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Myanmar's Rural Revolution: Mechanization and structural transformation

Myat Thida Win, Ben Belton and Xiaobo Zhang

Introduction

Development economists see structural transformation—the process by which labour leaves the rural agricultural sector for the more productive urban industrial and service sectors—as fundamental to economic development. As progressively more labour relocates from rural to urban zones the former are transformed from labour surplus to labour deficit areas, and a “turning point” is reached when rural wages begin to catch up with urban ones (Lewis 1954). Recent evidence of this pattern can be found in many Asian countries such as Bangladesh and China (Zhang et al. 2011; Zhang et al. 2014). Agricultural mechanization, the process by which capital in the form of machinery is substituted for labour in agriculture, is viewed by agricultural economists as a labour-saving response to labour scarcity and rising rural wages (Binswanger 1986; Takahashi and Otsuka 2009). Binswanger (1986, p. 32) notes that “mechanization is profitable and contributes most to growth where land is abundant, where labor is scarce relative to land and where labor is moving rapidly off the land”. As such, agricultural mechanization can be read as a symptom of structural transformation that helps to maintain the viability of farming in the face of labour shortages and rising production costs (Zhang et al. 2017).

In contrast to this model of development, in which economic and social transformation along the rural-urban axis is predictable and linear in form, recent work by development geographers highlights processes of agrarian transition that are far more complex, partial and varied than the mainstream economics literature would suggest (e.g. Rigg & Vandergeest 2012). For instance, Rigg et al. (2016, p. 118) observe that—contrary to the expectations of most commentators—smallholders in East and Southeast Asia “have persisted in the face of rapid and profound social and economic transformation”. But they do so in a variety of new hybrid forms that reflect the conjuncture of variations in physical geography, mobility, markets, and government policies.

These debates have particular resonance for Myanmar as it emerges from five decades of isolation and becomes more deeply integrated into the regional and global economy. Three processes central to structural transformation have emerged post-2011. First, the economy is

growing rapidly. GDP growth is forecast to reach 8.3 per cent in 2017, making Myanmar the fastest-growing major economy in the region (ADB 2016). Second, Myanmar is experiencing high levels of migration. For example, fourteen to twenty-six per cent of households in six townships in Chin State, Magway and Ayeyarwady had at least one migrant (Pritchard et al. 2017). International migration flows are well-established and relatively well-documented (e.g. Pearson and Kusakabe 2012), but internal rural-urban migration has increased significantly since 2011 (World Bank & LIFT 2016). Third, rural outmigration is driving wage increases in migrant sending areas. For example average inflation-adjusted wage rates for casual labour in four rural townships close to Yangon increased by forty per cent from 2011 to 2016, apparently in response to a migration-induced tightening of the labour market (Win and Thinzar 2016).

According to Dawe (2015), the two most important factors in determining the rate of agricultural mechanization are the level of wages and the land/labour ratio, with higher wages and land/labour ratios promoting the adoption of labour-saving machinery. The confluence of rapid urban growth, rural outmigration, and rising rural wages noted above thus suggest that rapid mechanization is likely to occur in at least some areas of Myanmar.

However, this transformation is not widely recognized to have taken place to date. For example, a major study of farm production economics conducted by the World Bank in 2013–14 in Ayeyarwady, Bago, Sagaing, and Shan State found very low rates of mechanization. For instance, levels of combine harvester use in rice cultivation stood at just one per cent. The report's authors argued that a combination of low wages in rural areas, excess agricultural labour, poor infrastructure, a lack of service providers, a poor regulatory environment, and lack of access to long-term capital by farmers were preventing investments in agricultural machinery (World Bank 2016). Recent media reports present a similar view. For example, a story in the *Myanmar Times* reports on the failure of farming to mechanize in the face of high rates of outmigration from the Ayeyarwady Delta (Myanmar Times 2016). The article states that “private market sellers and rental services remain underdeveloped”, and that combine harvester services are used by just fifteen per cent of farmers in Ayeyarwady, and remain too expensive “for the vast majority who own small plots”.

This chapter addresses, empirically, the disconnect between evidence of a dynamic and rapidly transforming economy, and the low levels of agricultural mechanization widely reported. It also

seeks to account for regional differences in observed patterns of mechanization. We use a mix of quantitative data and qualitative observations from our own surveys to analyze the current state of agricultural mechanization in four townships close to Yangon and provide insights from scoping in other areas of the country. Historical data from the national Integrated Household Living Conditions Assessment (IHLCA) survey of 2005 and 2010 is also drawn upon for comparative purposes.

Contrary to the findings of the World Bank (2016) we find ample evidence that extremely rapid agricultural mechanization has begun in the main area studied in Lower Myanmar. Our survey data shows that these changes occurred concurrently with greater labour mobility, high levels of out-migration, and rapidly rising wage wages. This confluence of events supports the inference that structural transformation is under way, at least in the main area studied. A particularly notable observed characteristic of agricultural mechanization is the emergence of machine rental services markets, which has made the adoption of agricultural machinery close to scale neutral at the point of use.¹ This finding belies the perception that mechanization is only possible with, or must result in, concentration of agricultural landholdings, lending support to the position that processes of agrarian transformation can occur in ways that are highly unpredictable and contextually specific.

Similarly, we find that agricultural machinery dealerships have increasingly spread beyond the country's traditional agricultural heartlands to penetrate more peripheral areas of the country, but this process has been far from uniform. Place-based spatial variations in uptake of different types of machinery are identified, linked to differences in physical connectivity, agro-ecology, crop choice, and the economic logic of different forms of farming (i.e. commercial and subsistence). The question of whether mechanization has contributed to rural differentiation, deagrarianization and shifts in the balance of gender relations is important, but cannot be answered with the data available, and remains an important topic for future research.

The paper is organized as follows. Section 2 presents data and methods. Section 3 provides a historical overview. Section 4 analyzes the current characteristics of mechanization in Myanmar

¹ A "scale neutral" agricultural technology is one which for which farm size does not pose a barrier to adoption.

from both demand and supply sides. Section 5 examines drivers of mechanization. Section 6 evaluates place based determinants of geographical variation in the extent and form of mechanization. Section 7 concludes.

2. Data and Methods

This chapter paper draws on four sources of data. (1) Historical data taken from datasets of the nationally representative IHLCA surveys for 2005 and 2010. (2) Information on agricultural machinery ownership and use from a structured survey of 1,100 households in Ayeyarwady and Yangon regions—the Myanmar Aquaculture-Agriculture Survey (MAAS)—completed by the authors in early 2016. (3) An enterprise survey of twenty-seven agricultural machinery supply businesses in Yangon (the Yangon Mechanization Cluster Survey), completed in mid-2016. (4) Rapid qualitative scoping assessments conducted in Ayeyarwady, Yangon, Mandalay, Magway and Sagaing regions, and Mon State from 2016 to early 2017. Surveys 2, 3 and 4 were conducted by a collaborative research team comprised of the Centre for Economic and Social Development (CESD), International Food Policy Research Institute (IFPRI), and Michigan State University (MSU). Details of the three structured surveys are outlined in sequence below.

The IHLCA datasets were used to estimate levels of ownership and use of agricultural machinery among farm households by geographical zone in 2005 and 2010. IHLCA is a nationally representative household survey for Myanmar of 18,660 households, conducted under the auspices of the Ministry of National Planning and Economic Development and the United Nations Development Programme. The survey instrument contained a detailed list of agricultural assets owned and used, including all the main categories of agricultural machinery (IHLCA, 2011).

