladesh, Thailand, and China for the same year, where it was 0.20, 0.34, and 0.40, respectively (FAO 2017). The service fees for combine harvester and power tiller services in KIS in real terms (in terms of price ratios to paddy price) are therefore comparable to Asia.

Capital assets used in KIS are relatively modern. For example, most rice mills are semiautomatic or automatic, typically characterized by the presence of rubber rolls attached to hullers (Table 4.2).[7] Many also have elevators and destoners installed, and about half have shellers, conveyors, and flow-through

[7]For typical classifications of millers around the world, see Reardon et al. (2012), Chakraverty and Singh (2014, Chapter 12), and Rickman et al. (2013).

facilities and are equipped with separate grading and sorting machines. Their milling capacity (about 10–20 tons/day) is also close to the typical capacity of semiautomatic or automatic mills, although they are smaller than typical mills of this type in Asia, which are usually 40–100 tons/day (Reardon et al. 2012). Such a dense presence of semiautomatic mills in KIS is remarkable. Even in Bangladesh, which has a nationwide average rice yield of 4 tons/ha, traditional single-huller millers still account for a majority of all mills and a majority of rice milled (Reardon et al. 2012).

Table 4.2 Type of milling facilities and business assets owned

Components of milling machines and assets	% owning	Value (US$)
Rice-milling facilities	100	26,875
Destoner	93	
Elevator	86	
Rubber rollers attached to hullers	71	
Shellers	50	
Flow-through facility	50	
Grading/sorting machine	50	
Silos	7	
Steam-pressure parboiler	7	
Mechanical dryers	0	
Building	100	14,438
Drying space	93	4.744
Warehouse	87	10,394
Land for milling facility	60	1,283
Truck	29	29,128

Source: Field survey in 2016.

Commercial supply chains of each type of machines are also developing. At least 20 percent of the power tillers in the area were obtained without subsidies from sellers, who also received no subsidies. Many combine harvester SPs obtained their harvesters from the private market. Although five of them obtained machines from the government through subsidies, five others purchased from domestic markets,

one purchased from international commercial markets, and four purchased from private domestic individuals (Table 4.3). Among those private individual sellers, two had obtained power tillers from the government through subsidies. All combine harvesters in the commercial market had been directly imported from abroad. Close to half of 15 combine harvesters were obtained from the private market without subsidies. All combine harvester owners know at least one commercial importer, and four know multiple importers. Machines are typically shipped three months after the order is placed. The growth of combine harvester service has been considerably market driven. Relatives living abroad are often important information sources for foreign technologies, such as tillers and harvesters, enabling international transfers of these modern technologies.

Table 4.3 Sources of combine harvesters

Sources of combine harvesters	Number of interviewees	Sellers' sources of combine harvesters (number of interviewees)		
		Obtained from the government	Directly imported	Do not know
Obtained from the government through subsidies	5			
Purchased from private domestic individuals	4	2	0	2
Purchased in domestic commercial market	5	0	5	0
Directly imported	1	0	1	0

Source: Field survey in 2016.

As described earlier, even with the relatively low seasonality of paddy production, the KIS area realizes sufficient production scale thanks to the KIS irrigation infrastructure. As a result, most SPs earn sufficient profits by operating within the KIS area alone.

Entry Costs for Starting Service Provider Businesses

This section discusses the entry costs for each SP. These costs are assessed by (1) the values of fixed capital and working capital required upon entry (financial entry costs) and (2) the knowledge required to

enter the business (informational entry costs). Sources of finance and knowledge are also discussed. Focus is placed on relatively recent entrants because information from the long past can be less reliable as it is based on recall; this also takes into account Ghana's history of substantial inflations and devaluations.

Where entry costs to an SP were high, the SP's own wealth was mobilized to finance a significant portion of financial entry costs. At the same time, in many cases, part of the required assets could be rented in, sparing the SP the need to own those assets upon entry, and thus reducing the entry costs. Finally, knowledge accumulated through years of rice farming helped them lower the costs of acquiring required business knowledge upon entry.

General Descriptions of Entry Costs

Rice Miller Service Providers

Table 4.4 summarizes the financial entry costs for rice millers. The entry-level milling capacity was about 17 tons/day for those who entered in 2005 or later. With such capacity, the entry costs were about $50,000, of which $42,000 was investment into fixed capital such as milling machines, land, building, other equipment, and warehouses. Working capital upon entry was in the order of $10,000, most of which was cash lent to farmers to secure harvests from them.

Table 4.4 Financial entry costs for the rice milling business (US$)

	Entry costs (US$)	% of millers accessing each asset upon entry into milling business			% financed by personal savings, friends, or relatives	% currently owning	Years between entry and investments
		Obtained the asset at entry	Rented	Did not use			
All	**53,306**						
All—Assets	**41,996**						
Milling facilities	18,710	93	7	0	85	100	
Other equipment	5,498	14	7	79	100		
Land	8,360	86	7	7	88		
Drying space	2,223	29	71	0	100	87	7.1
Building	4,488	50	0	50	72	100	4.5
Warehouse	2,717	0	NA	NA		93	7.2
All—Working capital	**11,310**						
Cash to buy paddy	879						
Cash lent to farmers[a]	10,324						
Cash to pay workers in advance	107						

Source: Field survey in 2016.

Note: [a] These figures are comparable to the yearly amount of credit average that millers provide to farmers today. NA = not available.

Critical knowledge for entering the milling business includes information on reliable sources of paddy suppliers, brands and specifications of milling machines, spare parts suppliers or repairers nearby, and machine operating skills (Table 4.5). Half of the rice miller SPs also consider knowledge on accounting or bookkeeping and reading skills as critical. Many had sufficient knowledge at entry, gained through self-learning or other informal channels. Only general knowledge on accounting or bookkeeping

and reading skills was gained in schools. Thus, the private sector acquired sufficient knowledge for running the rice mill business with relatively little formal training.

