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# Rapid Diffusion of Combine Harvesters in Cambodian Rice Farming: A Business Analysis

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## ABSTRACT

Combine harvesters have become widely used in recent years in rice farming in Cambodia on a custom-hiring basis. This study examines factors promoting investment in combine harvesters and the effects of the surge in new entrants in the custom-harvesting business. Analysis of 30 custom harvesters' data collected by the researcher in Takeo province indicates that the high profitability of the business, decrease in interest rate, and increasing price of land used as collateral prompted land-rich households to enter the custom-harvesting business by taking large loans from financial institutions. The secondhand combine harvesters' market in Vietnam has helped custom harvesters to sell their used machines to buy new ones. The surge in new entrants to the business, however, has driven down custom-harvesting service fees and has, thus, made the business unprofitable. This has partly been caused by financial institutions that have continued to provide funds to new entrants without anticipating excessive entry into the custom-harvesting business.

**Keywords:** agricultural mechanization, investment, microfinance, land price

**JEL Classification:** Q12, Q14

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## INTRODUCTION AND BACKGROUND

**A**lthough it is regarded as one of the poorest countries in Asia, Cambodia has experienced a surge in farm mechanization in recent years. Especially noteworthy is the rapid diffusion of combine harvesters in rice farming. The number of harvesters in the country is estimated to have increased from 395 in 2007 to 5,883 in 2015 (MAFF 2008; 2016), and combine harvesters were used in 70 percent of rice fields in the country in 2014 (Saruth, Lytour, and Sinh 2014).

Combine harvesters are used in Cambodia mostly on a custom-hiring basis, as is the case in Myanmar (Belton et al. 2017) and Vietnam (Takeshima et al. 2018). That is, a farmer purchases combine harvesters to get into the business of hiring them out to other farmers to harvest and thresh rice. Machine owners like this farmer are hereinafter referred to as “custom harvesters”.

The use of combine harvesters in Cambodian rice farming has been abetted by increased wage rates and labor shortages in rural Cambodia. However, a question arises as to the factors that may have prompted and enabled farmers to invest in expensive machinery like combine harvesters. There are two aspects to the question. The first has to do with profitability of investing in combine harvesters, a question that has remained largely unaddressed in past research, even outside Cambodia. The second is how farmers could finance the purchase of combine harvesters, which is a critical issue in light of the fact that farmers in developing countries generally find difficulty in accessing financing. Furthermore, the Cambodian government has not provided subsidies for the purchase of farm machinery. Previous studies on farm mechanization in developing countries have not given focused attention to how farmers financed investments in farm machinery. Some studies (Ji, Yu, and Zhong 2012; Mottaleb, Krupnik, and Erenstein 2016; Mottaleb et al. 2017) have only indirectly addressed the issue of financing in the course of comparing the characteristics of farmers who own farm machinery with those farmers who do not.

In the case of Cambodia, a study by Chhun, Bora, and Sothy (2015) found via regression analysis that the value of farm machinery owned by a farm household is positively correlated with the number of days spent working in non-agricultural occupations and the number of household members who migrate to find work. This finding suggests the possibility that income from non-agricultural jobs and remittances from migrating household members help to finance investment in farm machinery, but the study does not examine how the funds for this financing are actually raised. It also does not provide clues as to how farmers could purchase expensive machinery like combine harvesters because the dependent variable of the regression analysis, the total value of farm machines, includes the value of far less expensive machinery, such as water pumps and power tillers.

Also of interest is how the increase in the number of new entrants to the custom-harvesting business affects custom harvesters themselves. Increasing availability of the machines depresses harvesting fees, which is advantageous to farmers, but the reverse for the custom harvesters. Loans financing of their investment could lead to debt problems on the part of custom harvesters. To the author’s knowledge, no previous studies have examined the issues of excess entry or over-investment in custom-hiring services of farm machinery.

Against the backdrop of the issues presented above, this study examines why and how entry into the custom-harvesting business has increased so rapidly in Cambodia, from the viewpoint of the profitability and financing of the business. It also investigates the effect on the custom-harvesting business and on the custom harvesters themselves of the surge in entrants to the business. Special attention is also paid to the key roles played by financial institutions. Besides filling a seeming gap in the literature on farm mechanization in developing countries, the study aims to determine what role(s) the governments of developing countries can and should play in the process of agricultural mechanization.

The increasing use of combine harvesters also strongly affects the economy of farm households as well as rural labor markets. While important, from both policy and conceptual perspectives, these are beyond the scope of this study due to lack of data.

This paper is organized as follows. The second section examines the theoretical basis for the analysis of factors that are expected to promote investment of farmers in farm machinery, and the conditions under which farmers can borrow funds for the investment. It also examines the possibility of over-investment in relation to availability of debt financing. The third section describes the study approach and methodology and data employed in the study. Section 4 describes the nature of the custom-harvesting business in Takeo, while section 5 describes the profile of custom harvesters surveyed and their equipment. Section 6 examines the financing of custom harvesters' investments in combine harvesters, and investigates factors enabling them to raise the substantial funds needed to purchase the expensive equipment. Section 7 examines the effects of increasing competition among custom harvesters and evaluates the profitability of the custom-harvesting business and the changes it has undergone due to increased competition. The final section summarizes the major findings of the study.