The MAAS was fielded in May 2016 to fulfil a variety of purposes, including generating a baseline of information on farm yields, size, tenure status, management practices and profitability, and evaluating patterns of migration, and the ownership and utilization of agricultural machinery. A two-stage sampling strategy was followed. For the first stage, forty village tracts from four townships (Kayan and Twantay, Maubin and Nyaungdon) were selected purposively based on an assessment of the farming systems present in each. All the selected village tracts fell within approximately a sixty kilometre radius of Yangon. For second-stage

sampling, 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. This procedure yielded a sample of seventy-eight EAs. A census of households was conducted in every selected EA to serve as the final sample frame for randomized selection of respondent households. Eight farm and seven non-farm households were selected for interview in each EA. Respondents from 1,102 households, representing a total population of 37,390 households, were interviewed. Although the results of the survey provide insights into areas in close proximity to Yangon, they are not necessarily representative of more remote agricultural areas.

To supplement household-level data, the Yangon Mechanization Cluster Survey was conducted in July 2016 to generate a picture of the supply side of Myanmar's agricultural machinery market. Machinery supply businesses (machinery dealerships) were surveyed in a commercial area in western Yangon, located close to the main road and river routes leading to the country's agricultural heartland, the Ayeyarwady Delta. Pre-survey scoping interviews indicated that most of the machinery supply dealerships in Yangon are located in this area, which is by far the largest "cluster" of agricultural machinery supply businesses in Myanmar, and houses branches of most of the country's major suppliers. The survey thus captured information on a large share of national agricultural machinery sales. A census of businesses in the cluster was conducted prior to survey rollout. A total of thirty businesses selling agricultural machinery and twenty-seven shops selling spare parts for agricultural machines were listed. All agricultural machinery suppliers and spare parts shops in the cluster were selected for survey. Three machinery suppliers and five spare parts shops declined to participate, giving a total sample size of forty-nine businesses. This chapter presents survey findings on the twenty-seven agricultural machinery supply businesses.

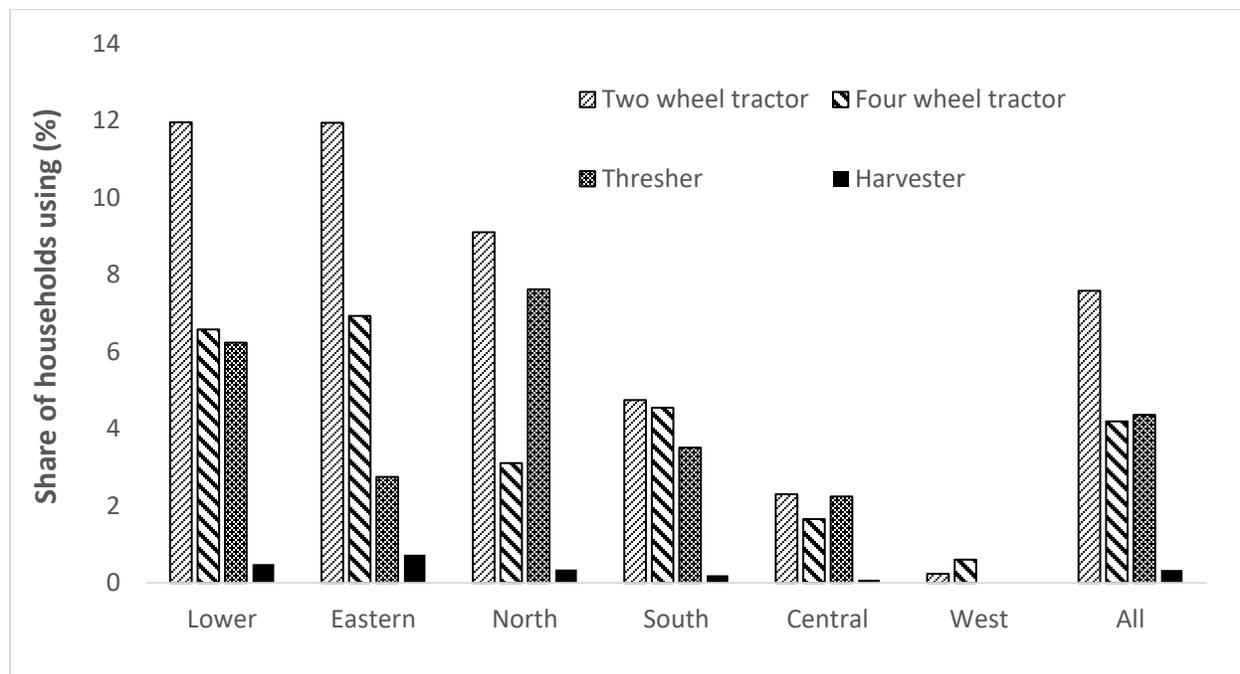
3. Historical Overview

Comparison of IHLCA data for 2005 and 2010 shows that agricultural machine use increased only incrementally over this period, from a very low base. For example, the share of farm households using four-wheel tractors increased four percentage points (from eight to twelve per cent). Similarly, use of two-wheel tractors (power tillers) increased three percentage points (from four to seven per cent of households), while use of mechanical threshers rose two percentage points (from four to six per cent). By 2010, overall rates of agricultural machine use remained

very limited, with just eight per cent of farm households nationally making use of the most common type of machine, the two-wheel tractor (Figure 1).

Mechanization was farthest advanced in the main rice-growing agricultural “core” regions of Lower Myanmar (Ayeyarwady, Yangon, Bago)—the agro-ecological zone where our own MAAS survey was implemented; among households with large landholdings; and among those double cropping paddy (i.e. with access to irrigation). However, even here, overall rates of machine use were very low. Machine use was almost non-existent in Rakhine and Chin States (isolated and predominantly upland areas on Myanmar’s western periphery), and were very limited among households with small landholdings and those growing a single non-paddy crop.

Figure 1: Share of agricultural households (per cent) using machinery, by area of country and type of machinery, 2010 (Source: IHLCA, 2010)



These patterns are consistent with the common perception of Myanmar’s rural economy and agricultural sector as static, traditional and lacking in dynamism. Little change took place over the five-year period between surveys, and the adoption of agricultural machinery was the exclusive preserve of the uppermost stratum of farmers. Rental markets for agricultural machinery also remained poorly developed in 2010. With the exception of threshers and combine harvesters, users of all types of agricultural machinery were more likely to own than to rent

them. Lack of access to rental services accounts in part for the concentration of machine use among a small segment of large farms.

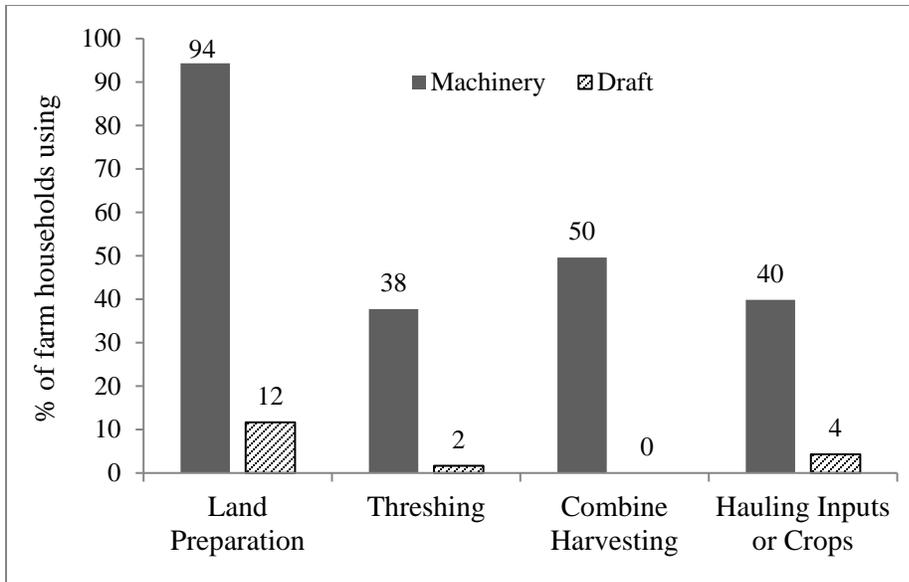
4. The scale and dynamics of recent mechanization

In contrast to the historical picture painted by IHLCA data, our own surveys implemented in 2016 reveal that rapid and widespread mechanization took place in the intervening years in surveyed townships in the Ayeyarwady Delta and some other areas of the country. Evidence of the current extent of agricultural mechanization and its recent dynamics is presented in the following sub-sections.