Table 4.5 Knowledge requirements and sources for rice milling business entry

Type of knowledge	Knowledge critical (%)	Among those who consider knowledge as critical	
		% with sufficient knowledge at entry	% through self-learning
Brands and specifications of milling machines	64	89	78
Frequency of machine breakdown and costs of repair or spare parts	36	40	60
How to operate milling machines	43	100	83
How to repair or maintain milling machines	29	75	100
Spare parts suppliers nearby	64	78	78
Repairers nearby	43	83	100
Reliable paddy suppliers	71	100	100
Potential customers outside KIS	14	50	100
Accounting and bookkeeping	57	100	38
Reading skills	50	100	13

Source: Field survey in 2016.

Power Tiller Service Providers

Financial entry costs for power tiller SPs are typically $1,400–$2,500 (Table 4.6). Working capital required to purchase fuel and pay operators up-front is generally less than $100. Similarly, no power tiller owners obtained other assets, such as loaders or sheds. These factors might have also lowered entry costs.

Table 4.6. Entry costs for power tiller services and sources

Category	All samples		Nonsubsidized samples		Financial source (%)	
Year of entry	2005 or later	2010 or later	2005 or later	2010 or later	Personal saving	Subsidies
All (US$)	2,250	1,440	2,442	1,560		
Power tillers and attachments[a]	2,163	1,345	2,345	1,483	59	35
Deposits to rent power tillers	12	21	0	0		
Working capital	75	74	97	77	100	0
Cash to pay operators in advance	*25*	*40*	*24*	*53*		
Cash to pay for fuel/oil in advance	*51*	*34*	*62*	*24*		
Cash to pay up-front for the rental of assets	*0*	*0*	*0*	*0*		
Cash to provide as credit to farmers	*0*	*0*	*0*	*0*		
Sample size	33	19	12	5		

Source: Field survey in 2016.

Note: [a] Only two reported costs for attachments separately from the costs for power tillers. We therefore report combined figures.

Critical knowledge upon entry into the power tiller business includes knowledge of multiple brands and specifications of power tillers, spare parts suppliers and repairers nearby, and typical frequency of machine breakdown and costs of repair or spare parts (Table 4.7). Some also considered knowledge of the plot characteristics (such as soil types and slopes) of their customers and of power tiller operations as critical. Most knowledge had been obtained through self-learning rather than through external training. These patterns are similar for both subsidized and nonsubsidized power tiller owners.

Table 4.7 Knowledge and sources upon entry into power tiller service business

Type of knowledge	Knowledge critical (%)	% by self-learning	% by external training
Multiple brands and specifications of power tillers	60	98	2
Spare parts suppliers nearby	56	97	0
Frequency of machine breakdown and costs of repair or spare parts	54	89	3
Repairers nearby	51	97	0
Plot characteristics (such as soil types and slopes) of customers	36	80	12
How to operate power tillers	35	92	4
How to repair or maintain power tillers	24	93	4
Potential customers outside Kpong area	23	100	0

Source: Field survey in 2016.

Combine Harvester Service Providers

For combine harvester SPs, as Table 4.8 shows, the actual combine harvester ($22,008) accounts for the bulk of the $29,220 in entry costs, followed by loaders ($5,724). However, only 5 out of 15 combine harvester SPs owned loaders upon entry; the rest rented the machine. Furthermore, 4 of these 5 loader owners had purchased loaders for activities other than their combine harvester business. The relatively small working capital requirement ($496) was mostly the advance cash lent to farmers to secure the harvest.[8] All costs were primarily financed by personal savings or informal borrowings from friends or relatives.

[8]All of the SPs also inherited land on which the combine harvesters sit. We do not include the value of this land, as it seems rare for new combine harvester SPs to buy a piece of land just to keep the machine.

Table 4.8 Entry costs for combine harvester business and sources

	Value (US$)	% in which personal savings, friends, or relatives were the major source
All	29,220	
All—Fixed capital	28,724	
Combine harvesters	*22,008*	67
Loaders	*5,724*	100
Loaders (deposit for rental)	*45*	100
Attachment to combine harvesters	*776*	100
Shed[a]	*137*	100
Registration	*21*	100
All—Working capital	496	
Cash to pay for fuel/oil in advance	*152*	100
Cash to pay in advance for the rental of various assets	*46*	100
Cash to provide as credit to farmers	*298*	100

Source: survey in 2016.
Note: [a] Close to half of combine harvester owners owned sheds upon entry, all of which had been inherited. We applied the typical values of tractor shed of 1,400 cedi in 2016, as reported in Houssou, Aboagye, and Kolavalli (2016), or approximately $342 in 2010 US dollars.

Critical knowledge for combine harvester service includes the brands and specifications of different combine harvesters, maintenance requirements, spare parts or repairers nearby, and the characteristics of soils on served plots (Table 4.9). Knowledge of machine operation or maintenance, potential customers outside KIS, and general reading skills were not critical upon entry. Most combine harvester owners had sufficient knowledge of spare parts and repairers nearby and of characteristics of served plots upon entry. Some knowledge of the brands and specifications of different combine harvesters or of maintenance requirements was gained after entry. Much knowledge had been acquired through self-learning rather than through any external training or support.

Table 4.9 Knowledge and sources upon entry into the combine harvester business

Type of knowledge	% perceiving the knowledge as critical	% had sufficient knowledge upon entry	% through self-learning
Multiple brands and specifications of combine harvesters	100	60	100
Typical frequency of machine breakdown and maintenance costs	93	43	100
Spare parts suppliers nearby	100	87	100
Repairers nearby	87	100	100
Plot characteristics (such as soil types and slopes) of customers	73	91	100
How to operate machines	7	100	100
How to repair or maintain machines	0		
Potential customers outside the Kpong area	0		
Accounting, reading, and writing	0		

Source: Survey in 2016.

