Chapter 8

MYANMAR'S RAPID AGRICULTURAL MECHANIZATION: DEMAND AND SUPPLY EVIDENCE

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Abstract: This chapter analyzes recent patterns of agricultural mechanization in Myanmar from the demand side (farms) and the supply side (machinery dealerships). On the demand side, we analyze the historical and current use of machinery in agriculture, based on a survey of rural households conducted in 2016 in the Ayeyarwady delta close to Myanmar's largest city, Yangon. On the supply side, we draw evidence from a survey of agricultural machinery supply businesses. Myanmar's agriculture sector has encountered labor shortages and rising wages since 2011 as workers have begun to move to urban industrial and service sectors. Farmers have responded by rapidly substituting machinery for manual labor. In surveyed areas of Ayeyarwady, draft animals used for land preparation have almost disappeared. Of paddy-farming households, 94 percent used machines for land preparation, and only 12 percent still used draft animals. Widespread mechanization of harvesting has also occurred. Half of all sampled paddy-farming households used combine harvesters (up from almost none in 2013), and 38 percent used mechanical threshers. Access to machines is virtually scale neutral due to vibrant private machine hiring markets. On the supply side, agricultural machinery dealerships have proliferated and spread from Myanmar's core agricultural zones to more intermediate and peripheral areas. Explosive growth of machine sales has been facilitated by a lack of restrictions and duties on machinery imports, liberalization of the banking sector that has allowed private banks to offer hire-purchase loans to customers of machinery dealerships, and changes to the law that allow land use certificates to be used as loan collateral.

Introduction

Myanmar's economy stagnated for almost five decades prior to the start of political reforms in 2011. Since that time the country has experienced rapid growth and is the fastest-growing major economy in the region (ADB 2016). Growth has been accompanied by nascent structural transformation. Rural

laborers have begun moving out of agriculture in large numbers to take up better-remunerated jobs in the more productive and rapidly expanding urban industrial and service sectors. Meanwhile, some parts of the country have seen massive out-migration of young people to richer neighboring countries such as Thailand.

Consequently, Myanmar's agricultural sector is increasingly faced with labor shortages that have caused real wages to spike in many rural areas, particularly during peak seasons. The trend is particularly acute in locations close to major cities such as Yangon. Rising labor costs have reshaped the structure of agricultural production, driving farmers to substitute capital, in the form of labor-saving agricultural machinery, for labor.

The pace of change has been dramatic. For example, a survey conducted by the World Bank in late 2013 and early 2014 in the country's main agricultural zones found extremely limited ownership and use of agricultural machinery. Only 0.5 percent of paddy farmers surveyed owned a combine harvester, and just 1 percent of farmers made use of one (World Bank 2016). Our own survey data, reported in this article, show that just two years later most paddy lands accessible by road in the country's "rice bowl," the Ayeyarwady delta, were harvested using combines. The scale and extent of this transformation are all the more spectacular given that it took decades for mechanization to unfold in many other Asian countries. Another remarkable feature of mechanization in Myanmar is that it has taken place so rapidly, largely in the absence of active government policies, which have been a prominent feature of mechanization in East Asian countries.[1]

Based on primary surveys, this chapter unravels the process of mechanization in Myanmar. The extremely rapid pace of mechanization in Myanmar makes it an advantageous place to study the mechanization process. Unlike in countries where mechanization has occurred over a much longer time frame, survey respondents retain excellent recall of their experiences with agricultural machinery. This enables us to provide a much more detailed and historically accurate analysis of the process than is usually possible.

A unique feature of our study is the use of primary survey data from both the demand side and the supply side. Previous literature on mechanization has mainly focused separately on either the demand side (farm households—for example, Kienzle, Ashburner, and Sims 2013) or the supply side (machinery suppliers or rental service providers—for example, Yang et al. 2013). On the

1 For example, China provided subsidies for machinery purchase (Zhang, Yang, and Reardon 2017).

demand side, we analyze the historical and present use of machinery in agricultural production, based on a survey of rural households in the Ayeyarwady and Yangon regions. On the supply side, we gather evidence from an enterprise survey of 49 agricultural machinery supply businesses in Yangon and a scoping assessment of machine supply businesses and rental service providers conducted in Ayeyarwady, Yangon, Mandalay, and Magway regions.

The chapter is organized as follows. The following section provides details on the survey methodologies adopted. The section after that sets out the demand-side story of mechanization in Myanmar, providing details on rates, current levels, and characteristics of mechanization. The next section presents the supply-side story, with discussion of agricultural machinery imports, domestic manufacturing, sales volumes, financing arrangements, and the changing geographical distribution of machine suppliers over time. Following that, we analyze the policy context in which the changes described in the preceding sections have occurred. The final section concludes, exploring the implications of the Myanmar case for countries where mechanization is still in the early stages.

Methodology

Results presented here draw on two surveys conducted in Myanmar: a household survey of agricultural machinery users and an enterprise survey of machinery supply businesses. Details are provided below.

Myanmar Aquaculture-Agriculture Survey

The Myanmar Aquaculture-Agriculture Survey (MAAS) was implemented in May 2016. The survey was designed to fulfill several requirements. These included generating a baseline of information on crop and fish farm yields, farm size, land tenure status, crop management practices and profitability, patterns of migration, and access to agricultural credit. The survey included modules on the ownership and use of agricultural machinery, and on purchase prices and dates. A separate recall module included questions on the use of machinery for land preparation and harvesting during the survey year, and 5 and 10 years previously. Data collected from these modules provide the basis for the demand-side analysis presented later. Data on migration rates and wages are drawn from other modules of the MAAS.