4.1 Changes in machine ownership

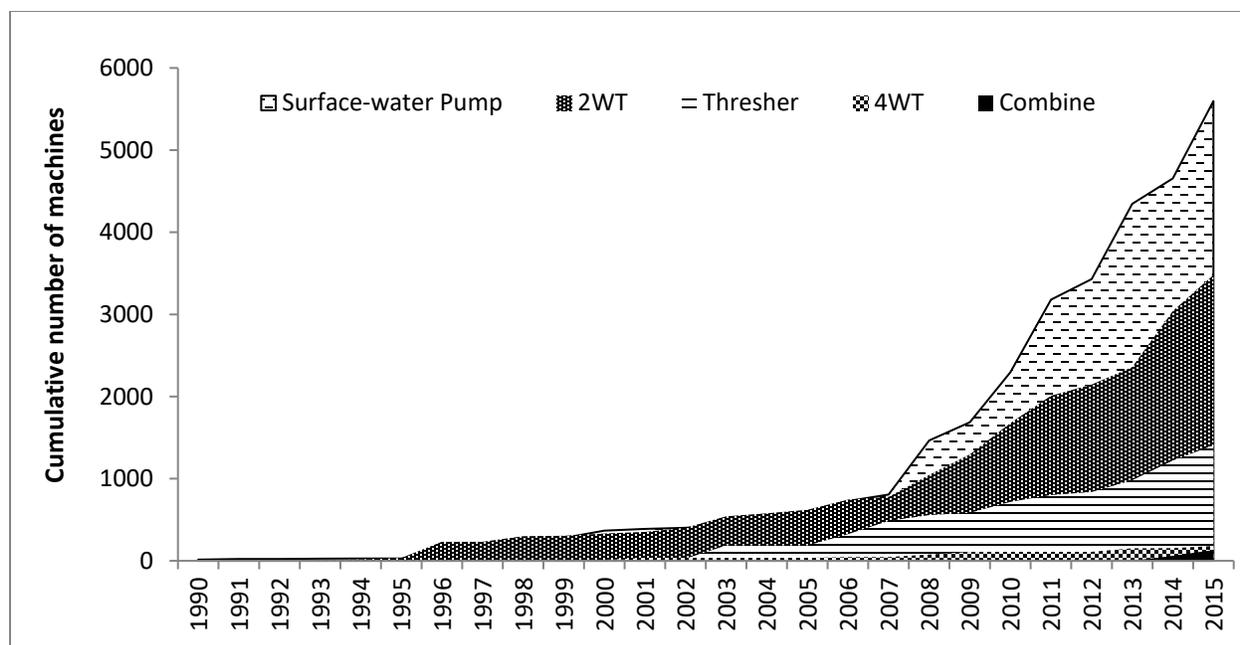
Compared to data from IHLCA 2010, results from MAAS indicate that a dramatic change in agricultural machinery use had taken place in the four townships surveyed by 2016. Machinery had almost completely replaced animal traction in agriculture in the areas surveyed by this time. Ninety-four per cent of households reported using machinery for land preparation in 2015–16, while only fourteen per cent of farm households continued to use draft animals for this purpose. Sixty-eight per cent of farm households used two-wheel tractors for land preparation, and seventeen per cent used four-wheel tractors. The use of draft animals for transporting inputs or crops all but disappeared, while forty per cent of households used machines for this task (Figure 2).

Figure 2. Machinery and Draft Animal Use in Paddy Cultivation, 2015–16 (Source, Own survey: MAAS 2016)



Widespread mechanization of harvesting and threshing also occurred. Half of all sampled paddy farming households reported using a combine harvester for this purpose, and thirty-eight per cent used mechanical threshers to separate manually harvested paddy from paddy straw. This means that close to ninety per cent of paddy produced in the area of Lower Myanmar surveyed underwent mechanized harvesting and/or threshing. The enormity of this shift is apparent when one considers that only 0.5 per cent and six per cent of households in Lower Myanmar made use of either a combine or thresher, respectively, in 2010 (Figure 1).

Figure 3. Cumulative Purchases of Selected Machinery (1990–2015). Source: MAAS (2016)



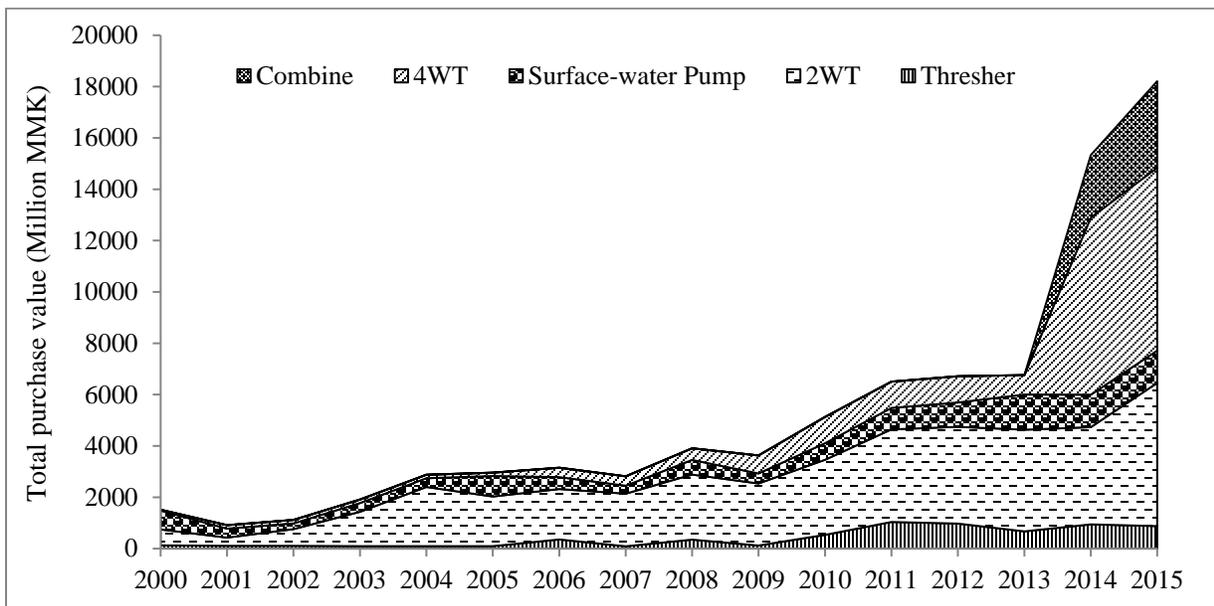
Changes in machine use have occurred in step with rapid increases in ownership of agricultural machinery, and changes in the composition of that machinery. This is illustrated in Figure 3, which presents data on the (population weighted) number of machines of different types purchased by households in surveyed village tracts in each year from 1990 to 2015. Very limited adoption of surface-water pumps began in the early 1990s, followed by two-wheel tractors in the mid-1990s. Purchases of mechanical threshers and four-wheel tractors began almost a decade later, after 2000. Combine harvester purchases are a very recent phenomenon, occurring only from 2013. Sales of water pumps, two-wheel tractors and threshers all grew very slowly until the late 2000s, whereupon they increased rapidly, accelerating particularly quickly from 2010 onwards. This trend is consistent with the sequential pattern of mechanization observed in many countries, in which stationary “power intensive” operations such as pumping water and threshing are mechanized first, followed by mobile “control intensive” operations such as harvesting (Pingali 2007, p. 2008).