Traders

Table 4.10 summarizes the entry costs for traders. Most entry costs involve the working capital required to buy paddy up-front, typically $250, which was worth 0.2–0.5 tons of milled rice equivalent, and a fraction of typical trading quantities upon entry (about 3 tons of milled rice). Assets used for trading include drying space, warehouses or storage spaces, weighting machines, and trucks. Most traders rent, rather than own, these assets (Table 4.11). Total entry costs for trading were about $400–$500, and much of this was financed through traders' own savings.

Table 4.10 Costs for entering the trading business

Years of entry	After 2005	After 2010
Trading quantities at entry (tons of milled rice per year)	3.1	2.8
Total (US$)	454	389
Production assets	115	59
Truck	*24*	*0*
Rental deposit (truck)	*87*	*55*
Rental deposit (other)	*4*	*4*
Working capital required in advance	339	330
Cash to buy paddy or milled rice	*273*	*242*
Cash to pay workers in advance	*1*	*1*
Cash to pay for the rental of various assets	*55*	*89*
Cash to pay for fuel	*10*	*0*

Source: Field work in 2016.

Table 4.11 Percentage of interviewed traders renting or owning key assets

Assets	Own	Renting
Drying space	11	83
Warehouse or storage space	6	51
Land for warehouse or storage space	6	0
Truck	3	83
Weighting machine	6	37

Source: Field survey in 2016.

Critical knowledge for entering trading includes the sources of paddy, market demand, and conditions (Table 4.12). Large traders regard the business as more knowledge intensive than small traders do, suggesting that management skills become more important as the businesses expand. Most of this knowledge has been acquired through self-learning rather than external training.

Table 4.12 Percentage of traders regarding knowledge as critical for entry into the trading business

Type of knowledge	Large traders (N = 19)[a]	Small traders (N = 16)[a]
Where to obtain sufficient quantities of good-quality paddy	71	27
Where to obtain sufficient quantities of good-quality milled rice	81	45
Popular varieties in the market	81	45
How to market products	81	45
Prices in different markets and seasons	81	36
Sufficient number of buyers	81	45
Where to obtain loans	63	18
Accounting and bookkeeping	81	36

Source: Field work in 2016.
Note: [a] "Large traders" refers to those who sell more than 25 tons of milled rice a year, while "small traders" refers to those who sell 25 tons or less of milled rice a year.

Production Service Providers

Table 4.13 summarizes the entry costs into production services. For those who entered since 2012, the entry costs were around $1,300 for starting production services on about 1 ha.

Table 4.13. Financial entry cost for entering the production services business (US$)

Years entered	**2005 ~**	**2010 ~**	**2012 ~**	**% using or paying**	**% paid from own savings or informal credit**
Area leased upon entry (ha)	**1.89**	**1.24**	**0.96**		
Total (US$)	2,686	1,866	1,307		
Asset investments	1,073	478	190		
Power tiller	*155*	*219*	*0*	100	9
Tractor	*321*	*0*	*0*	22	3
Attachments	*214*	*0*	*0*	6	3
Irrigation pump	*94*	*33*	*11*	31	16
Tubewell	*2*	*2*	*4*	16	9
Mechanical threshers	*107*	*0*	*0*	41	0
Drying space	*3*	*4*	*0*	100	0
Truck or car	*0*	*0*	*0*	75	0
Generators	*8*	*13*	*0*	9	0
Warehouse or storage space	*0*	*0*	*0*	50	0
Other assets	*170*	*207*	*176*	22	13
Working capital	1,613	1,389	1,117		
Cash to pay the lease in advance	*458*	*352*	*218*	84	80
Cash to pay laborers in advance	*161*	*92*	*74*	81	81
Cash to pay nonlabor inputs in advance	*484*	*409*	*381*	100	97
Cash to pay in advance for the rental of various assets	*496*	*517*	*430*	91	85
Cash for any other items	*14*	*18*	*15*	44	44

Source: Field survey in 2016.

Both the knowledge of the characteristics of leased-in plots (soil types, pests, drainage access, and so on) and the knowledge of optimal crop husbandry practices for the leased-in plots were considered critical for entry into production services (Table 4.14). Although a fraction of production service SPs

obtained knowledge on optimal crop husbandry practices through external training, most of this knowledge had accumulated through self-leaning or informal knowledge transfer. Many production service SPs had been acquainted with the lessors for a relatively long time (typically, 10–12 years) before entry into production services.

Table 4.14 Sources of knowledge upon entry to the production services business

Type of knowledge	% critical or somewhat critical	% had sufficient knowledge before entering	Source of knowledge (%)		
			Self-learning, own experience	Observing family members or others	External training
Characteristics of leased-in plots (soil types, pests, drainage)	100	91	78	19	0
Optimal crop husbandry practices for leased-in plots	100	100	66	28	6

Source: Field survey in 2016.

Key Aspects of Entry Barriers

Financial Entry Costs

For all SPs, entry costs were substantially reduced because many capital assets could be rented, sparing the need to make up-front payments. Many millers relied on transportation services provided by other truck owners, instead of owning truck themselves, which saved them about $30,000. Similarly, most millers rented drying space or warehouses from others upon entry; they did not tend to make this type of substantial investment until about five years after entry. Most combine harvester SPs rented instead of owned loaders upon entry. Those who did own loaders from the start typically had them for businesses other than the SP business. About 20 percent of power tiller SPs rented rather than owned power tillers upon entry. Few power tiller SPs used loaders, sheds, or the land on which sheds were built since the

entry. Most traders, upon entry, rented drying space, warehouses, or storage spaces from millers; they also rented weighting machines or hired transporters. Many traders could also obtain most paddy on credit upon entry, requiring no up-front payment. Most production service SPs relied on service providers for many operations upon entry, including renting power tillers, drying space, and trucks or cars; relatively little fixed capital investment was needed.