## THEORETICAL MODEL

In theory, a farmer would have incentive to invest in a farm machine when the net present value (NPV) of the cash flow from the investment is positive.<sup>1</sup> Farmers are likely to be able to sell the machine (in the secondhand market or for scrap) after it has been used for several years. Thus, the positive cash flows consist of annual revenues earned from hiring out the machine, imputed revenues for using the machine on the

owner's own land, and the resale or scrap value of the used machine when disposed of, net of the loan principal used to purchase the machine. The negative cash flows consist of the own (non-loan) funds used to purchase the machine, the variable cost of operating the machine, interest payments for the loan, the opportunity cost of owner's own funds used in purchasing the machine, and repair costs. Thus, the NPV of the cash flow for a farmer with farm size  $A$  from purchasing a farm machine at price  $K$  by borrowing money in the amount of  $bK$  ( $0 \leq b \leq 1$ ), selling it at price  $S(T)$  and repaying the debt after using it for custom-hiring service for  $T$  years, is expressed as follows:

$$V = -(1-b)K + \sum_{t=1}^T \frac{R(t)}{(1+\rho)^t} + \frac{S(T) - bK}{(1+\rho)^T}$$

where:

$$R(t) = (\rho - c)[Q(t) + A] - D(t) - [r_b b + r_o (1 - b)]K$$

is the net revenue from the custom-hiring service in year  $t$ ,  $r_b$  is the interest rate of the loan, and  $r_o$  is the opportunity cost of farmer's own fund,<sup>2</sup>  $p$  and  $c$  represent the fee and the variable cost of the custom-hiring service per operating area, respectively, and  $Q(t)$  and  $D(t)$  are the operating area and repair cost in year  $t$ , respectively.  $\rho$  is the discount rate.

The larger the value of  $V$ , the stronger the incentive for a farmer to invest in the farm machine. This implies that the investment would increase with the level of the fee ( $p$ ) and the resale price of the machine ( $S$ ). A decrease in the loan interest rate  $r_b$  also makes the investment more attractive. In reality,  $p$ ,  $c$ ,  $Q(t)$ ,  $D(t)$ ,  $S(T)$ , and, hence,  $V$  are uncertain variables, which would reduce the incentive for a risk-averse farmer to invest. On the other hand, the uncertainty can also lead to optimistic prediction of  $V$ .

<sup>1</sup> This abstracts from non-financial and indirect benefits and costs that may be associated with ownership and operation of the machine, such as timeliness of access to the machine (versus having to queue if rented from someone else), prestige, cost of shed/garage to house the machine, etc.

<sup>2</sup> The net revenue from operating on the farmer's own farm is equal to  $(p-c)A$  because the farmer needs to spend  $cA$  for the operation but can save  $pA$  by not using another custom hiring service.

When, however, the machine is expensive (that is,  $K$  is large), the farmer's own fund is not likely to be sufficient to finance the investment, and, hence,  $b$  needs to be increased; in other words, he/she needs to borrow a large amount of money. Taking out a large loan is not easy because lenders generally ration credit to cope with imperfect information regarding the types of borrowers and their behavior (Stiglitz and Weiss 1981). Nevertheless, theory also predicts that no credit rationing will occur if lenders require borrowers to provide collateral of enough value to cover the loss from a possible default (Bester 1985). In the case of Cambodia, microfinance institutions, which, as a whole, are a major source of funds for rural households mainly lend money in the form of individual loans with collateral, not so much in the form of group loans with joint liability, as is typical elsewhere. This suggests the possibility that Cambodian farmers would take out a large loan from microfinance institutions as long as they possess high-value assets acceptable as collateral.<sup>3</sup>

However, large loans secured by collateral may have adverse effects. Collateral reduces the risk on the part of lenders by offsetting losses from default, thus, reducing the incentive to carefully screen loan applicants and their investment projects (Manove, Padilla, and Pagano 2001). This implies that because of the uncertainty of  $V$ , those who (erroneously) expect a high return on their investment will apply for and can also easily borrow a large amount of money, as long as they can provide collateral with sufficient value. Eventually, such borrowers may be unable to repay their debts and lose their assets used as collateral. A custom-harvesting business in rural Cambodia is likely to get into such a situation. Where early entrants in the business appeared to have made a

large profit, and if large loans were available from financial institutions, many farmers would rashly enter the custom-harvesting business by taking out large loans. Consequently, to attract farmer customers, a large number of new entrants in the custom-harvesting market would drastically decrease harvesting fees and, thus, the profitability of the business, which might produce many insolvent debtors.