Examining the total value of machines purchased over time reveals an even more dramatic change. Figure 4 depicts the rate of mechanization in terms of the total value (adjusted to 2015 prices) of different types of machinery purchased in the survey area from 2000 to 2015. Similar to the pattern illustrated in Figure 3, expenditure on machinery grew slowly from a low base in 2000, and was initially comprised mainly of two-wheel tractors and water pumps. The total value

of sales began to increase more rapidly after 2009–10 as the purchase value of threshers and four-wheel tractors rose, and then more than tripled in the space of just two years from 2013 to 2015.

Four-wheel tractors and combine harvesters alone contributed about half of the total value of machinery purchases in 2015. The contribution of four-wheel tractors to the total value of purchased machinery was low prior to 2013, even though the total number of four-wheel tractor units purchased changed little before and after 2013, suggesting that expensive high-performance imported four-wheel tractors were increasingly purchased after 2013.

Figure 4. Total Real Purchase Value of Selected Machinery (2000–15). Source: MAAS (2016)



4.2 Changes in machine supply

Our survey of agricultural machinery dealerships in Yangon provides evidence of similar patterns in the volume and composition of machinery sales. The product assortment offered by suppliers has diversified over time. Sales were initially comprised primarily of small machines (water pumps, engines and two-wheel tractors). Numbers of suppliers stocking these grew quickly from 2005, and more than two-thirds of businesses surveyed stocked them in 2016, reflecting high levels of demand and widespread use. The number of dealerships stocking four-wheel tractors increased sharply from 2009, followed by combine harvesters, which were first

sold in 2012, and grew rapidly thereafter, with both types of machine sold by around forty per cent of dealers in 2016.

Five of the machinery dealerships surveyed began to stock mechanical rice planters in 2016, suggesting the possibility of a further shift toward an even more specialized labour-saving technology. However, few sales of these machines had been made at the time of the survey, and their uptake is likely to be slower than that of other types of machinery because of technical and organizational complexities in preparing rice seedlings for use with them.

Growth in the volume of sales made by machine supply businesses between 2012 and 2016 parallels the upsurge in machine ownership evident in Figures 3 and 4. The total number of units sold (all types of machinery) increased by 592 per cent over this period, from 18,283 to 126,572 (Table 1).² Sales of four-wheel tractors and combine harvesters increased particularly quickly after 2014. Annual combine harvester sales grew nearly 6,000 per cent in four years (from 40 to 2,372), with ninety per cent of this growth taking place in 2015 and 2016 (Table 1). Sales of four-wheel tractors increased almost 1,100 per cent between 2012 and 2016 (from 275 to 3,200). The average number of sales staff employed by surveyed dealerships grew forty-three per cent between 2013 and 2016, reflecting the increasing volume of sales made.

Table 1: Annual sales by surveyed machinery dealerships in Yangon (2012–16)

Item	Year				
	2012	2013	2014	2015	2016
Two wheel tractor & accessories	9598	11715	14912	14872	20684
Engine, dynamo & water pump	8105	11547	62806	59103	99026
Four wheel tractor	275	420	870	1662	3200
Combine	0	40	237	955	2372

² This figure excludes sales made by branches outside the cluster. 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 usually similar.

Reaper	305	335	860	1351	1244
Thresher	0	30	220	167	46
Total	18283	24087	79905	78110	126572

Large machines have already begun to replace smaller ones. Sales of threshers dwindled by seventy-nine per cent from a high of 220 in 2014 to 46 in 2016, while annual growth in sales of reapers peaked in 2015 after three years of brisk growth and fell by eight per cent thereafter. Four-wheel tractors also appear to have eaten into sales of two-wheel tractors, sales of which plateaued from 2014 to 2015.

4.3 The Machine Services Rental Market

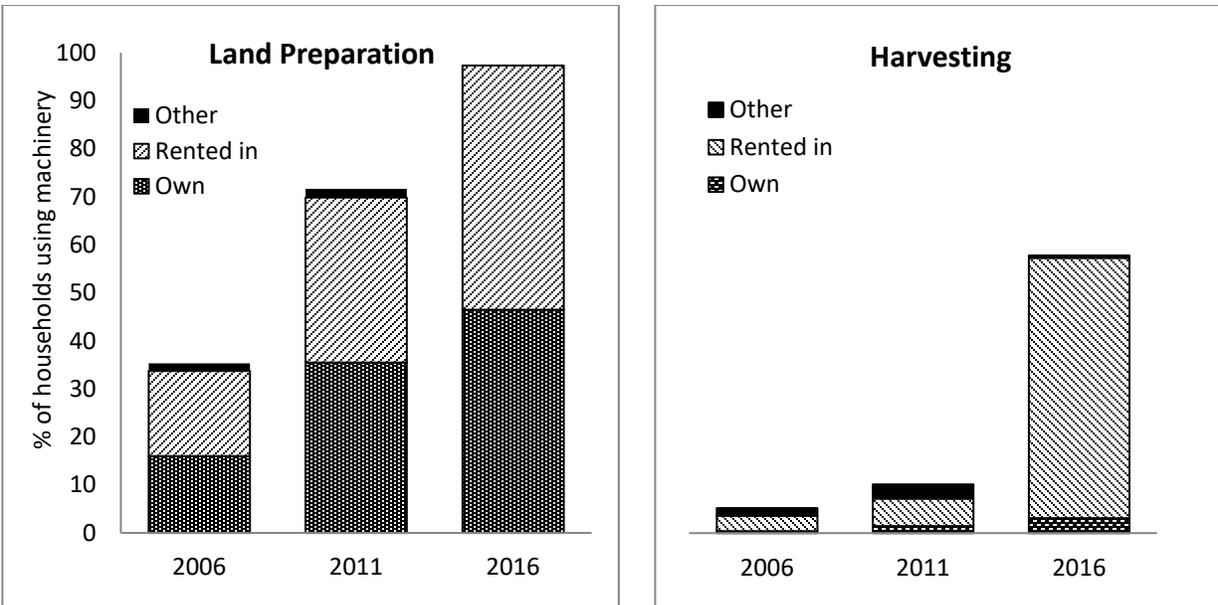
A machine rental services market has developed in step with increasing agricultural machinery sales since 2010. Although sales and ownership of agricultural machinery increased dramatically after 2010, most farm households access this equipment through short-term rentals. The growth of rental services has played a critical role in facilitating farmer access to these items. As expected, ownership of agricultural machinery is most common among farmers with large landholdings, while smaller farmers are more likely to access machinery by renting. Use of rental services is most common for the most expensive machinery (combine harvesters and four-wheel tractors). The emergence of rental service markets has driven sales of these machines, as renting out machinery provides revenue that enables owners to pay off outstanding hire purchase loans and quickly recoup their investments.