Entry costs for millers were also lower than what would be expected from the current operational scale, because many millers started small and gradually expanded capacities by re-investing into larger milling facilities. In the beginning, equilibrium fees for millers were higher because nobody was providing service with larger machines. Over time, however, fees came down as more economies of scale kicked in. Of course, by then, modernization had already deepened.

Knowledge Requirement upon Entry

Critical knowledge required upon entry into these modern service provisions generally included brands and specifications of relevant machines, the typical frequency of machine breakdown, nearby spare parts suppliers or repairers, and machine operating skills (in particular, for rice miller, combine harvester, and power tiller SPs). Other specific entry knowledge requirements included information on reliable sources of paddy suppliers (for millers), knowledge of plot characteristics (such as soil types and slopes) of customers (for combine harvester and power tiller SPs) and lessors (production service SPs), sources of paddy, market demand and conditions (for traders), optimal crop husbandry practices for leased-in plots (for production service SPs), and accounting, bookkeeping, and reading skills (for rice miller SPs).

Most of this knowledge was obtained through self-learning or informal knowledge transfer rather than though external training. The few exceptions were related to knowledge of optimal crop husbandry practices (for production service SPs) and general knowledge of accounting, bookkeeping, and reading skills (for millers); this knowledge was often gained in schools. Overall patterns of knowledge acquisition patterns are similar for both subsidized and nonsubsidized power tiller owners. Many production service

SPs had been acquainted with their lessors for a relatively long time (typically, 10–12 years) before entry into production services.

Rice Farming as the Source of Finance and Knowledge for SPs

Most entry investments were largely financed by personal savings or informal loans from friends or relatives, whether for rice miller, combine harvester, or other SPs. Although subsidies covered about 30–40 percent of finance costs of power tillers, much of the remaining 60 percent was financed by the owners' personal savings. The use of loans from informal or formal sectors for power tiller investments seems rare.

The survey reveals the potentially important roles of rice production activities for the growth of all the types of SPs. Specifically, rice production is likely to have been the primary source of savings and of various critical knowledge that enabled financial investments at the entry into various service provisions. In addition, rice farming is still the primary source of income for many SPs, suggesting that the growth of SPs is through their expansions of scope rather than purely through specialization.

Table 4.15 summarizes the major sources of income before entry into each service provision business. Although this information is based on the interviewees' recall and perceptions rather than the estimated incomes, it still provides useful insights. Rice farming had been the most important source of income before the entry for rice miller, combine harvester, and power tiller SPs. If we include the production of crops other than rice, farm production had been the primary source of incomes for more than half of rice miller, combine harvester, and power tiller SPs. Relatively few had been primarily engaged in nonfarm income-earning activities before entry. The only exception is the traders (excluding rice millers who also trade rice), who had primarily been in petty trading or had no incomes at all before entry.[9] However, as was mentioned earlier, entry barriers for trading are generally low. These findings are

[9]This is probably because many traders are women who had originally been engaged in subsistence household activities, relying on the income of other household members. Some traders had been primarily in petty trading businesses, which might have helped them gain trading skills.

consistent with the findings on the major sources of knowledge, also described earlier. Most SPs had gained knowledge critical to their business through self-learning, which had been made possible because many had been primarily engaged in full-time rice production.

Table 4.15 Largest source of income before entry into each service provision (%)

Source of income	Rice miller SPs	Power tiller SPs	Combine harvester SPs	Traders
Rice farming	43	58	44	20
Rice trading	0	35		
Other farming	21		33	6
Agricultural inputs	14	3	11	
Other off-farm activities	21	4	11 (construction)	34 (petty trading)
No income				40

Source: Field survey in 2016.

Higher Returns as the Primary Incentives for Entry into Service Provision

This section provides some indicative evidence consistent with the hypotheses that higher returns induced entry to SPs rather than specializing in paddy production. We first briefly summarize the profitability of each SP; we then show the result of a simple back-of-the-envelope calculation.

Profitability of Each Type of Service Provider

Rice Milling Service Providers

The rice milling business incurs costs of approximately $212,294 per year (Table 4.16). As mentioned earlier, millers themselves obtain paddy not only for sales purposes but also for milling for fee. The cost of obtaining paddy ($182,859 per year) accounts for much of the total cost. The total revenue of $222,899 leaves a net profit of $10,605 per year. Most rice is sold ungraded; graded rice accounts for only 3 percent of own sales and 15 percent of rice milled for fee.

Table 4.16 Profitability of the rice milling business (US$ per year)[a]

Categories	All	Small mills	Large mills
Total cost	212,294	90,021	334,566
Costs of paddy and transportation	192,251	70,457	314,045
Paddy obtained	182,859	67,918	297,799
Purchased paddy	*130,629*		
Own-farm paddy	*52,230*		
Transportation	9,392	2,539	16,245
Paddy collection	*4,319*		*7,362*
Milled rice transportation	*5,073*		*8,883*
Milling costs	20,043	19,565	20,522
Milling costs per kg of milled rice	0.020	0.026	0.017
Labor costs	10,989	10,480	11,498
Plant manager	*365*		
Machine operators	*2,472*		
Other casual laborers	*2,619*		
Agents	*29*		
Nonlabor costs	5,777	6,475	5,078
Electricity	*3,405*		
Fuel or diesel for machines	*32*		
Fuel or diesel to run generators	*0*		
Oil	*124*		
Grease	*56*		
Bags	*1,365*		
Stitches	*441*		
Other materials	*148*		
Tax/fee payment	*207*		
Maintenance costs	1,461	1,397	1,526
Spare parts	*1,199*		
Labor to replace spare parts	*37*		