The MAAS adopted a two-stage sampling strategy. For the first stage, 40 village tracts from four townships—Kayan, Twantay, Maubin, and Nyaungdon—falling within approximately a 60 km radius of the city of

Yangon (Myanmar's largest commercial center, with a population of approximately 5 million) were selected purposively based on an assessment of the cropping systems present in each. For the second stage, enumeration areas (EAs) were selected from these village tracts by probability proportional to size, using the national population census of 2014 as the sampling frame. The locations of the surveyed village tracts are illustrated in Figure 8.1.

This procedure yielded a sample of 78 EAs. A census of households was conducted in every selected EA to serve as the final sampling frame for randomized selection of respondent households. Eight farm and seven nonfarm households were selected for interview in each EA. Respondents from 1,120 households, representing a total population of 37,390 households, were interviewed. The total number of crop-farming households interviewed was 329.[2] Here, we would like to add a cautionary note. Our sample may overestimate the degree of mechanization because labor shortage is more acute in the Yangon region than elsewhere. In addition, infrastructure in Yangon is generally in better condition than elsewhere.

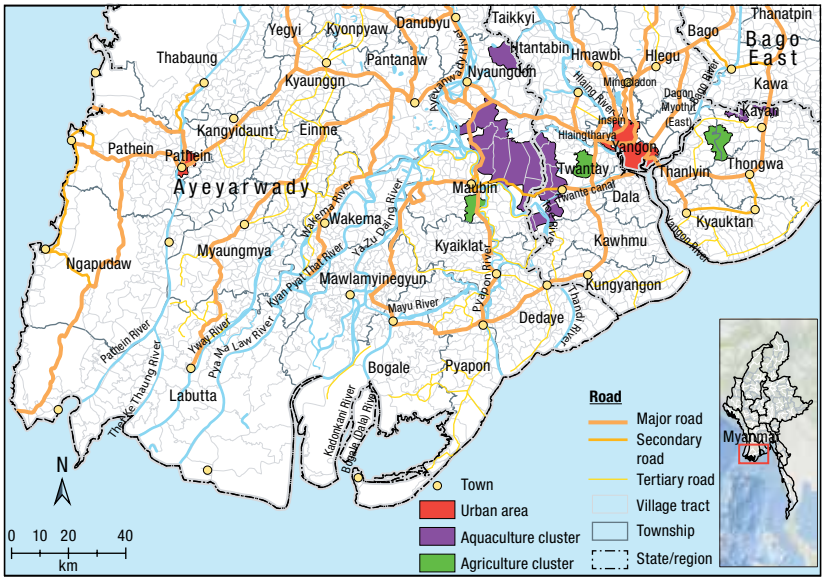
Supply Side: Machinery Supplier Cluster Survey

The supply-side section of the chapter draws on data from an enterprise survey of agricultural machinery dealerships, conducted by the authors in July 2016 at Mingalar Than Myint compound in Yangon. The compound is located in a commercial area and is close to the main road and river routes leading to the Ayeyarwady delta—Myanmar's main rice-growing zone. Scoping interviews conducted prior to the survey indicated that most of the machinery supply dealerships in Yangon are located within the compound, which therefore constitutes by far the largest cluster of such businesses in Myanmar. Most of the largest machinery supply businesses in Myanmar operate branches in this cluster. The survey was thus able to capture information on a large share of national agricultural machinery sales.

A census of businesses in the cluster was conducted prior to the survey, identifying 30 businesses selling agricultural machinery and 27 shops selling spare parts for agricultural machines. All agricultural machinery suppliers and spare parts shops listed in the census were selected for the survey. Of these, 3 machinery suppliers and 5 spare parts shops declined to participate, giving a total sample size of 49 businesses. The survey instrument was developed based

2 Other interviewees were from landless households (549) and households engaged in fish farming (242).

FIGURE 8.1 Location of village tracts surveyed, Myanmar, 2016



Source: Authors' own survey (2016).

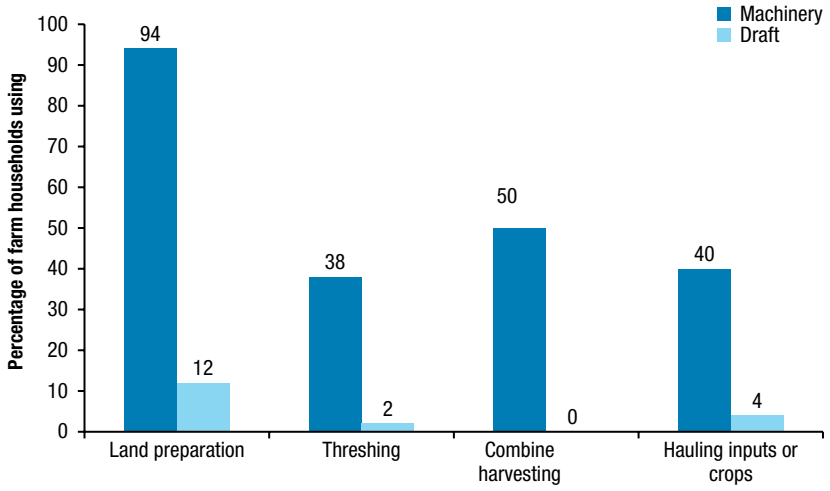
on scoping interviews, and pretested with similar businesses located outside the cluster prior to implementation. This chapter presents survey findings from the agricultural machinery supply businesses.