The rental services market for large machines is dominated by larger farmers and other rural entrepreneurs who buy machines principally to rent out to others. Combine harvester owners often offer rental services in both the local vicinity and more distant areas of the country to take advantage of regional differences in the timing of harvesting seasons. After providing services in nearby villages, combine owners from the Delta transport their machines to other rice farming regions, such as Shwebo in Central Dry Zone, using rented trucks. Similarly, combine owners from the Dry Zone provide rental services to the Delta during their local off-seasons. Rentals of

smaller machines (two-wheel tractors, threshers etc.) are provided principally by farm households with medium or large landholdings, within the immediate vicinity of their villages. The machine rental services market is dominated by this vibrant informal private sector. Although the government's Agricultural Mechanization Department (AMD) offers some machinery rental services, none of the households surveyed in MAAS reported making use of them. The provision of machine rental services by formal businesses (e.g. machinery dealerships) is also very limited.

Recall data on the share of farm households owning, renting or borrowing machinery used for land preparation and harvesting at three five-year intervals (2006, 2011, and 2016) is presented in Figure 5. The percentage of households using some type of machinery for land preparation rose steadily from thirty-six per cent in 2006 to seventy-two per cent in 2011, reaching ninety-seven per cent in 2016. In all three years, approximately half of these households reported owning the machine used, while the other half rented in. The share of households using machines for harvesting changed little from 2006 to 2011 (increased from five to ten per cent), but jumped steeply to fifty-seven per cent in 2016. Rentals accounted for ninety-three per cent of all machines use for harvesting in 2016.

Figure 5. Use of Machinery for Land Preparation and Harvesting In Paddy Cultivation, by Source of Machinery, 2006–16. Source: MAAS (2016)

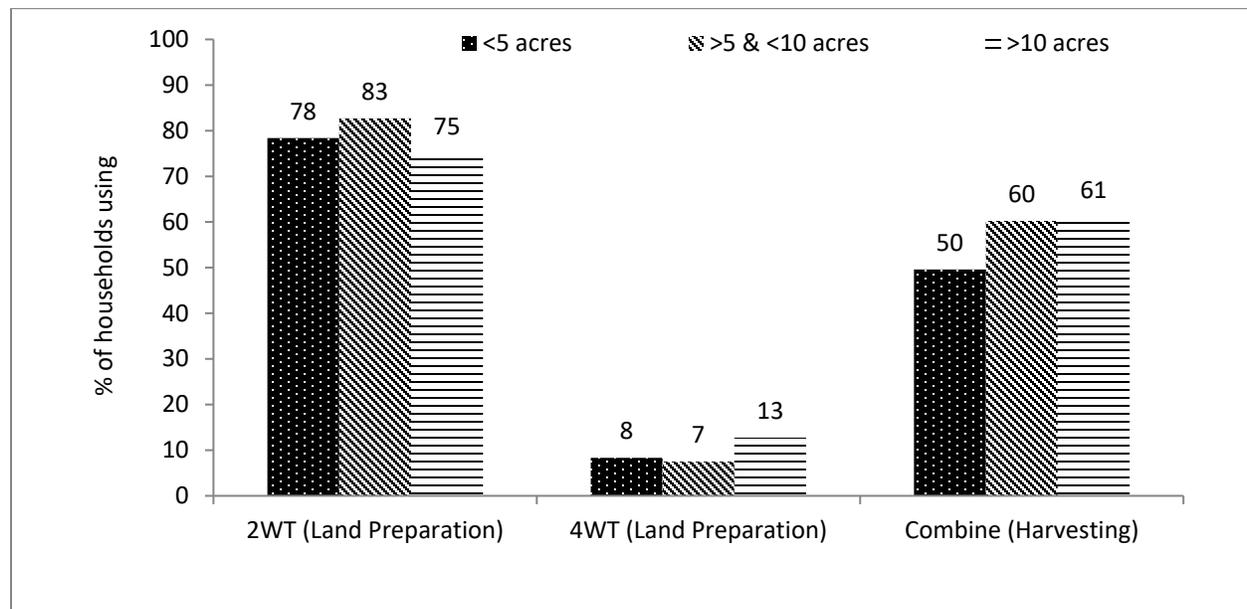


4.4 Mechanization and Farm Size

Agricultural mechanization is commonly perceived not to be scale neutral because machines are “lumpy” inputs that require high levels of initial capital investment and “reach their lowest cost of operation per unit at relatively large areas”, thus favoring adoption by large farms (van Zyl et al. 1995, p. 3). This leads Pingali (2007, p. 2790) to state, with reference to Southeast Asia, that “in the absence of land consolidation and the re-design of the rice land to form large contiguous fields, the prospects for large-scale adoption of the harvester-combines are limited.”

Evidence from MAAS contradicts this characterization. In surveyed village tracts, farm size and adoption of agricultural machinery are, at best weakly correlated. Figure 6 presents data on the share of farm households using machinery for land preparation and harvesting in paddy cultivation during the twelve months preceding the survey, by farm size. Farms are divided into three categories (<5 acres, 5–10 acres, and >10 acres). The three categories correspond approximately to small, medium and large farms in the Myanmar context. The share of households using two-wheel tractors and four-wheel tractors for land preparation varies very little among farm size categories. Use of combine harvesters varies somewhat more, ranging from fifty per cent on farms sized <5 acres to sixty-one per cent on farms of >10 acres, but the difference is small.

Figure 6. Share of Households Using Machinery for Land Preparation and Harvesting in Paddy Cultivation, by Farm Size Group (2015/16). Source: MAAS (2016)



The highest rental rates occur among households with small farms. For instance, more than ninety-five per cent of farms under five acres that made use of combine harvesters in 2015–16 rented these in, as compared with seventy-four per cent of farms operating >10 acres of land. The rapid growth of competitive machinery rental markets has allowed smallholders to enjoy many of the benefits obtained from mechanization by larger farmers (e.g. reduced labour costs, timely completion of activities). Accelerated social differentiation and land consolidation (as might be expected if only large farms were able to utilize these technologies), thus appears unlikely to occur as a result of the introduction of machinery. These results also demonstrate that land consolidation is not a necessary precondition for the widespread adoption of agricultural machinery. However, although our scoping experience and surveys indicate that the rental market is flourishing in the Delta and some parts of Dry Zone, it may remain less well-developed in remoter areas where infrastructure is poor. It is probable, though we have yet to test this empirically, that farm size and machine use are more closely correlated in those areas.

Myanmar's experience in this respect is similar to that of other Asian countries. For instance, the adoption of two-wheel tractors, made possible by a thriving rental market, is very widespread in Bangladesh, where just three per cent of households own such a machine, but eighty per cent of

farmland is tilled with them (Biggs et al. 2011). Moreover, average farm sizes in Bangladesh are around an order of magnitude smaller than in Myanmar, and are continuing to decline. Similarly, Zhang et al. (2017) find that despite small landholdings and a high degree of land fragmentation, farmers in China have outsourced activities such as harvesting to specialized mechanization service providers, who travel throughout the country to harvest crops at very competitive prices.