Table 4.16 Continued

Categories	All	Small mills	Large mills
Labor to do regular maintenance	*22*		
Building	*38*		
Other materials required	*165*		
Depreciation	1,816	1,212	2,420
Milling machine	*1,004*		
Grading or sorting machine	*239*		
Destoner	*69*		
Building	*103*		
Warehouse	*90*		
Drying space	*86*		
Other assets	*10*		
Truck	*215*		
Revenue	222,899	87,599	358,199
Own	*205,181*		
Milled for fee	*13,285*		
Credit interest from farmers	*4,433*		
Net profit	10,605	–2,422	23,633

Source: Field survey in 2016.
Note: [a] We refer to those with mills worth more than $27,000 (median of the sample) as large mills and the rest as small mills.

Of the $20,043 of milling costs, labor (plant manager, machine operators, other casual laborers) and electricity account for about 70 percent, while maintenance and depreciation account for about 20 percent. These breakdowns are similar to semiautomatic/medium mills in Bangladesh (see Table 4.8 in Reardon et al. 2012). The high transportation costs ($9,392) relative to the milling costs is also consistent with patterns seen in Bangladesh, China, and India (Reardon et al. 2012).

A significant share of paddy is obtained from own-farm production (worth $52,230 based on farm budget estimates). Own paddies are about 10 percent cheaper than paddy purchased from other farmers, given the typical paddy production costs in KIS (Table 4.17). The costs of paddy obtained and

transportation are greater for the large mills,[10] because those mills mostly process paddy for their own sales, rather than the milling for fee that smaller mills focus on. For large mills, paddy transport costs ($7,362) account for 30 percent of the profit ($23,633); however, this may still be considerably low given the quantities, thanks to the high and stable yield in KIS, which enables millers to acquire large quantities of paddy at fairly low transport costs. The agglomeration effects of the public irrigation scheme may be once reason inducing SPs to upgrade rice mills. Large mills can still earn profits, even with tight margins and relatively low overall capacity utilization rates, thanks to low milling costs ($0.017/kg of milled rice). Also thanks to lower milling costs, large mills enjoy greater profits than small mills. Thus, profitability might have induced SPs to upgrade to larger mills in KIS.

[10]We refer to those with mills worth more than $27,000 (median of the sample) as large mills and the rest as small mills.

Table 4.17 Typical rice production budget (US$ per hectare per season)

		Value
Seed	73	
Land preparation	163	
Fertilizer/agrochemicals	582	
Nitrogen, phosphorus, and potassium fertilizer		*346*
Urea		*42*
Sulfan/sulfate of ammonia		*120*
Herbicides/weedicides		*54*
Fungicides		*20*
Insecticides		*8*
Labor	988	
Transplanting		*163*
Bund repair and leveling		*27*
Nursery preparation and care		*22*
Weeding		*163*
Fertilizer/chemical applications		*98*
Bird scaring		*81*
Harvesting/postharvest[a]		*434*
Irrigation service charge	55	
Other fees	163	
Interest payment[b]	235	
Total cost	2,267	
Yield (ton/ha)	5.5	
Price (US$/kg)	0.46	
Gross revenue	2,530	
Net profit	263	
Subleasing fee	170	

Source: Authors' calculations based on information obtained from KIS office and fieldwork.

Note: [a] For harvesting cost, the cost of renting a combine harvester is also included. Costs also include bags and carting of paddy.

[b] Interest rate payments assume a borrowing interest rate of 50 percent per year.

Power Tiller Service Providers

Profitability for power tiller SPs differs for those who obtain power tillers through subsidies and those who do not (Table 4.18). Labor costs for operating the machine and the cost of fuel account for about 70 percent of total costs, while maintenance and depreciation costs combined account for 20–25 percent. All owners hire operators instead of operating the tillers themselves. Nonsubsidized owners earn greater profits by keeping the costs, particularly of operators, significantly lower than subsidized owners do; nonsubsidized owners also achieve a comparable overall revenue and earn higher profits. This is consistent with other studies showing that those who acquire power tillers or tractors from the private market are generally more efficient than those who receive machines from the government (Takeshima et al. 2015; Diao, Silver, and Takeshima 2016).

Table 4.18 Profitability of power tiller service provisions (US$ per year)

Cost items	All	Subsidized power tiller owners	Nonsubsidized power tiller owners
Labor—manager	113	113	112
Labor—operators	1,606	1,713	1,262
Cost of fuel	1,438	1,491	1,267
Cost of oil	116	113	115
Maintenance	462	510	308
Spare parts	*428*	*474*	*282*
Workmanship	*34*	*37*	*26*
Depreciation	723	859	286
Power tillers	*709*	*844*	*277*
Power tiller subsidies			
Other fixed assets	*14*	*15*	*8*
Total costs	4,458	4,800	3,350
Total revenue	4,572	4,813	3,797
Net profit	114	14	447

Source: Authors' calculations based on information obtained from KIS office and fieldwork.

Combine Harvester Service Providers

Table 4.19 summarizes the profitability for combine harvester SPs. Labor (managers and operators), fuel, and rental of trucks (for machine transportation) are major cost items. The expenses for maintenance and repairs are relatively low. Total revenues are about $37,000, which can cover the costs including depreciations. The net income of $3,894 is positive but not necessarily high as compared with Thailand (which is about $6,000 for medium SPs) or China (which is about $13,000) (Poungchompu and Chantanop 2016; Yang et al. 2013). The net income is also slightly lower than their rice farming incomes in KIS as mentioned above.