Demand-Side Evidence of Agricultural Mechanization

Mechanization as a Labor-Saving Technology

The process of mechanization is already so advanced that machinery has almost replaced the use of draft animals (the traditional form of traction) in agriculture in the areas surveyed. The share of farm households using agricultural machinery and draft animals to perform activities related to paddy cultivation during the 2015 monsoon and 2016 dry seasons is presented in Figure 8.2. Use of machinery was most common in land preparation, for which almost all paddy-farming households (94 percent) used machines, with only 12 percent reporting still using draft animals. The share of households

FIGURE 8.2 Machinery and draft animal use in paddy cultivation, Myanmar, 2015/2016



Source: Authors' own survey (2016).

using draft animals for other activities was even smaller. Widespread mechanization of harvesting has also taken place. Half of all sampled paddy-farming households used large-scale machinery (combine harvesters) for this purpose, and 38 percent used small-scale machines (threshers).

This transformation is closely linked to a tightening labor market. Analysis of MAAS data revealed accelerating rural-to-urban migration taking place in study areas close to Yangon city, resulting in rural labor shortages and rising wage rates. Of the households surveyed, 16 percent reported having a household member who was a long-term migrant. Of these, 92 percent were domestic (migrating within Myanmar), and 90 percent worked in urban areas (Htoo and Zu 2016). Migration is a very recent phenomenon. More than 80 percent of all long-term migrants migrated from 2010 onward, corresponding with the period when Myanmar's political system and economy began to open. These outflows have accelerated over time, with one-third of all migrants having left home in 2015 alone. In addition to long-term migrants, 44 percent of all workers in regular salaried employment commuted, residing at home but working in nearby, mainly urban areas (Htoo and Zu 2016).

Simultaneous increases in reported agricultural wage rates are consistent with the occurrence of structural transformation. The real agricultural daily wage rate in surveyed villages increased by 8 percent between 2011 and 2013,

from 2,600 Myanmar kyats (MMK) to MMK 2,800, and it jumped by a further 32 percent, to MMK 3,700, in 2016, corresponding to the movement of labor out of agriculture.[3]

The timing of these wage increases corresponds to the rapid rise of mechanization, suggesting that migration, labor shortages, and mechanization are closely connected. Table 8.1 illustrates changes in the share of agricultural households using machinery for land preparation and for harvesting over the period 2006–2016. The percentage of households using some type of machinery for land preparation rose steadily, from 36 percent in 2006 to 72 percent in 2011, to reach 97 percent in 2016. The share of households using any type of machinery for harvesting doubled, from 5 percent in 2006 to 10 percent in 2011, and then jumped sharply in the subsequent five years, reaching 57 percent in 2016. This latter trend appears closely related to the increasing costs of labor employed in paddy harvesting.

The Sequential Nature of Mechanization

Ownership of agricultural machinery increased slowly until 2008 but grew exponentially thereafter, accelerating particularly quickly after 2010 (Figure 8.3). In most countries, the process of agricultural mechanization follows a sequential pattern. Stationary, power-intensive operations such as pumping water and threshing are mechanized first, followed by mobile, control-intensive operations such as harvesting (Pingali 2007). A similar pattern is also apparent in Myanmar. Figure 8.3 summarizes the cumulative number of purchases of machines of different types made by households in the surveyed village tracts in each year from 1990 to 2015. Consistent with the sequence reported by Pingali (2007), limited adoption of surface-water pumps and two-wheel tractors (2WTs) began in the early 1990s, followed by mechanical threshers and four-wheel tractors (4WTs) post-2000, almost a decade later. Adoption of combine harvesters is a very recent phenomenon, occurring only from 2013 onward.

This sequence is also reflected in Table 8.2, which depicts the total annual value (at constant 2015 prices) of purchases of machinery made by households in the areas surveyed during the period 2000–2015. Two-wheel tractors (2WTs) and water pumps together accounted for most of the value of machine sales during the first half of this period, with threshers and four-wheel tractors (4WTs) contributing a growing share thereafter.

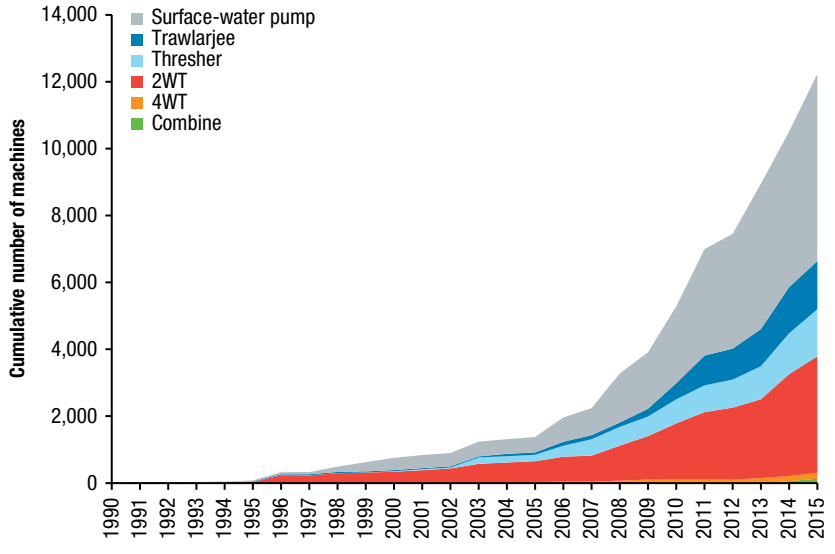
3 1 US dollar = MMK 1,200 in early 2016.

TABLE 8.1 Share of farm households using machinery for land preparation and harvesting, Myanmar, 2006–2016 (percentages)

Machine use	2006	2011	2016
Land preparation	36	72	97
Harvesting	5	10	57

Source: Authors' own survey (2016).