## STUDY AREA AND METHODOLOGY

The study uses data collected by the author in a survey conducted in February and March 2018 from 30 custom harvesters in Takeo province in southern Cambodia.<sup>4</sup> Takeo province is located 25–110 km south of Phnom Penh and shares a border with Vietnam. With its large tracts of flat land and relatively better access to water compared to other Cambodian provinces, agriculture in Takeo is dominated by rice cultivation. Rice farming in Takeo is characterized by its relatively large share of dry season cultivation and high land productivity, which make the province the second largest rice producer in Cambodia. However, the average farm size in Takeo is much smaller than the national average, perhaps, owing to its high population density. Though the small farm size would suggest a lower necessity for farm mechanization in the province, combine harvesters have become widely used in Takeo in recent years.

In the survey, respondents were asked about their business operation in 2017 as well as for retrospective information on their business before 2017, and the history of ownership of combine harvesters. In the absence of any list of custom harvesters at the time of the study, the author selected 30 custom harvesters non-randomly by going around the province. The limitations of this study include its non-random sampling

<sup>3</sup> Under the regulation of the financial sector in Cambodia, financial institutions are classified into three categories, that is, commercial bank, specialized bank, and microfinance institution. The classification is based neither on loan size nor the type of borrowers, but on the type of financial operations allowed to perform and some prudential regulations to comply with. Hence microfinance institutions can lend loans of up to several thousand US dollars.

<sup>4</sup> The 30 custom harvesters studied were located in the following districts (the number of custom harvesters surveyed is shown in parentheses): Bati (1), Samraong (3), Prey Kabbah (3), Angkor Borey (1), Borey Cholsar (3), Treang (10), Koh Andaet (4), Tram Kok (3) and Kiri Vong (2).

methodology, small sample size, and limited geographical scope. However, these drawbacks are not considered fatal because the study is not aimed at statistically examining the effects of variables, but rather to reveal how custom harvesters finance their investments and to gain qualitative insights into factors behind the rapid diffusion of combine harvesters in Cambodia.

### THE CUSTOM-HARVESTING BUSINESS IN PRACTICE

Based on data collected from the custom harvesters surveyed, this section describes how their business operates.

With their combine harvesters at hand or on order, the first concern of custom harvesters is finding client farmers. There are three methods: (1) waiting for contacts from clients, assuming that the target market is made aware of the availability of a combine harvester for hire; (2) going to rice fields or villages to find clients; and (3) using agents to market the service. The third method is used to find clients in remote regions. Agents look for farmers needing custom-harvesting services and introduce them to custom harvesters in exchange for a referral fee, which in 2017 was around KHR 15,000 (about USD 3.70) per hectare of rice field harvested.

Custom harvesters of rice fields work mostly in the district in which they live. In order not to let their combine harvesters sit idle, many also go to other districts in Takeo as well as in other provinces, including neighboring provinces such as Kampot and Kandal, with some going as far as the northwestern provinces of Pursat and Battambang, to offer their combine harvester services.

After finding clients, the custom harvesters need to move their combine harvesters to the rice fields. If the rice field is near the custom harvester's house, the owner simply drives it to the field. If the rice field is far from the custom harvester's home, the owner hires a truck to transport the combine harvester. Ten out of the 30 custom harvesters surveyed owned trucks with which

they transported their combine harvesters, as well as transported others' custom harvesters for a fee.

Three workers are required for harvesting, threshing and bagging work, including one driver and two workers to put threshed rice in bags. The baggers are required because most combine harvesters used by the custom harvesters surveyed do not have an "unloader" or equipment that sucks and discharges threshed rice from the tank of the combine harvester automatically into ready containers. Without an unloader, threshed rice stored in the tank would be discharged from the tank's outlets before it becomes full of threshed rice. To save time, the combine harvester continues to harvest rice without stopping to discharge threshed rice, and two baggers stand by the tank of the combine harvester and set bags under the spouts to receive the rice grains being discharged. Most custom harvesters surveyed hire such workers. Some owners choose to drive and operate their combine harvester themselves, or have a family member, such as a son or son-in-law, work as driver/operator. As of 2017, the standard wage per hectare for a driver was KHR 20,000 (about USD 4.90) and that for a packer was KHR 10,000 (USD 2.45).

Custom harvesters charge a fee from the client farmers for their services, which include harvesting, threshing, and bagging rice based on the size of the rice field harvested. For the cases of custom harvesters surveyed for this study, the fee was around KHR 300,000 (about USD 75) per hectare in 2017 (Table 1).

### PROFILE OF CUSTOM HARVESTERS

This section presents the basic characteristics of the households of the 30 custom harvesters surveyed, all of which are family-run. Of the 30 households surveyed, 29 are engaged in farming and 10 run non-agricultural businesses other than custom-harvesting. As is common with households in rural Takeo, seven households also have members who commute to factories within the province and 14 households have members who have migrated to work outside the province.