Table 4.19 Profitability of combine harvester business (US$ per year)

Categories	**Costs**
Labor costs	7,834
Manager	*4,585*
Operators	*3,250*
Nonlabor costs	18,583
Fuel or diesel	*11,815*
Oil	*791*
Rental of shed	*7*
Rental of truck (for transporting machine)	*5,969*
Maintenance costs	1,531
Spare parts	
Engine related	*128*
Transmission system	*81*
Hydraulic system	*66*
Cutting and feeding system	*105*
Threshing/cleaning system	*39*
Separation system	*10*
Wheels, tires, brakes	*839*

Table 4.19 Continued

Categories		*Costs*
Electrical system		*88*
Air conditioner/ventilation		*0*
Other major parts		*64*
Labor to replace spare parts		*110*
Depreciation costs	5,131	
Combine harvesters		*3,961*
Loader		*1,030*
Other attachments		*140*
Shed		
Total costs	33,079	
Revenue	36,973	
Net income	3,894	

Source: Field survey in 2016.

Trading

Table 4.20 summarizes the average profitability of the trading business. Costs of paddy account for 85 percent of the total cost of business. For the remaining 15 percent, labor and transportation costs account for more than half, and milling costs account for about a quarter. Costs associated with fixed capital assets are small because, as mentioned earlier, few trading SPs own those assets. Overall profit is similar or slightly higher among smaller traders, which is consistent with the literature (Fafchamps, Gabre-Madhin, and Minten 2005). No sign of returns to scale in trading is observed. Trading costs ($0.13/kg of milled rice) are comparable with those in other African countries, such as Uganda, which are also found to be efficient (Kikuchi et al. 2016).

Table 4.20 Profitability of trading (US$ per year)

	All	Large traders	Small traders
Labor costs	1,656	2,431	673
Managers/supervisors	*105*	*188*	*0*
Other casual laborers (loading/unloading, bagging, and so on)	*1,551*	*2,243*	*673*
Labor for screening of paddy suppliers, monitoring of paddy quality	*0*	*0*	*0*
Workers/agents for gathering market information system	*0*	*0*	*0*
Nonlabor costs (excluding transportation costs)	3,434	5,732	523
Milling costs	*2,190*	*3,744*	*345*
Bags	*537*	*884*	*125*
Electricity	*385*	*710*	*0*
Others	*322*	*394*	*53*
Transportation costs	2,909	5,129	97
Paddy	*1,486*	*2,629*	*37*
Milled rice	*1,423*	*2,500*	*60*
Fixed assets, related	81	140	9
Depreciation	*74*	*132*	*1*
Repair and maintenance	*4*	*7*	*2*
Rental of various fixed assets	*3*	*1*	*6*
Marketing fees	319	516	67
Total operating costs	8,399	13,949	1,370
Paddy costs	48,429	75,263	14,438
Total costs	56,828	89,212	15,808
Net profit	865	351	1,517
Milled bags (50 kg) sold	1,238	2,066	255
Total revenue	57,693	89,563	17,325

Source: Field survey in 2016.

Production Service Providers

Profitability for production service SPs is assessed from the typical farm budget and leasing fee (refer to Table 4.17). Typically, the revenue is $2,530 per hectare per season, and the cost is $2,267, with a profit of $263. A fraction of farmers may earn less than $170, which is a typical subleasing fee, and may have incentives to lease out to production service SPs instead. Simultaneously, many production service SPs (especially millers and combine harvester owners) may be wealthy enough and require no credit, saving the interest payments ($235) and incurring lower costs. Many are therefore likely to earn profits and thus incentivized to provide production services.

Comparisons of Returns from Entering SPs and Returns from Paddy Production

All SPs are privately profitable, as shown above, suggesting they have emerged in competitive manners. Average annual revenues and costs are on the order of $222,899 and $212,294, respectively, for millers; $3,797 and $3,350, for nonsubsidized power tiller SPs; $36,973 and $33,079, for combine harvester SPs; $57,693 and $56,828, for traders; and $2,530/ha and $2,267/ha for production service SPs. The net profit margins are about 5 percent for rice millers, 13 percent for nonsubsidized power tiller SPs, 12 percent for combine harvester SPs, 1 percent for traders, and 16 percent for production service SPs.

An important question is whether higher returns of respective service provisions are driving these SPs to enter the businesses, instead of specializing in paddy production by renting in more land. We obtain some insights into this question through a back-of-the-envelope exercise. Specifically, we compare the average net profit margins of each type of SP with hypothetical returns they would have earned had they invested the same amount of resources for rice production without owning the respective capital assets (hypothetical returns, hereafter).

Hypothetical returns from expanding rice production only are estimated by using the typical profit margins per hectare provided in Table 4.17, with the assumption that no credit is taken so that no interest payments are needed. This is based on the idea that many of these modern SPs have sufficient wealth to cover all the production costs. For combine harvester SPs and rice millers, it is also assumed

that they own power tillers, the cost of which is, again, relatively small given their wealth. These assumptions lead to greater hypothetical returns from expanding rice farming without owning respective machines; thus, we obtain more conservative inference on the relative returns from owning respective machines and engaging in service provisions instead.

Hypothetical returns from rice farming at a scale comparable to the operational scales of service providers are then calculated at different return-to-scale (RTS) parameters, starting from a constant RTS to a gradually declining RTS. Specifically, a simple rice production function is $Y = AC^{\alpha}$, in which Y and C are rice production revenue and cost, respectively; A is a scalar calibrated so that the production function fits the conditions in KIS; and α is the RTS parameter. From this, profit is calculated as $Y - C = AC^{\alpha} - C$, and net profit margins are calculated as $(Y - C)/C$. Hypothetical returns are then calculated by plugging into C the value of average costs of each type of SP (33,079 for combine harvester SP, 3,350 for nonsubsidized power tiller SPs, and 212,294 for rice miller SPs).