FIGURE 8.3 Cumulative purchases of selected machinery, Myanmar, 1990–2015



Source: Authors' own survey (2016).

Note: A trawlarjee is a rudimentary motorized vehicle consisting usually of a tractor engine mounted onto a cart or trolley. 2WT = two-wheel tractor; 4WT = four-wheel tractor.

The total value of machinery purchases began to increase significantly after 2009, and accelerated extremely rapidly from 2013 onward, more than tripling in just two years, from 2013 to 2015. Combine harvesters (of which there were no purchases reported prior to 2014) and 4WTs contributed about half of the total value of machinery sales in 2015. The contribution of 4WTs to the total value of purchased machinery was low prior to 2013. The number of 4WT units purchased changed little before and after 2013, suggesting that more expensive high-performance machines were increasingly adopted after 2013.

TABLE 8.2 Real purchase value of selected machinery and average annual growth rate, Myanmar, 2000–2015

Year	Purchase value (million MMK)	Annual growth rate (%)
Prior to 2010	5,126	10
2011–2013	6,759	2
2013–2015	18,209	64

Source: Authors' own survey (2016).
Note: Purchase values are in constant 2015 prices. MMK = Myanmar kyats.

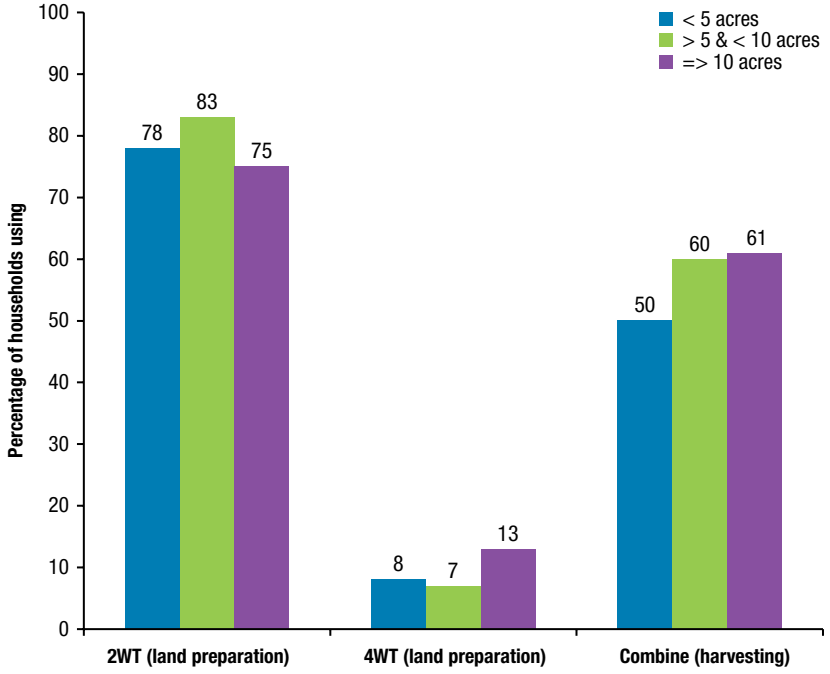
Small-Scale versus Large-Scale Mechanization

Agricultural machinery can be categorized as small-scale (for example, 2WTs and threshers) or large-scale (for example, 4WTs and combine harvesters). In Myanmar during the time covered by our survey, large-scale mechanization was most advanced in the case of harvesting, with more than 40 percent of all agricultural households in our sample using combine harvesters for harvesting. A similar percentage of households used threshers. A large majority of households (68 percent) used 2WTs for land preparation, whereas 17 percent used large 4WTs. The comparatively low rate of 4WT use in the areas surveyed reflects the fact that these heavy machines are not well suited for preparing soft or waterlogged soils for paddy cultivation in the delta. Their adoption is more widespread in Myanmar's central dry zone, where conditions are more arid, nonpaddy crops are more widely grown, and soils are drier.

Mechanization and Farm Size

In the locations where the survey was implemented, farm size and the adoption of agricultural machinery were weakly correlated at best, indicating that such machinery is a scale-neutral technology. Capital constraints and the indivisible nature of agricultural machinery mean that large farms are generally assumed to be more likely to mechanize than smallholders. However, as illustrated by Figure 8.4, there is very little variation by farm size in the share of households using 2WTs and 4WTs. Use of combine harvesters varies more with farm size, but the difference is still small, ranging from 50 percent on farms with area less than 5 acres to 61 percent on farms with area greater than 10 acres. This finding has important implications. First, it means that small farms can benefit from the cost and time savings of machinery use, and will not find themselves at a relative disadvantage, as they might if only large farms

FIGURE 8.4 Share of households using machinery for land preparation and harvesting, by farm size group, Myanmar, 2015/2016



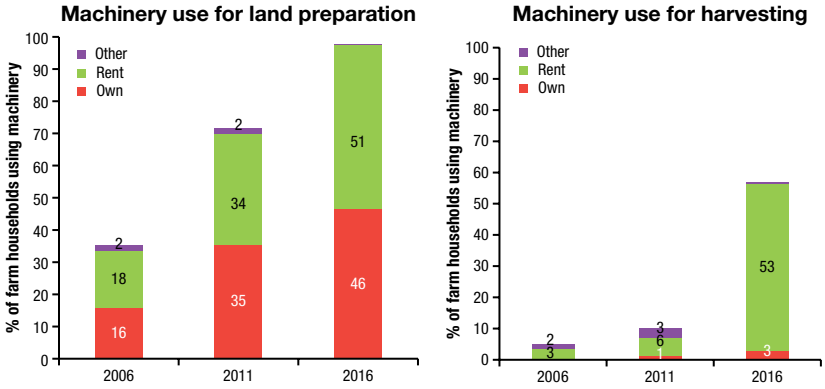
Source: Authors' own survey (2016).
Note: 2WT = two-wheel tractor; 4WT = four-wheel tractor.

adopted. Second, it means that the consolidation of fragmented landholdings is not a prerequisite for mechanization, as some accounts suggest (for example, Pingali 2007).