**Table 1. Average fee for custom-harvesting service per hectare (thousand KHR, weighted by the harvested area)**

Year	Total	Wet Season	Dry Season
2011–2014	413	401	441
2015	414	461	290
2016	341	376	254
2017	318	337	239

Source: Data collected by the author from 30 custom harvesters in 2018

Table 2 shows the asset holdings of the custom harvesters' households. Twenty-nine of the 30 households owned farmland, with the average size of 3.44 ha, which is relatively large in Cambodia. According to the agricultural census conducted in 2013, the average size of farmland owned by households is 1.61 ha for Cambodia as a whole, and 0.91 ha for Takeo province (NIS and MAFF 2015). In addition, some custom harvesters also own other farm machines besides combine harvesters, such as a tractor or a truck. These data indicate that the custom harvesters surveyed are relatively better-endowed. However, it could not be determined from the data whether these custom harvesters possessed enough prior resources to invest in combine harvesters, or whether they had accumulated enough assets for the purpose from the custom-harvesting business.

**Table 2. Asset holdings of custom harvesters**

	Average	Percentage of Custom Harvesters Owning the Asset
Farmland (ha)	3.44	97
Cattle (head)	1.00	40
Power tiller	0.47	47
Tractor	0.40	30
Rice mill	0.20	20
Thresher	0.03	3
Motorbike	2.20	97
Passenger car	0.10	10
Truck	0.30	30

Source: Data collected by the author from 30 custom harvesters in 2018

Table 3 shows the data on ownership of combine harvesters of the custom harvesters surveyed. Twenty of the 30 custom harvesters bought their first combine harvester in 2015 or later, which means that most of them started their custom-harvesting business in recent years. The data indicate that the number of custom harvesters increased rapidly from 2015. This implies that the number of entrants in the custom-harvesting business in the province surged in recent years, although it is possible that there had been many entrants even before 2015, inasmuch as the data in Table 3 do not account for those who left the custom-harvesting business by the time of the survey. Some custom harvesters also owned two combine harvesters and used both for their custom-harvesting business.

Although not shown in Table 3, 14 of the 30 custom harvesters reported having replaced their combine harvesters since they first purchased them until the time of the survey in 2018. From this, it may be surmised that the 30 custom harvesters purchased 58 combine harvesters in total, all of which were made by Kubota

**Table 3. Ownership and purchase of combine harvesters 2009-2017**

Year	Total Number of Combine Harvesters	Total Custom Harvesters as of Yearend	Bought First Combine Harvester in the Year
2009	1	1	1
2010	0	0	0
2011	2	2	2
2012	4	4	2
2013	5	5	2
2014	6	6	2
2015	15	14	6
2016	27	22	8
2017	38	29	7

Source: Data collected by the author from 30 custom harvesters in 2018

in Thailand, except for one Yamaha combine harvester. Of those 58 combine harvesters,<sup>5</sup> 46 (79%) were purchased brand new and 12 (21%) were purchased secondhand. The new ones were purchased from farm machinery dealers for an average price of USD 25,611, and secondhand ones were purchased from other farmers for an average price of USD 14,250.

The custom harvesters surveyed generally replaced their combine harvesters frequently. For the 20 combine harvesters sold for which data are available, the period of use, or the period between purchase and sale, was 19 months on average. Even if we exclude three combine harvesters that were sold within one month of purchase and, hence, could be regarded as being purchased for trade, the average period of use was 22 months. For 15 of those 17 combine harvesters, the period of use was less than 36 months. The average sale price was USD 11,164 for 22 combine harvesters, for which, price data are available.

According to the respondents, they sold their combine harvesters because they were already old or broken. Some respondents also told the author that old combine harvesters broke down easily and that they had difficulty in finding clients if their combine harvester was relatively old. Another respondent also said that he would miss opportunities of getting hired if his combine harvester broke down frequently. These findings imply that the combine harvesters of these respondents were replaced frequently to avoid frequent breakdown. Reducing the probability of breakdown would also be a reason why custom harvesters tended to prefer brand new combine harvesters to secondhand ones.

## PURCHASE OF COMBINE HARVESTERS

### Sources of Funds

In Cambodia, there has been no subsidy program by the government or any private organization for the purchase of farm machines; thus, custom harvesters need to finance the purchase of combine harvesters by themselves. Table 4 shows the financing methods used. The figures in the upper half of the table indicate that borrowing money was the most commonly used method. Summing up the cases of “borrowing money (and not selling anything)”, “both borrowing money and selling used combine harvester”, and “both borrowing money and selling assets”, borrowing was used in 73 percent of the purchases. In purchasing the first combine harvester, borrowing was used more frequently (87%) and selling assets was used in only 27 percent of purchases. However, for purchasing the second and subsequent combine harvesters, selling their old combine harvester was resorted to as frequently as borrowing money to buy a new one, with each of them being used in about 50 percent of purchases. Table 4 also indicates that combine harvesters were rarely purchased without borrowing money or selling anything.