In some cases, returns to capital assets may be of greater interest than the average net profit margins shown here. However, these two measures are similar if the production function of service provision is homothetic (that is, if uses of noncapital inputs, such as electricity, change proportionately with capital investments), and they exhibit constant RTS. Although, ideally, marginal returns should be estimated by regressing the profit on capital values as well as other inputs, our small sample size does not allow us to obtain accurate estimates. We therefore only show the average net profit margins.

The results (shown in Table 4.21) suggest that returns to investments by combine harvester, power tiller, and rice miller SPs may be relatively higher than returns from investing the same amount of capital in rice production, unless the rice production exhibits a RTS that is fairly close to 1. However, rice production in African countries, including under irrigated conditions, often exhibits a diminishing RTS (Adesina and Djato 1997). The marginal costs of renting in more land could also rise due to transaction costs involved with finding and negotiating with more lessors, with accessing more workers, and so forth. Expanding rice production by renting in more land tends to face decreasing net profit margins, which is in part why the calculated net profit margins from rice farming become lower if the same level of capital

invested by combine harvester, power tiller, or rice miller SPs were instead used for rice farming. These findings suggest that higher returns from service provisions are inducing people to enter these businesses instead of focusing on rice production only.

Table 4.21 Comparison of returns from investments in respective machines and service provisions and hypothetical returns from rice farming without respective machines

Categories	**Type of service provisions and respective machines owned**								
	Combine harvester			**Power tiller**			**Rice miller**		
	Net profit margins	**Profits (US$)**	**Costs (US$)**	**Net profit margins**	**Profits (US$)**	**Costs (US$)**	**Net profit margins**	**Profits (US$)**	**Costs (US$)**
Average returns from service provisions	12%	3,894	33,079	13%	447	3,350	5%	10,605	212,294
Hypothetical returns from expanding rice production only without investing in respective capital and engaging in service provisions (at different RTS)									
RTS = 1.00	16%	5,402	33,079	15%	513	3,350	16%	34,672	212,294
RTS = 0.99	13%	4,369	33,079	15%	497	3,350	11%	23,613	212,294
RTS = 0.98	10%	3,364	33,079	14%	480	3,350	6%	13,050	212,294
RTS = 0.97	7%	2,385	33,079	14%	464	3,350	1%	2,960	212,294
RTS = 0.96	4%	1,433	33,079	13%	448	3,350	–3%	–6,678	212,294
RTS = 0.95	2%	506	33,079	13%	432	3,350	–8%	–15,885	212,294

Source: Authors' calculations.

Note: Shaded cells indicate that hypothetical returns are lower than the average returns from service provisions for each type of service provider.

More specifically, investments into these machines are profitable for SPs not only because they bring additional earnings from service provisions but also because they raise the profitability of rice production at greater scales. Once these SPs own their respective machines (combine harvesters, milling facilities, power tillers), they may achieve greater RTS in rice farming as well. This is partly why these

service providers still earn substantial incomes from rice farming operated at a relatively larger scale.[11] However, the increase in RTS from rice farming may still be limited because further expansion of rice production is less profitable than specializing in providing services.

[11]Importantly, many SPs continue to rely on rice farming as their primary income sources. Millers and combine harvester owners may account for potentially 40 percent of areas cultivated under production services, but they were mostly not sampled from our interviews of production service SPs. Power tiller owners also account for about 20 percent, as is estimated through the following back-of-the-envelope calculations based on the results shown earlier. Millers may sublease in as much as 25 ha/yr on average, or 375 ha in total. Combine harvester SPs sublease in about 10 ha/yr, or 150 ha in total. These two groups account for 40 percent of the area subleased (assuming 1,333 ha, or one-third of 4,000 ha in KIS, as in Takeshima et al. 2013). In addition, power tiller owners also sublease in 3 ha/yr on average, or a total of 240 ha. These three groups thus account for close to 60 percent (≈ (375 + 150 + 240)/1,333) of total subleased farm in KIS. As described above, relatively extensive engagement in direct rice farming helps millers obtain paddy at lower costs. Although most millers stated that rice milling is the largest source of their income, a significant producer surplus from rice farming is integrated into their rice milling income.

Almost all power tiller SPs are also rice farmers, and 65 percent consider rice farming as their primary source of income, rather than power tiller–hiring services. Although many of the interviewed production service SPs currently own power tillers, only 9 percent owned them upon entry. Therefore, they first entered into production services and later invested in power tillers. Similarly, 6 of 15 combine harvester owners consider rice farming, which they provide through production service SPs, as their largest income source. This can be seen through a back-of-the-envelope calculation of their rice farming incomes. On average, combine harvester SPs cultivate more than 10 ha/yr (5 ha of leased-in plots per season for two seasons, plus their own registered rice plots). Based on the farm budget, rice farmers can earn $500/ha if not requiring credit. Furthermore, harvesting costs are even lower for combine harvester owners. Cultivating more than 10 ha, they can roughly make $5,000 a year, which may be greater than the income from the combine harvester business alone ($3,894, as shown in Table 4.19).

5. POTENTIAL EFFECTS OF THE GROWTH OF MODERN SERVICE PROVIDERS ON RICE PRODUCTION COMPETITIVENESS IN KIS

Although the effects of the growth of these modern SPs on rice production competitiveness in KIS need to be formally investigated in future studies, we can construct a few key hypotheses.

The growth of these modern SPs is likely to significantly reduce the production costs per unit of paddy through the exploitation of economies of scale. Some reductions in production costs may be realized through reduced costs of land preparation, harvesting, milling, and marketing, enabled by the divisions of labor and specializations provided by the SPs' activities. Production costs are also reduced by economies of scale in overall production. Production service SPs facilitate the reduction of coordination costs of inputs by engaging in larger-scale production services; many of these production service SPs are also rice miller, combine harvester, or power tiller SPs.