Hiring Services

Observed scale neutrality is accounted for by the rapid growth of an active hiring services market for agricultural machinery. This is illustrated in Figure 8.5, which presents data on the share of households owning versus renting machinery for land preparation (left-hand panel) and for harvesting (right-hand panel) in 2006, 2011, and 2016. Use of machinery for harvesting jumped dramatically from 2011 to 2016, mirroring the growth of combine harvester sales after 2013. The vast majority of machines used for harvesting were accessed by hiring. The emergence of the hiring services market has also driven combine harvester sales, because hiring out machinery provides

FIGURE 8.5 Use of owned or rented machinery for land preparation and for harvesting in paddy cultivation, Myanmar, 2006–2016



Source: Authors' own survey (2016).

revenue that enables owners to pay off outstanding hire-purchase loans and quickly recoup their investments. Among households using machines for land preparation, approximately equal shares of respondents owned and hired the machines used (predominantly 2WTs) in all three years. Although the country's Agricultural Mechanization Department (AMD) offers some machine hiring services, the market is dominated by a vibrant private sector; none of the households in the surveyed village tracts reported making use of machinery offered by the AMD.

As expected, ownership of agricultural machinery is most common among farmers with large landholdings, whereas smaller farmers are more likely to access machinery through hiring services. Use of hiring services is most common for expensive machinery (for example, combine harvesters). The hiring market for combine harvesters is dominated by larger farmers who buy machines to hire out to other farmers as a business, in addition to using them on their own farms. More than 95 percent of farms with area under 5 acres that made use of combine harvesters hired these services in 2015/2016, as compared with 74 percent of those operating more than 10 acres of land (Table 8.3).

Regional Variations

The use of machinery in agricultural production is subject to regional variations that reflect geographical differences in labor costs. Our scoping work in both the delta and the dry zone points to differences in the severity of labor shortages and their impacts on both farm wages and the adoption of

TABLE 8.3 Share of households using owned versus rented machinery for land preparation and combine harvesting, by farm size category, Myanmar, 2015/2016 (percentages)

	Farms < 5 acres		Farms 5–10 acres		Farms > 10 acres	
Equipment use	Owned	Rented	Owned	Rented	Owned	Rented
Land preparation	31	69	54	46	87	13
Combine harvesting	4	96	8	92	26	74

Source: Authors' own survey (2016).

labor-saving machinery, with effects in delta townships close to Yangon being the most extreme.

However, the characteristics of machine use also vary by region according to agroecological conditions and crops farmed. Combine harvesters are used only to harvest rice. Commonly farmed pulse varieties are not sufficiently erect to allow combine harvesting. Locally manufactured threshers have been adopted widely for paddy, and are occasionally modified for threshing pulses such as green gram. 4WTs are increasingly used for land preparation, particularly in the dry zone, but use of draft animals remains widespread in the dry zone, in part because using machinery during the later stages of land preparation for oilseeds and pulses causes excessive soil compaction. In contrast, in the main rice-growing areas of the Ayeyarwady delta, 2WTs have already almost completely replaced animal traction.

Supply-Side Evidence of Mechanization

Key Players in the Mechanization Supply Chain

The agricultural machinery supply chain in Myanmar is rather simple, and the market for agricultural machinery is highly concentrated. Most of the 26 agricultural machinery dealerships surveyed in the Yangon mechanization cluster specialize exclusively in machinery sales. The 3 largest dealerships surveyed accounted for 58 percent of the estimated value of sales made during the first six months in 2016, and the 8 largest dealerships together accounted for 91 percent of the total value of sales. Similarly, whereas 70 percent of machine supply businesses (19 enterprises) had 3 or fewer branches, the largest single business operated 23 branches nationwide.

More than half of these businesses market their products with assistance from rural sales agents (distributors). Distributors stock small numbers of machines consigned by dealerships, on which they can earn sales commissions,

or seek out and refer potential customers to dealerships after vetting their reputation and creditworthiness.

There is some diversification in the activities and services of machinery suppliers, particularly among larger enterprises, but the capacity to manufacture agricultural machinery is still limited. Domestic manufacturing is presently limited to production of simple welded parts, mainly trawlarjee frames and metal wheels for 2WTs.[4] Several local companies also manufacture threshers, and most farmers use these locally made threshers instead of imported ones, but such manufacturers mainly operate independently of the machinery supply businesses surveyed.

A few machinery dealerships subcontract out the manufacture of small machines to companies located in China. Manufacturing started as early as 1990, whereas subcontracting began after 2005. One-third of dealerships assemble imported machine parts in Myanmar to reduce import costs. Assembly of 2WTs and trawlarjees was first initiated in 1995. Companies producing trawlarjee frames and wheels for 2WTs combine these with complex imported parts such as engines. Four dealerships have recently begun to assemble 4WTs and combines.

The vast majority of agricultural machinery sold in Myanmar is imported from neighboring China and Thailand. Of all small machines (one-wheel tractors and 2WTs, engines, dynamos, water pumps, and roller boats) sold by dealers in 2016, 87 percent originated from China. Of 4WTs and combines, 57 percent originated from Thailand, reflecting a strong preference among buyers for the Kubota brand machines manufactured there. Imports of machines from other countries were limited. The majority of machine imports are via overland border trade; 65 percent of dynamos and water pumps, and 58 percent of combines were imported in this way.