In accordance with these data, the lower half of Table 4 shows that when purchasing the first combine harvester, borrowed money accounted for an average of 58 percent of the purchase price of the combine harvester, while proceeds from selling assets accounted for only nine percent of the purchase price. Although not presented in Table 4, of 30 cases of first-time purchases of combine harvesters, borrowed money accounted for higher than 75 percent of the purchase price in 10 cases, and higher than 95 percent of purchase price in seven cases. On the other hand, custom harvesters relied to nearly the same degree on borrowing money and selling used combine harvesters or assets, when purchasing the second and subsequent combine harvesters.

In 10 cases (for six custom harvesters) a portion of the funds came from co-investors, most of whom were relatives of the custom harvester.

<sup>5</sup> The 58 combine harvesters include Kubota DC70, DC70G (both with 69 horsepower (hp) each with a harvesting capacity of 0.30–0.70 ha/hour), and DC68 (no data available) as well as Yamaha AW82V (80.8 hp and 0.71 ha/hour).



**Table 4. Source of funds for the purchase of combine harvesters**

	First Combine Harvesters	Second and Subsequent Combine Harvesters	Total
<b>Number of purchases<sup>a</sup></b>	30	26	56
<b>Percentage of cases by source of funds (%)</b>			
Borrowing money <sup>b</sup> (and not selling anything)	66.7	30.8	50.0
Selling used combine harvester (and not borrowing money)	–	26.9	12.5
Selling assets (and not borrowing money)	6.7	3.8	5.4
Both borrowing money and selling used combine harvester	–	23.1	10.7
Both borrowing money and selling assets	20.0	3.8	12.5
Neither borrowing money nor selling anything	6.7	11.5	8.9
<b>Average rate of dependency on each source of funds (%)<sup>c</sup></b>			
Borrowing money <sup>b</sup>	58.1	36.6	47.9
Selling used combine harvester	–	29.2	13.8
Selling assets	8.8	3.6	13.8
Funds from co-investors	8.0	1.9	5.1
Other <sup>d</sup>	25.2	28.6	26.8

Source: Data collected by the author from 30 custom harvesters in 2018

<sup>a</sup>In two cases, two combine harvesters were purchased at the same time.

<sup>b</sup>Including hire purchase

<sup>c</sup>Average ratio of the amount raised by each source of funds to the price of the combine harvester (%)

<sup>d</sup>Defined as the difference between the purchase price and the sum of the amount raised by the four sources mentioned in the upper lines

Although not shown in Table 4, there were also cases in which income earned by migrant labor in the family was used. In at least five cases, the purchase was financed partly or wholly by income that the custom harvester or his/her spouse earned in South Korea. In another two cases, the custom harvesters borrowed money without interest from their sisters or child, who had migrated for work to Thailand or Phnom Penh.

### Loan Financing

What led custom harvesters to rely on loans to purchase combine harvesters? The reason could be that financial institutions provided them a large loan at a relatively low interest rate with a long repayment period.

Of the 56 total cases of purchase of combine harvesters, 41 purchases were financed by loans. Of those 41 cases, in 35 cases, custom harvesters borrowed from formal lenders, these being

financial institutions that included three banks, six microfinance institutions, and two consumer credit companies providing hire purchase finance. In 12 cases, money was borrowed from informal lenders, all but one of whom was the relative of the custom harvester (seven of those 12 cases had the loans obtained from both formal and informal lenders). There was no case where custom harvesters borrowed or resorted to a hire purchase loan from machine dealers.

Informal loans were provided under soft conditions, as the repayment period was not set, and all but one loan was interest-free. However, the conditions on formal loans were also attractive to borrowers. The average interest rate for formal loans was 1.37 percent per month, which is much lower than the standard interest rate of microfinance in rural Cambodia in the early 2000s, which ranged from 3.0–4.0 percent per month (Yagura 2008). The repayment period averaged 41

months, extending up to 48 months or longer for 44 percent of the formal loans. The most notable feature of formal loans was their relatively large size. While the average loan size was USD 4,538 for informal loans, average size for formal loans was almost 4 times at USD 16,436.

This loan size is significantly large for microfinance in Cambodia. According to the data compiled by the Cambodia Microfinance Association (CMA), the average size of loans provided by microfinance institutions in Cambodia was USD 2,302 as of the end of 2017.<sup>6</sup> However, the large loan size is in line with the commercial orientation of microfinance institutions in Cambodia. According to the same CMA data, from 2008 to 2017, while the number of borrowers increased 2.2 times from 825,238 to 1,849,246, the average loan size increased 6.9 times, from USD 336 to USD 2,302. In fact, the number of borrowers stopped increasing from 2015, but microfinance institutions expanded their business by enlarging the loan size per borrower.

Furthermore, as indicated in Table 5, for formal loans taken by the custom harvesters surveyed, repayment periods have become longer and interest rates have fallen in recent years. In other words, conditions for loans from financial

institutions have changed in such a direction as to make investment in combine harvesters more attractive. In this regard, it must be noted that the recent decrease in the interest rate is not directly related to government regulation. In April 2017, the Cambodian government started to cap loan interest rates at 18 percent per year, which corresponded to 1.5 percent per month. However, as shown in Table 5, the decrease in the rate of interest charge on the custom harvesters started a year earlier, in 2016, when the rate was even lower than the cap.