Although the KIS command area is a constraint, where irrigation allows year-round production, production intensity (frequency of production per year) may be raised. This is because of the faster land preparation and harvesting enabled by the growth of these modern SPs. This increase may lead to increased net area cultivations. Similarly, to the extent that combine harvesters and modern rice mills reduce processing losses or that power tillers raise tillage efficiency, paddy yields may also rise.

The income distributional impacts are not clear. Given the connectivity of KIS to major urban markets where KIS paddy competes with imported rice (Takeshima et al. 2013), increased productivity may not lead to substantial reduction in paddy price for consumers. Thus, additional surplus will be captured by these modern SPs and other KIS registered farmers. An even greater share of this surplus may be captured by these modern SPs if they collude effectively and wield market power. However, if the rent is large enough, it may induce further entry of SPs and reduce the market power of modern SPs, shifting the surplus back to other KIS-registered farmers.

Lastly, it is unclear whether the growth of rice miller, combine harvester, power tiller, and production service SPs alone leads to sustainable increases in productivity. For example, it is unclear whether such growth further induces provisions by larger entrepreneurs of semipublic goods such as

newer varieties, expanded irrigation facilities, and feeder road construction, among others. If these cannot be induced endogenously, then the growth of modern SPs will only bring the productivity to the frontier; it will not push up the frontier. In such a case, the public sector continues to play a critical role in providing these public goods. Otherwise, the growth of modern SPs may be reverted.

6. CONCLUDING REMARKS

The growth of active private-sector SPs is integral to the agricultural transformation. Backward and forward linkages have often been considered weak in the agricultural sector in SSA countries such as Ghana. Consequently, governments and donors continue to be interested in how these private-sector SPs can emerge in SSA's agricultural sector. However, relatively little is known about how this can happen. Whereas past studies pointed toward the efficiency and low entry barriers for relatively indigenous SPs (such as traders), little has been studied about how more modern SPs may emerge in SSA's agricultural sector.

Over the past two decades, KIS in Ghana has witnessed growing private SPs of modern technologies, including power tillers, combine harvesters, and semimodern rice mills, as well as production services, at a scale rarely seen elsewhere in SSA. Small surveys of current business practices of these SPs and of their business entry histories provide important insights into how these SPs emerged and what they may imply for the government's efforts in modernizing the irrigated rice system in Ghana, in particular, and the agricultural sector in SSA, in general.

Overall, these SPs are profitable, albeit with varying economic structures. Profitability and economic sustainability are likely to be important drivers of the growth of these modern SPs.

Entry costs for these SPs are variable. Capital-intensive service provisions with semimodern rice mills and combine harvesters face substantial entry costs, because the SPs themselves owned the main capital assets upon entry. However, supporting assets, such as trucks, storage, and warehouses have often been rented (for example, trucks by millers and traders and loaders by combine harvester owners). Some power tiller SPs started the business not by owning but by renting the machines. Some SPs (in particular, rice millers) started out at a small scale and gradually expanded their operations, thus keeping entry costs lower. For traders and production service SPs, entry costs mainly involved working capital and were not high.

Many of these modern private SPs (semimodern milling, power tiller, combine harvester, production services) emerged out of rice farmers in KIS, who had accumulated wealth from rice farming that could finance their entry costs into respective businesses. It was also through rice farming that they learned the knowledge relevant to these businesses. The supply emerged within KIS in parallel with demand because external markets for these modern services have been largely absent; thus, their emergence in KIS has been a more endogenous process than seen elsewhere. Patterns in KIS are consistent with the broad literature on the process of agricultural development, industrialization, and service provisions, though it took place in a more localized context. Rice productivity has been raised by the provision of successful varieties selected for the KIS environment, by sufficient investments into the irrigation infrastructure and road network, and by allowing subleasing by registered farmers, among others (Takeshima et al. 2013). This productivity growth and surplus both raised demand for services throughout the year and provided resources that could be invested to meet such demand. In addition, because the surplus was sufficient, it mitigated the liquidity constraints and allowed more agents to have sufficient wealth to enter capital-intensive service provisions, encouraging competition and preventing an oligopoly. This, in turn, led to relatively narrow margins of millers or combine harvester SPs and power tiller owners. Potential profitability is likely to have induced self-learning and learning by doing to accumulate required knowledge, as has been done in agricultural settings elsewhere (Foster and Rosenzweig 1995; Munshi 2008).

The SPs in KIS emerged by exploiting both the economies of scale and the economies of scope. Their investments into modern mills and machinery, as well as their expansions in business over time, indicate that they pursued the economies of scale. However, many of them (excluding traders) expanded their businesses while keeping rice farming as their primary income source partly through the use of production services. Consequently, few of them specialized solely in service provisions. They also expanded their scope to modern service provisions, instead of simply specializing in expanded rice production. The complementarity between rice production and the ownership of modern capital (rice mills, power tillers, combine harvesters) may dominate once rice production reaches a certain scale and

exceeds the benefits from specializing in expanded rice production (for example, through timeliness of land preparation, harvesting, or milling). The growth of larger-scale rice producers in KIS might have been an important precondition for the emergence of these modern SPs.

Lastly, it is important to note that, arguably, the public irrigation infrastructure in KIS may have offered important agglomeration effects for the growth of these modern SPs. This growth may not be associated with more atomistic small-scale private irrigation production scattered across wider areas. Transportation costs still account for substantial shares of operating costs among rice miller and combine harvester SPs, even though they almost exclusively operate within KIS. Their operating costs may rapidly increase once they start covering wider geographical areas; thus, they may be discouraged from investments in a modern capital.

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