Real prices of small machines sold in Myanmar fell significantly from 2006 to 2016 (as reported by MAAS respondents), providing additional incentives to mechanize. The purchase price of 2WTs fell at an average rate of 5.8 percent per year over this period, and that of surface-water pumps declined by 5.1 percent per year. China's low-cost manufacturing capacity appears to be a main driver of lower prices for these types of machinery. Access to imports of small, low-cost Chinese machines such as 2WTs and water pumps is also known to have stimulated rapid mechanization in other countries in the region, including Bangladesh (Biggs, Justice, and Lewis 2011).

4 A trawlarjee is a rudimentary motorized vehicle consisting usually of a tractor engine mounted onto a cart or trolley.

Machine Sales

Mirroring the results of the demand-side survey, numbers of dealerships selling almost all categories of agricultural machinery grew swiftly from 2012 to 2016 (Table 8.4). The number of units sold annually (all machine types) increased by a massive 535 percent over this period, rising from 21,223 to 134,700.[5]

Sales have been dominated by small machines in terms of numbers, but sales of 4WTs and combine harvesters grew particularly rapidly after 2014. Combine harvesters grew nearly 6,000 percent in four years, up from 40 units in 2013 to 2,372 in 2016; 90 percent of this growth took place in 2015/2016 alone. Annual sales of 4WTs increased by almost 1,100 percent between 2012 and 2016, rising from 275 units to 3,200 (Table 8.5).

Large machines already appear to have begun to replace smaller ones. Annual sales of threshers dwindled by 79 percent, from a high of 220 units in 2014 to 46 in 2016. Annual increases in sales of reapers peaked in 2015, after three years of brisk growth, and fell by 8 percent thereafter. 4WTs also appear to have eaten into sales of 2WTs, which plateaued in 2014/2015 (Table 8.5). The average number of sales staff working for dealerships in the cluster grew by 43 percent between 2013 and 2016, corresponding to increasing volumes of sales.

Geographical Expansion

As the volume and value of machinery sales made by branches within the Yangon cluster has skyrocketed, so too has the number of machinery supply business outlets outside the cluster, spreading beyond initial core markets, which have become increasingly competitive.

The establishment of machine supply shops in Yangon occurred earlier than in most other areas of the country. Five machinery supply businesses surveyed in the Mingalar Than Myint compound were already established in 1990. Numbers grew gradually until 2004 and then doubled in the six years leading up to 2010 (from 11 to 23), before increasing more slowly to reach 27 in 2016. Establishment of new branches outside the cluster by businesses located within it occurred far more rapidly than establishment of new businesses inside the cluster, particularly after 2010.

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5 This figure excludes sales made by branches outside the Mingalar Than Myint compound. Sales volumes for 2016 are extrapolated, based on sales made during the first six months of 2016. Key informants confirmed that sales during the first and second half of the year are similar.

TABLE 8.4 Cumulative number of agricultural machinery dealers selling different types of machine, Myanmar, 1995–2016

	Number of dealers selling					
Year	All	2WTs	4WTs	Combines	Water pumps	Reapers
1995	7	2	0	0	1	0
2000	11	4	0	0	3	1
2005	13	5	0	0	6	1
2010	23	8	4	0	11	5
2015	26	12	10	8	13	10
2016	27	13	12	11	13	10

Source: Authors' own survey (2016).
Note: 2WT = two-wheel tractor; 4WT = four-wheel tractor.

TABLE 8.5 Annual sales of selected machinery by dealerships in Mingalar Than Myint compound, Myanmar, 2012–2016

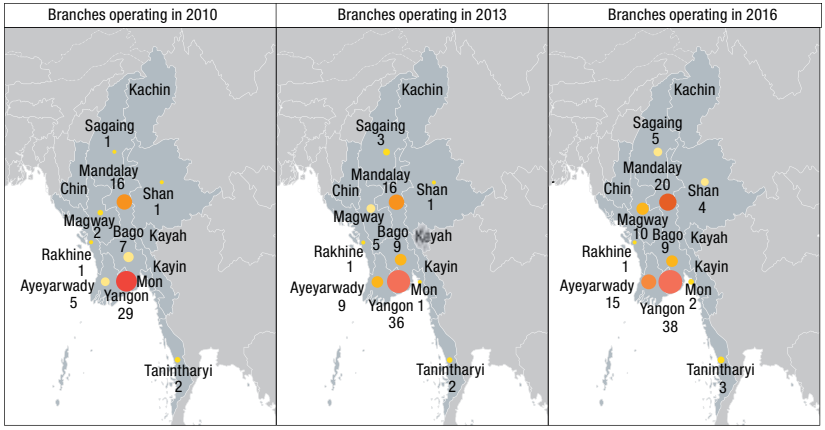
	Annual sales by year					Year-over-year change in sales (%)			
Machine type	2012	2013	2014	2015	2016	2012–2013	2013–2014	2014–2015	2015–2016
2WTs & accessories	9,598	11,715	14,912	14,872	20,684	22	27	–0.3	39
Engines/dynamos/water pumps	8,105	11,547	62,806	59,103	99,026	42	444	–6	67
4WTs	275	420	870	1,662	3,200	53	107	91	92
Combine harvesters	0	40	237	955	2,372	n.a.	493	303	148
Reapers	305	335	860	1,351	1,244	10	157	57	–8
Threshers	0	30	220	167	46	n.a.	663	–24	–72

Source: Authors' own survey (2016).
Note: 2WT = two-wheel tractor; 4WT = four-wheel tractor; n.a. = not applicable.