To examine the effect of the reduction in the interest rate, a regression model was estimated based on 56 cases of machine. Size of the loan taken from financial institutions to purchase the combine harvesters was regressed against a dummy variable taking a value of one if the combine harvesters were purchased in or after 2016, along with other explanatory variables.<sup>7</sup> Apart from linear regression using ordinary least squares (OLS), a Tobit model was also applied because the value of the dependent variable is zero (i.e., no loan was obtained from financial institutions) in 20 cases.<sup>8</sup> As indicated by the estimation results (Table 6), for combine harvesters purchased in 2016 or later, the size of the loan was estimated to be larger by USD 6,300 based on the Tobit model, and USD 6,070 based on OLS, compared to those purchased before 2016, with the difference being statistically significant.

Though the increase in the loan size since 2016 could also be attributable to other factors not considered here, this result is consistent with

**Table 5. Terms of loans from financial institutions**

Year	N	Loan size (Thousand USD)	Repayment Period (Months)	Monthly Interest Rate (%)
2009–2014	6	16.8	33.0	1.57
2015	7	11.6	39.4	1.56
2016	8	16.9	43.5	1.27
2017	11	20.1	48.0	1.19

Source: Data collected by the author from 30 custom harvesters in 2018

Note: The figures are the average of loans taken by the custom harvesters surveyed in the respective year(s).

<sup>6</sup> This data is presented in the annual report of AMK, one of the major microfinance institutions in Cambodia (AMK 2017).

<sup>7</sup> In this regression analysis, characteristics of custom harvesters such as asset size are not controlled because only the data as of 2018 is available. Therefore, the estimation result can also be interpreted as an indication that those who purchased combine harvesters in or after 2016 tended to have smaller own funds or assets to sell and, hence, needed to take larger loans. Even in that case, however, the decline in the interest rate is considered to induce those less affluent households to invest in combine harvesters by relying on loans.

<sup>8</sup> OLS is also applied because the maximum likelihood method, which is used for the Tobit model, suffers from small-sample bias.

**Table 6. Results of regression analysis of determinants of the size of a formal loan**

	Tobit		OLS
	Coefficient	Marginal Effect	Coefficient
Purchased in or after 2016 (dummy)	9.51** (4.01)	6.30** (2.81)	6.07** (2.88)
ln (purchase price of combine harvester)	36.60*** (11.21)	25.38*** (7.91)	16.88*** (4.50)
1st combine harvester (dummy)	4.44 (3.30)	3.07 (2.22)	2.84 (2.08)
Constant	-117.14 (37.59)		-47.97 (14.31)

Notes:  $N=56$ . Significance level: \*\*5%; \*\*\*1%. The loan size and the price of combine harvester are expressed in thousand US dollars, deflated by GDP deflator. Figures in parentheses are cluster-robust standard errors, with the custom harvester as the cluster unit because some custom harvesters purchased more than one combine harvesters.  
ln = natural logarithm

the argument that the decrease in the interest rate induced custom harvesters to borrow more from financial institutions to buy combine harvesters.

Regarding loan size, a sharp rise in land prices appears to have enabled custom harvesters to obtain large loans from financial institutions. When loan size is large, financial institutions including microfinance in rural Cambodia lend only in the form of individual loans, not group loans. In such cases, borrowers of individual loans are required to pledge collateral, with farmland generally used as collateral in rural areas.<sup>9</sup> Because the maximum loan size is determined by the value of the collateral, rising land prices enable rural households to access larger loans even with no change in their landholding size. Custom harvesters in five cases surveyed sold their rice fields to buy a combine harvester, and the sales price of the fields averaged USD 13,118 per hectare. Land prices drastically increased in the past decade, with rice

fields in Takeo having sold for only around USD 1,000 per hectare in 2002 (Yagura 2005).<sup>10</sup> The significant increase in land price greatly reduced the size of rice fields necessary to borrow enough money to buy a combine harvester. Assuming that the price of a rice field is USD 13,118 per hectare based on the above data, and that financial institutions can lend money up to 75 percent of the value of collateral,<sup>11</sup> a custom harvester needs

<sup>9</sup> Since the dissolution of collective farming in the early 1980s, farmlands had been de facto private property in Cambodia. The Land Law that took effect in 2001 formally recognizes the private ownership of a farmland and sets out the rules for using immovable property including farmland as loan collateral.

<sup>10</sup> Even if discounted by the inflation rate, the land price has increased to a large degree. Rice fields were sold in five cases, which included two cases in 2015, one case in 2016, and two cases in 2017. The inflation rate from 2002 to 2016 in Cambodia was 170 percent based on the GDP deflator and 200 percent based on consumer price index and, hence, USD 13,118 in 2016 is roughly equal to USD 7,000 at 2002 constant price.