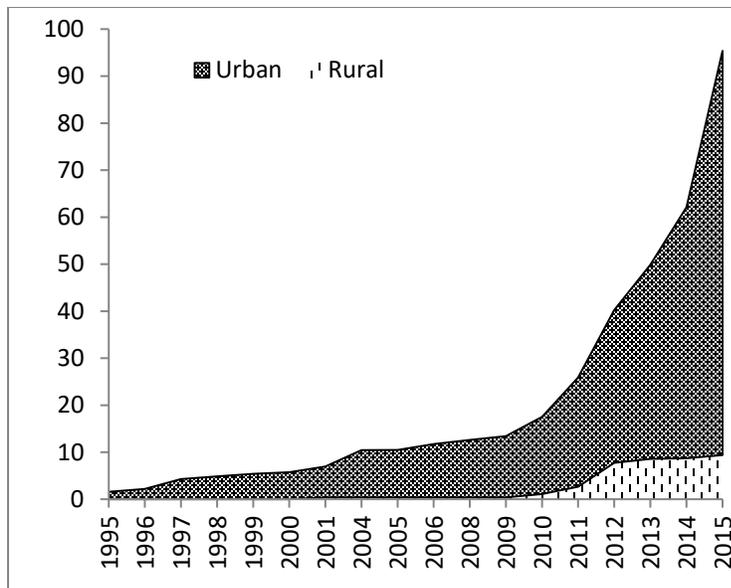
5. Drivers of mechanization

This sub-section elaborates on the characteristics of two key drivers of mechanization. First, from the demand side, changes in the Myanmar labour market are linked to migration and increasing mobility. Second, from the supply side, changes in access to formal financial services have made it easier for buyers to purchase agricultural machinery.

5.1 Migration, land and the changing labour market

In addition to data on mechanization, MAAS collected information on migration, wage rates and landholdings. Migration flows follow a similar timeline to the adoption of agricultural machinery. Eighty per cent of current migrants left their households after 2010 (Figure 7). Migration increased rapidly but steadily from 2011 until 2014, after which it accelerated further. These shifts coincide with the relaxation of restrictions on freedom of movement imposed under military rule, and rapid urban growth post-2011.

Figure 7: Cumulative share of migrants by year and destination (Source: Htoo & Htun 2016)



The role of urban growth in stimulating migration is reflected in the fact that a large majority (seventy per cent) of migrants from the four townships surveyed engaged in manufacturing work, with most of the remainder working in services, or as skilled labour in trades (Htoo and Htun 2016). Ninety per cent of migrants from surveyed households were reported to work in urban areas. The most important of these was nearby Yangon, which was the destination of sixty-one per cent of all migrants. Unlike in other areas of the country such as Mon State, where international migration (particularly to Thailand) is very common, only eight per cent of migrants from the locations surveyed worked abroad.³ In addition to permanent migrants, forty-four per cent of all individuals working a monthly salaried job resided at home but commuted regularly to nearby urban areas, representing a further reduction in the rural workforce (Htoo and Htun 2016).

Sixteen per cent of households surveyed in the four townships close to Yangon had at least one long-term migrant at the time of interview. Although this share seems modest, average age at first migration is twenty-one, meaning that migrants are disproportionately concentrated among the most productive, economically active segment of the labour force, and their departure results in a large reduction in the availability of rural workers. The gender balance of migrants in

³ Others migrated to regions outside Yangon and Ayeyarwady (21%), elsewhere in Yangon and Ayeyarwady (5%), and 'other locations' (5%).

surveyed townships was approximately equal (fifty-five per cent male, forty-five per cent female). As men and women participate in harvesting (the most labour-intensive agricultural activity) in roughly equal numbers, the gender implications of mechanization are not immediately clear, but deeper analysis is warranted.

The question of whether systemic or idiosyncratic “push factors” have contributed to this migration boom also warrants consideration. Rates of landlessness were high in the communities surveyed, with well over half of all households (fifty-eight per cent) having no agricultural land. Moreover, although the mean area of agricultural land cultivated is 10.2 acres, farmland is highly unevenly distributed: the third of households with the smallest agricultural landholdings own just three per cent of the total area of farmland, while the third of households with the largest agricultural landholdings own sixty-nine per cent. It is probable that landless households and agricultural producers with very small landholdings struggle to reproduce themselves, providing a strong incentive to migrate in search of alternative opportunities. However, migration rates were not found to differ widely across categories of households with different resource endowments and livelihood strategies (e.g. landed/landless, farm/non-farm).

Moreover, high levels of landlessness and small agricultural holdings do not appear to be a recent, nor recently intensified, phenomenon. Although the area surveyed has experienced high levels of land confiscation in the past, with approximately ten per cent of households reporting having lost land due to confiscation or appropriation by the state or private entities within the past thirty years, few households had lost any land for this reason since 2006. The rate of loss of land due to indebtedness has also changed little recently. Cyclone Nargis is known to have displaced large numbers of households from Ayeyarwady region, but this happened in 2008, two years before migration began to gather pace, and the cyclone did not severely damage villages in the townships surveyed.

The movement of labour to urban areas has brought about a tightening of the rural labour market in the areas surveyed. The real (inflation adjusted) agricultural wage rate increased moderately from 2011 to 2013, by eight per cent (MMK⁴ 2607 to MMK 2820), before jumping by a further

⁴ MMK = Myanmar Kyat. USD 1 was valued at approximately MMK1200 in 2016.

thirty-two per cent to MMK 3718 in 2016. Although it is not possible to establish causality on the basis of this trend alone, there is a strong correlation between the timing and characteristics of rural-urban migration, increasing rural wage rates, and the adoption of agricultural machinery, all of which accelerated most rapidly at precisely the same time. This confluence of events supports the interpretation that structural transformation is beginning to take hold in this area of Myanmar.

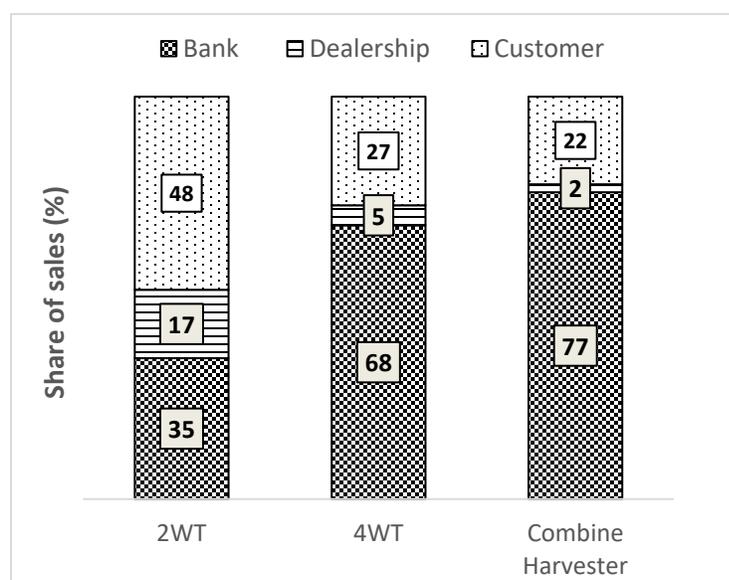
5.2 The emergence of formal financial services

On the supply side, the advent of customer finance provided by private banks has played a pivotal role in the growth of machinery sales and the emergence of machine service rental markets. Two forms of customer finance are available: (1) Hire purchase financing offered by machinery dealerships using their own working capital; (2) Hire purchase financing provided by banks and other commercial financial institutions. In both cases, customers make an initial down payment on the item they intend to buy. In the case of direct financing by dealerships, the remainder of the balance is repaid by the customer to the dealership, in installments with interest, over a fixed period (usually twelve months). In the case of hire purchase arrangements made through banks, the bank usually pays the loan balance to the machinery dealership and the customer repays the loan to the bank, with interest, over a fixed period (again, usually twelve months). Interest rates are capped at thirteen per cent per year, in line with national financial regulations. The uptake of these services has been remarkable. Banks first offered hire purchase arrangements in 2013, but by 2016 these loans accounted for the majority of purchases of combine harvesters (seventy-seven per cent) and four-wheel tractors (sixty-eight per cent), and one third (thirty-five per cent) of purchases of two-wheel tractors (Figure 8).