The pattern of spatial development observed suggests that labor shortages and wage rate increases (the main drivers of mechanization) occurred first in the agricultural zone surrounding Yangon, and began to be transmitted to more remote and less dynamic areas only after 2013. On the supply side, it also suggests that businesses have sought to extend their customer base by opening new branches in more peripheral hinterland areas, as the oldest markets in the country's agricultural heartland have matured.

Before 2011, branches linked to businesses in the cluster were highly concentrated in Yangon, Mandalay, Bago, and Ayeyarwady (Figure 8.6). Together these regions form a "core" agricultural corridor running down the center

FIGURE 8.6 Number and location of machinery suppliers, Myanmar, 2010, 2013, and 2016



Source: Authors' own survey (2016).

Note: The dots are scaled to the number of businesses in each region and the number of businesses is labeled.

of the country, following the course of the Ayeyarwady River and including Myanmar's two largest commercial centers (the cities of Yangon and Mandalay). Businesses in the cluster operated a total of 57 branches in 2010, of which 89 percent were located in these four core regions.

Most growth from 2011 to 2013 occurred in the southern part of the core zone, close to Yangon. The number of branches operated by businesses in the cluster grew by 30 percent during this period, to reach 70. Branch numbers increased by a further 29 percent from 2014 to 2016. Growth in the delta continued during this period but was also accompanied by increasing numbers of newly established branches in the northern part of the core corridor (the Mandalay region); in the intermediate regions of Magway and Sagaing; and in the peripheral states of Shan, Mon, and Tanintharyi. Geographic concentration decreased as a result, and 23 percent of branches are now located outside of the four original core regions.

Hire-Purchase Arrangements

Customer finance has played a critical role in catalyzing the adoption of agricultural machinery. Two forms of customer finance are available: (1) hire-purchase financing offered by machinery dealerships using their own working capital and (2) hire-purchase financing provided by banks and other commercial financial institutions.

For both types of hire-purchase arrangement, customers make an initial down payment on the item they intend to buy (usually 30 percent of its value). If financing is provided directly by the dealership, the customer repays the loan balance to the dealership in installments (usually two) over a fixed period (usually 12 months), with interest. The repayment system for hire-purchase arrangements made through banks is similar, except that the bank transfers the balance of the loan to the machinery dealership upon commencement of the agreement and the customer repays the outstanding amount to the bank. In either case, the agreement is guaranteed using the loan recipient's agricultural land use certificate (called Form 7) as collateral.[6]

Half of the agricultural machinery dealerships surveyed, including all those stocking large machines, offered at least one type of financing arrangement. Specifically, three dealers (11 percent of the total) provided direct hire-purchase financing, five dealers (18 percent) provided hire-purchase financing in partnership with banks, and seven dealers (26 percent) offered both services. Around six banks, all commercial, provided hire-purchase loans for agricultural machinery in partnership with machine suppliers. Interest rates were capped at 13 percent per year, in line with national banking regulations.

The boom in machinery sales detailed above could not have occurred in the absence of bank-financed hire-purchase agreements; this is particularly apparent for 4WTs and combine harvesters, the average cost of which ranges from $13,000 to $31,000, depending on country of origin.[7] Banking regulations do not allow machinery suppliers (or other types of business) to borrow more than the value of their assets. If bank financing for purchases of large machinery had not become available, the capital constraints faced by machinery dealerships would have caused sales to grow far more slowly. This is confirmed by Table 8.6, which shows that in 2016 hire-purchase agreements through banks accounted for a large majority of purchases of combine harvesters (77 percent) and 4WTs (68 percent). This is all the more remarkable given that banks only began to offer hire-purchase financing in 2013, following the passing of the Farmland Law of 2012, which made agricultural land use rights transferable and enabled Form 7 to be used as collateral against formal loans.

6 One bank, Yoma, does not require collateral for its hire-purchase loans, accepts a lower down payment, and offers repayment schedules of two to three years.

7 Dollar figures are US dollars throughout the chapter.

TABLE 8.6 Share of 2016 sales of selected machinery, by type of finance, Myanmar

Type of machine	Hire-purchase arrangement with bank (% of sales)	Hire-purchase arrangement with machinery supplier (% of sales)	Up-front cash payment by customer (% of sales)
Two-wheel tractor	35	17	48
Trawlarjee	46	28	26
Four-wheel tractor	68	5	27
Combine harvester	77	2	22

Source: Authors' own survey (2016).

Policy Environment

Agricultural mechanization has long been a policy priority for Myanmar. The AMD and the Department of Cooperatives (both under the Ministry of Agriculture, Livestock, and Irrigation) provide, respectively, agricultural machinery hiring services and machinery sales through hire-purchase finance arrangements. However, despite their activities, the market share of agricultural machinery hiring services and sales provided by government-led programs was extremely limited at the time of the survey, because the private sector has proven highly responsive and efficient in meeting demand.

Private machinery suppliers tend to stock machinery brands demanded by farmers, for which repair services and spare parts are widely available. In contrast, government departments have often made their purchasing decisions based on the availability of equipment provided through bilateral agreements and loans from other governments. For example, several respondents interviewed during the scoping exercise reported that Myanmar had received a loan facility from the Republic of Korea's government aimed at supporting mechanization and offered on the condition that loans would be used to buy a particular brand of Korean combine harvesters and 4WTs. The Myanmar government sold these machines that it received with a preferential four-year hire-purchase term (four times longer than that usually offered commercially). However, the manufacturer reportedly failed to provide spare parts or after-sale repair services, and the equipment was said to be poorly suited for use under local conditions. The result was that demand for the machines was limited despite the attractive financing.