<sup>11</sup> This lending policy corresponds to that of a bank and two microfinance institutions, the sets of information which were collected by the author through interviews with the managing staff of branches of those financial institutions in Pursat Province on August 15 and 16, 2017. In addition, according to the lending policy of those financial institutions, a formal certificate of land ownership is not necessary to use a plot of land as collateral; any documents indicating the ownership of the plot will suffice. The loan ceiling is also determined solely by the price of land and not affected by whether the borrower has the formal certificate.

to have at least 2.6 ha of rice field as collateral for a loan to wholly finance the purchase of a combine harvester priced at USD 25,611. In fact, the custom harvesters surveyed owned an average of 3.4 ha of farmland, as shown above. This suggests that such was the landholding size necessary for respondents to borrow enough money from financial institutions to purchase a combine harvester. With the significant increase in land price, one can expect that they could now borrow enough money with only around 3 ha of rice fields. On the other hand, if the price of rice fields was as low as USD 1,000 per hectare as in 2002, 30 ha of rice fields would have been needed in order to borrow enough money to buy a combine harvester at USD 25,000.

### Frequency of Replacement

As argued earlier, many custom harvesters sold their used combine harvesters to partly finance

the purchase of their second and subsequent combine harvesters. As shown in Table 7, they sold assets such as rice fields and cattle when they purchased their first combine harvester,<sup>12</sup> but they mostly sold their used combine harvesters to buy their second and subsequent combine harvesters. The sales price of combine harvesters sold for replacement was USD 11,000 on average, which can cover about 43 percent of the price of a brand-new combine harvester.

As discussed in section 4, the custom harvesters surveyed generally replaced their combine harvesters frequently. This might suggest that they have been able to make enough profit from their custom-harvesting business within a short period of time, but this does not always seem to be the case. As Table 4 shows, when buying the second and subsequent combine harvesters, a combination of proceeds from resale of combine harvesters and borrowed money was used in

**Table 7. Used combine harvester and assets sold to purchase new combine harvester**

	Number of Cases for which the Respective Asset was Sold		Average Sales Price (Thousand USD)
	For purchasing First combine harvester	Second or subsequent combine harvester	
<b>Used combine harvester</b>	–	13	10.9
<b>Assets</b>			
Rice field	4	1	6.5
Cattle	3	0	2.8
Gold	3	0	4.9
Tractor	1	1	13.3
Power tiller	1	0	1.8
Passenger car	1	0	6.5
Other land	1	0	NA

Source: Data collected by the author from 30 custom harvesters in 2018.

Note: "NA" indicates that the data is not available.

<sup>12</sup> Five custom harvesters sold their rice fields to buy their combine harvesters, but they sold only a part of their total rice field and did not abandon farming. This means that their motivation was not to switch occupation but to diversify their occupation.

23.1 percent of the cases. This indicates that their custom-harvesting business could not make enough profit and that they replaced their combine harvesters only because their combine harvesters were no longer reliable, or broken, as suggested by respondents themselves (see section 4).

Who were the used combine harvesters sold to? It cannot be taken for granted that buyers for used combine harvesters could be readily found and could be sold at a favorable price. That custom harvesters tend to replace their combine harvesters frequently suggests that many secondhand combine harvesters are offered for sale in Takeo. On the other hand, custom harvesters generally expressed preference for brand-new combine harvesters over secondhand ones. The likely answer is that the used machines find their way outside the province of Takeo. Indeed, there is evidence suggesting that used combine harvesters are finding their way to Vietnamese farms.

Of 23 combine harvesters sold by custom harvesters surveyed, only two were sold to Cambodian farmers and the other 21 were sold to traders. Of the latter, 10 combine harvesters were sold to Vietnamese traders and the other three were sold to Cambodian traders accompanied by Vietnamese traders. Most of the combine harvesters sold to these traders are considered exports to Vietnam because there are dealers buying used combine harvesters in Cambodia and exporting them to Vietnam. Two such dealers near the Cambodia-Vietnam border in Takeo province were found by the author.

It appears, then, that the secondhand market in Vietnam made it easy to find buyers for used combine harvesters in Takeo. Demand for used combine harvesters was boosted by the demand from the Vietnamese side, which helped raise their selling price in Takeo even in the face of a large local supply of used combine harvesters. This situation not only made it possible for custom harvesters to replace their combine harvesters frequently, but also induced investment in combine harvesters by increasing the profitability of the custom-harvesting business, based on the theoretical model presented in section 2.

## INCREASED COMPETITION AND PROFITABILITY

### Competition and Declining Rental Fees

Table 1 shows the average fees for custom-harvesting services—harvesting, threshing and bagging paddy rice—per hectare of rice field weighted by the harvested area. The fee level has decreased sharply since 2015 for the dry season, and since 2016 for the wet season.<sup>13</sup> Although not shown in Table 1, the fee levels do not differ much between Takeo province and other provinces; that is, the fee levels have similarly declined across all Cambodia.