The success of these schemes stems from their removal of credit constraints to both machinery dealerships and their customers. Banking regulations mean that machinery dealerships are only able to borrow from banks up to the value of their fixed assets, making it difficult for them to extend large volumes of customer credit, particularly in the case of large machines which cost from \$13,000 to \$31,000 on average, depending on brand and country of origin. This is reflected in Figure 8, which shows that direct hire purchase financing from machinery suppliers accounted for just five and two per cent of four-wheel tractor and combine harvester sales in 2016. Hire

purchase arrangements have also improved the ease with which customers can access machinery, as the ability to obtain finance from a bank removes the need to save the entire cost of a machine before making a purchase, or to borrow from informal lenders at rates of interest averaging five per cent per month (sixty per cent per year).

Figure 8: Share of 2016 machinery sales by source of finance and machine type. Source: Mechanization Cluster Survey (2016)



The emergence of formal financing for machinery purchases has been possible in part due to the Farmland Law, instituted in 2012, which made agricultural land use rights transferrable. All land in Myanmar is the property of the state (Union), with households granted use rights that allow land to be used for specific purposes. Prior to 2012, agricultural land use rights were not legally transferrable from one individual to another. The new law means that loan applicants can now use agricultural land use certificates (“Form 7”) as guarantees for bank loans.⁵ This pattern is

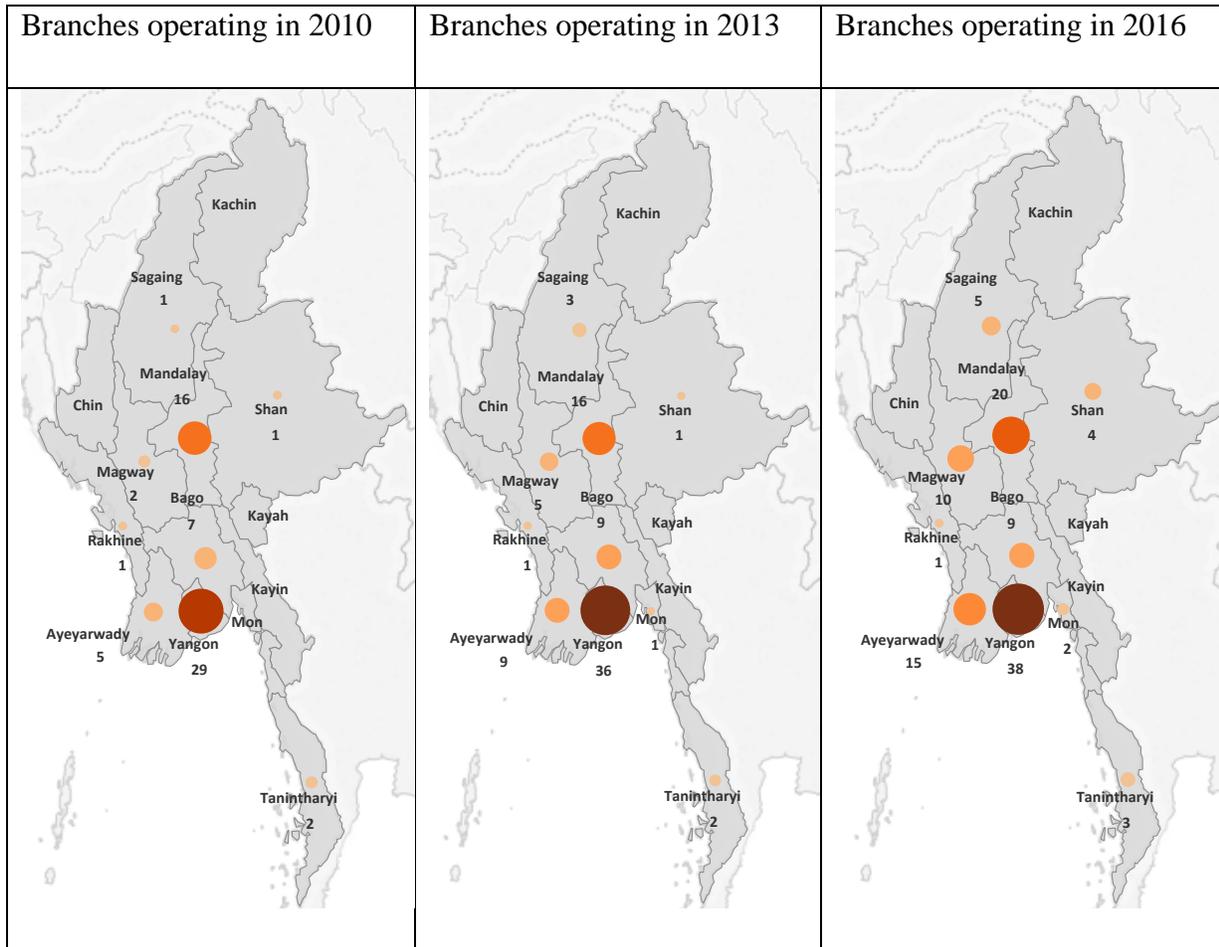
⁵ Form 7 replaced the previous land titling document, “Form 105”, which was assigned to parcels of land already registered on cadastral maps of agricultural land. The system of creating cadastral maps and associated agricultural land use categories dates from the British colonial period. An informal market in sales and, to a much lesser extent, rentals of land already existed in the townships surveyed prior to this change, so the main effect of the law in these locations appears to have been to strengthen pre-existing formal tenure, rather than to incorporate “new” land (e.g. land accessed under customary tenure rules) into new sets of tenure arrangements.

consistent with Pingali’s observation (2007, p. 2801) that “formal land titles empower small farmers further by providing them the collateral necessary for acquiring credit for the purchase of machinery.”

6. Geography and spatial variation

Data presented above on the adoption of agricultural machinery and its links to economic transformation are specific to four townships located close to Myanmar’s largest and most economically dynamic city, raising the question of whether this case is a localized geographical anomaly, or indicative of more pervasive structural change at the national level. The Yangon Mechanization Cluster Survey provides evidence of a generalized tendency, but one that is proceeding at different intensities in different locations. This pattern reflects the influence of a variety of factors discussed below.

Figure 9: Number and location of machinery suppliers, 2010, 2013, and 2016.



Machinery dealerships surveyed in Yangon were asked for the location and date of establishment of other branches that they operated. These data are summarized in Figure 9, for the years 2010, 2013 and 2016. Before 2011, sales outlets were highly concentrated in Yangon, Mandalay, Bago and Ayeyarwady. Yangon and Mandalay cities are Myanmar's two largest commercial centers, while rural Ayeyarwady, Bago, and Yangon are part of Myanmar's "rice bowl", providing the majority of the country's paddy. Together these four regions form a "core" agricultural corridor, running through the center of the country along the course of the Ayeyarwady River. The businesses surveyed in Yangon operated a total of fifty-seven branches in 2010, of which eighty-nine per cent were located in these four "core" regions. From 2011 to 2013 the number of branches operated by surveyed businesses grew thirty per cent, to seventy. Most of this growth occurred in the southern part of the core zone, in rice-growing areas close to Yangon. From 2013 to 2016, branch numbers increased by a further twenty-nine per cent. Growth in Lower Myanmar continued during this period, but was also accompanied by the establishment of branches in the northern part of the core corridor (Mandalay), as well as in the agriculturally "intermediate" regions of Magway and Sagaing, and the "peripheral" states of Shan, Mon and Tanintharyi. Geographical concentration of machinery businesses decreased as a result, with seventy-seven per cent of branches located in the original core regions in 2016.