The AMD has provided machinery hiring services to farmers since long before the emergence of the private hire market. However, demand for these services remains low. This is in part because much of the fleet of machinery available for hire by the government is obsolete or does not include brands

preferred by farmers. In addition, accessing these services is often more complicated and time-consuming than accessing the mechanization services offered by private providers.

Although government attempts to support mechanization directly have proven largely ineffective, Myanmar's mechanization policy has been successful in supporting the rapid emergence of a market-led, supply and demand–driven model of mechanization service provision, which came about in response to the incentives created by economic structural change. This success is largely because government policies have had few distortionary effects. In particular, there are no restrictions on imports of agricultural machinery that might hamper the sector's development, and agricultural machinery is not subject to any import duty.

Several other policies implemented after 2011 have played important complementary roles in supporting the growth of agricultural mechanization. Until 2012, private banks were not allowed to extend credit to farmers, on the basis that this facility was already provided by the state-owned Myanmar Agricultural Development Bank (OECD 2014). Various other restrictions placed on the banking sector have also been partially relaxed, although these reforms still have a long way to run.

Since 2012, this development has been complemented by the issuance of formal, transferable land use rights to agricultural land, through the provision of the Form 7 title document that enables farmland to be used as collateral to access credit from banks and machinery dealerships for the purchase of machinery.

Conclusions

Agricultural mechanization is already well advanced in the areas of Myanmar surveyed by the MAAS, almost completely replacing the use of draft cattle. Economic reforms and the growth in the nonfarm sector since 2011 have stimulated the onset of a process of structural transformation, as labor moves from agriculture to the more productive urban industrial and service sectors. Resultant rural labor shortages and increases in real wage rates have been major drivers of rural mechanization, particularly from 2013 onward. The declining real price of some types of machinery has contributed to the acceleration of this process.

Results from our supply-side survey of agricultural machinery dealerships in Myanmar's largest cluster of these businesses mirror those from our demand-side survey of machinery users in townships close to the city.

Adoption of machinery began with small, relatively low-cost machines such as engines, dynamos, water pumps, and 2WTs. The adoption of combine harvesters and 4WTs is a more recent phenomenon, having accelerated particularly rapidly from 2013 onward. Combine harvesters have already begun to replace smaller, single-purpose machines (threshers and reapers) for harvesting. Demand for 2WTs for land preparation remains high, but 4WTs have begun to eat into this market somewhat.

The spectacular growth in the volume and value of sales made by businesses surveyed in the Yangon cluster, combined with the rapid geographic spread of their branches, confirms the demand-side growth reported from the delta. Sales by machinery dealership branches located in the cluster increased by more than 500 percent from 2012 to 2016 alone, and particularly after 2013, there has been geographic expansion of dealership branches beyond core agricultural regions in the delta and lower dry zone to more peripheral states and regions. This suggests both that the core market is maturing and driving suppliers to seek to open up new markets, and that agricultural wage rates—a key driver of mechanization—are beginning to rise in areas distant from the country's main urban centers.

These findings have resonance beyond Myanmar. Smallholders account for the majority of famers in most developing countries, including those in Africa south of the Sahara. The persistent concern that mechanization is not applicable to smallholder farmers has led to calls for the establishment of large commercial farms in Africa south of the Sahara (Collier and Dercon 2014). However, as Pingali found, the limited spread of mechanization in Africa reflects the predominance of low-yielding subsistence production systems, itself the result of "relatively inelastic demand conditions due to low population densities or poor market infrastructure," with the result that mechanization is not cost effective (2007, 2781).

Myanmar's experience of rapid, scale-neutral mechanization provides a counterpoint to the position of Collier and Dercon (2014), and thus makes a contribution to the debate as to whether, and under what conditions, mechanization is likely to prove viable for smallholder farmers in Africa. The rather limited role of direct policy intervention in agricultural mechanization in Myanmar (except through laissiez-faire policies) and the evident importance of broader structural conditions and policies that favor an enabling environment also provide support for Pingali's (2007) observation, by suggesting that efforts to promote mechanization are unlikely to succeed until the fundamentals are in place.

As for recommendations for Africa, the recent experiences in Myanmar offer useful insights. First, in Myanmar, improvements in access to financial services following post-2011 reforms have also accelerated the adoption of agricultural machinery, particularly from 2013 onward. The sale of machinery via hire-purchase financing, under which buyers can pay for machinery in installments after entering a contract with a machinery supplier, has been a key innovation in this regard, particularly in the case of expensive machines such as 4WTs and combines. Hire-purchase arrangements financed by banks have played a pivotal role in supporting the boom in sales of agricultural machinery on the supply side, by partially overcoming capital constraints that prevented dealerships from providing direct financing to their customers at sufficient levels. The issuance since 2012 of transferable land use rights that can be used as loan collateral, along with partial relaxation of restrictions on the banking sector, has made this possible. For African countries, land policy reforms that enable increased use of land use rights as collateral may lead to greater use of bank credit for tractor purchase. Second, although banks extend credit mainly to better-resourced farmers who use land as collateral, in Myanmar there is a trickle-down effect for smallholder farmers, who are able to hire mechanization services at competitive rates. The rise of private hiring markets has dramatically improved access to these machines among farmers with small and large landholdings alike, rendering the technologies effectively scale neutral. Third, less distortion in import policies after the economic reform led to a significant inflow of cheaper, "good enough" machines such as power tillers from manufacturers in neighboring countries such as China.

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