This pattern of spatial development can be interpreted in two ways: (1) On the supply side, machinery suppliers may have sought to open new branches in hinterland areas in order to extend their customer base as markets in the country's agricultural heartland have matured. (2) On the demand side, labour shortages and wage rate increases that first occurred in the agricultural zone surrounding Yangon may have spread to remoter and less dynamic rural areas, as mechanization has followed labour shortages and rising wages. However, striking as these changes are, observations made in the field during scoping research indicate a greater degree of complexity and variability than suggested by these narratives alone.

First, certain crops and farming environments lend themselves more readily to particular types of mechanization than others. As seen in Figure 9, mechanization was initially concentrated in Lower Myanmar, where virtually all crop farmers produce monsoon paddy. Farmers in this zone rapidly adopted two-wheel tractors (which quickly replaced draft animals for land preparation)

and combine harvesters. Adoption of four-wheel tractors proceeded more slowly here because large machines are not well suited to operation on wet soils. In addition, the homogeneity of rice-based farming systems in the Delta means that rental service providers have a large customer base to work with, leading to the widespread provision and adoption of their services.

In contrast, mechanization in the Dry Zone has proceeded at a somewhat slower pace (and with different characteristics), despite increases in domestic and international outmigration, growing labour shortages and rising real wages of a similar magnitude to those experienced in the Delta. Oilseeds (mainly peanut and sesame) and pulses (mostly importantly green gram, pigeon pea and chick pea) are the main crops cultivated. Paddy cultivation occurs in a scattered pattern in about half of the villages, and is concentrated particularly in a small number of townships with large-scale dam irrigation. The predominance of non-rice crops, which are grown on dry soils, means that adoption of four-wheel tractors has preceded more rapidly than the use of two-wheel tractors in the Dry Zone. However, although four-wheel tractors are now widely used for the initial plowing of hard soils, they are poorly suited to performing the repeated harrowing that the oilseed crops require prior to planting. As a result, almost all Dry Zone farmers continue use animal traction for this latter function. Adoption of combine harvesters in the Dry Zone has been rapid in irrigated rice growing pockets where there are large contiguous areas of paddy, but slower in areas where paddy farms are fewer and more dispersed, because operation in the latter areas does not offer sufficient economies of scale to rental service providers. Furthermore, harvesting of pulses and oilseeds has yet to be mechanized at all, as the open pollinated varieties currently grown are not sufficiently erect for combines to work effectively.

Second, adoption of agricultural machinery can occur in response to different logics, depending on whether the orientation of farm households is predominantly subsistence or predominantly commercial. Production of paddy in Lower Myanmar is strongly oriented to the market. For example, seventy-five per cent of the monsoon paddy produced by households in MAAS survey areas is sold, and the share sold varies little with farm size. Most farms in these areas also plant a (commercial) dry season crop of green gram or paddy. In mechanizing, these farmers seek not only to minimize production costs, but to reduce risk (e.g. delayed harvest due to labour shortages resulting in crop damage), and minimize the fallow period between crops.

In contrast, in Mon State, paddy is a more subsistence-oriented crop, with only half of rice producers selling any paddy, and the marketed surplus averages only thirty per cent. In addition, few farms plant a dry season crop of any kind (CESD, IFPRI & MSU 2016). Levels of migration in Mon are much higher than in surveyed townships around Yangon, with almost half of the households in the state having at least one migrant member, ninety-five per cent of whom work in Thailand. Remittances in Mon account for a similar share of household income as agriculture (twenty-two versus twenty-four per cent, respectively) (CESD, IFPRI & MSU 2016), and arguably subsidize farming livelihoods to a large extent. Mechanization was already fairly advanced in Mon State in 2015, with fifty-eight per cent of households using a machine for land preparation, and fifty-seven per cent using a machine for threshing. However, given the context in which it occurs, the logic of mechanization in Mon State appears to have less to do with maximization of returns subject to constraints (as it is in Lower Myanmar), than with assisting an aging population of farmers, who are unable or unwilling to migrate to find higher paying jobs abroad, to stay on the land.

7. Conclusions

Our research reveals extremely rapid agricultural mechanization occurring in four townships close to Yangon. Following decades of stagnation, economic reforms and accompanying urban growth since 2011 appear to have given rise to the beginnings of a structural transformation, in which labour is moving from agriculture to urban industrial and service sectors. In surprisingly short order this shift has led to rural labour shortages and rising wage rates, and a corresponding jump in the use of machinery for land preparation, harvesting and threshing. Of particular note is the finding that the concurrent rise of rental markets for mechanization services has enabled farmers with small and large landholdings alike to access machines, making adoption virtually scale neutral at the point of use, thereby supporting the viability of smallholder agricultural production in the face of rising labour costs. Increasing access to formal financial services and the introduction of transferrable land use rights have also contributed to accelerated sales and the use of agricultural machinery, especially from 2013 onwards. In these respects, the patterns of mechanization observed correspond well with the dynamics predicted by conventional economic theory.

However (as indicated in the preceding section), despite the pervasive influence of these “fundamentals”, the form, pace and depth of mechanization reflect regional geographical variations that include the extent and nature of migration and labour shortages, physical accessibility, logics of production (subsistence versus market), and crop choice (in large part a function of differing agro-ecologies). These findings underline that, despite commonalities in their underlying drivers, contemporary processes of agrarian transition are marked by place-specific diversity, unevenness, and spatial complexity, with often unpredictable outcomes (Rigg and Vandergeest 2012). This chapter demonstrates, along with other research in this volume on Special Economic Zones (Maung & Wells 2018) and on Myanmar’s periphery (Gabusi 2018), that the variable of place is pivotal to understanding the local impacts of Myanmar’s economic and political transformations.

Two important questions for future research remain unanswered. First, is whether the advantages gained by producers able to access agricultural mechanization services are contributing to geographical differentiation in farm competitiveness. This may occur if rental services are concentrated in areas with large numbers of potential users that offer economies of scale to machine services providers (e.g. major rice growing regions in Lower Myanmar and the command areas of large irrigation schemes in the Dry Zone that are well served by combine harvester rentals), but do not reach areas where crop production is more scattered (such as parts of the Dry Zone where rainfed paddy cultivation is dispersed widely). It is also possible that similar patterns of inequality in access to services may emerge at a smaller scale within villages that receive machine rental services, for farms with plots that are difficult for machines to access (e.g. in low lying or waterlogged areas, or those that are particularly uneven, or distant from access roads).

Second, although mechanization evidently offers significant benefits to most farmers, its effects on landless households (who in most parts of Myanmar represent a large part of the rural population, including many of its poorest members) remain unclear. Further analysis is required to determine whether rising rural wage rates, out-migration and emerging opportunities in the rural non-farm economy off-set or exceed any reductions in income caused by the loss of casual work for agricultural wage labourers. Such research would help us understand in more depth the varied and contingent impacts of Myanmar’s mechanization revolution, and has an important

role to play in guiding agricultural, rural development and social policies implemented by Myanmar's new government.

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