The decline in the fee level coincided with the increase in new entrants to the custom-harvesting business, which is indicated in Table 3. However, demand for custom-harvesting services is likely to have increased within the same period during which farmers in Takeo province started to replace manual labor with combine harvesters. This indicates that the increase in the supply of custom-harvesting services exceeded the increase in demand, which further suggests that competition among custom harvesters had intensified since 2016.

Table 8 shows the scale of operation by custom harvesters surveyed. While the averages of total annual harvested area and for the wet season do not show a clear time trend, average total

<sup>13</sup> There are two possible reasons why the fee level in the dry season is lower than that in the wet season. First, total cultivated area of rice is much smaller in the dry season than in the wet season in Takeo province as well as in Cambodia as a whole. This means that competition among custom harvesters is more intense in the dry season than in the wet season. Second, harvesting dry season rice consumes less time and fuel than wet season rice, because in the dry season the soil of rice fields is dry and because high-yield varieties, which have short culm and are less likely to lodge, are generally grown in the dry season.

**Table 8. Scale of the operation by custom harvesters**

Year	Average Annual and Seasonal Total Harvested Area (ha) <sup>a</sup>			Proportion of Custom Harvesters Who Operated in the Respective Region (%) <sup>a</sup>		
	Yearly total	Wet season	Dry season	District of residence <sup>b</sup>	Other districts in Takeo	Other provinces
2011–2014	222	156	165	100	0	0
2015	259	188	112	100	14	36
2016	212	151	85	86	36	41
2017	248	199	69	90	30	57

Source: Data collected by the author from 30 custom harvesters in 2018

<sup>a</sup>Calculated for custom harvesters who owned a combine harvester in the respective year

<sup>b</sup>The district in which the custom harvester resides

harvested area for the dry season clearly declined.<sup>14</sup> It is also evident that even as custom harvesters mainly operate in their district of residence, the proportion of them operating outside their district of residence has increased steadily. Though there is a possibility that the rice production in the dry season in 2016 and 2017 decreased in Takeo province, which may have been instrumental in the decline in the area of the operation by custom harvesters, the data suggest that increased competition among custom harvesters had made it more difficult for the custom harvesters to find business in their district of residence, thereby driving them to find clients in other regions.

While the increasing competition among custom harvesters and the resultant decline in the fee level are advantageous to farmers hiring the

custom-harvesting service, there is a reverse effect on custom harvesters. In the survey, 27 of the total 30 respondents answered that they had at least one problem in their custom-harvesting business. The 27 respondents all indicated “decrease in the fee,” “increasing competition”, or “increasing difficulty in finding clients” as a problem they faced. Of these three problems, “decrease in the fee” was mentioned by 23 respondents and the other problems were each cited by 10 respondents.

### Changing Profitability

In this section, we estimate income obtained from the custom-harvesting business, and the internal rate of return (IRR) on the investment in a combine harvester. We then evaluate the change in the level of the income and IRR between 2015 and 2017, to examine the effect of the decline in the fee level. The estimation is not performed for each custom harvester surveyed, but only a single value of income and IRR are calculated based on the average values of cost and revenue data collected from the custom harvesters surveyed. This method was adopted because the depreciation of the combine harvester, one of the items accounting for fixed cost, could only be estimated by the regression method using the data of all custom harvesters surveyed. Another reason was that data on the cost of repair and machine oil for combine harvesters were unavailable for many custom harvesters surveyed, and appeared to include errors where the data were available.

<sup>14</sup> The average operation area has not decreased in the wet season probably because, unlike in the dry season, the use of custom-harvesting service has not been widespread in the wet season by 2014 and, hence, the increase in the supply of custom-harvesting services was offset by the increase in the demand in the wet season. The late diffusion of the use of combine harvesters in the wet season seems to be related to smaller farm size. In Takeo province, the wet season rice cultivation is practiced mostly in regions where rice can be grown only in the wet season because of the lack of irrigation in the dry season. Compared with regions where the dry season rice cultivation is possible, those regions seem to have smaller farm size per farm household and hence labor shortage might be less serious. Another possible reason is that farmers who grow rice only in the wet season can spend more time in harvesting because they do not prepare for the dry season after the harvesting work.

The calculation was performed based on several assumptions. A custom harvester is assumed to purchase a brand-new combine harvester at USD 24,168, use it for 24 months and then sell it at USD 11,602. The purchase price is derived from the average price of a brand-new combine harvester purchased in 2016 by the custom harvesters surveyed. The resale price is estimated by the least square method using the data on 17 cases of resale of combine harvesters earlier mentioned under the section on profile of combine harvesters.<sup>15</sup> The resale price of USD 11,602 is estimated using the result of the regression analysis at the purchase price of USD 24,168 and the period of use of 24 months. Depreciation, which is defined as the decrease in value of the machinery per year, is half of the difference between the purchase price (USD 24,168) and the sales price (USD 11,602), given the average 24 months of usage of the machines. For harvesting fees in 2015 and 2017, the average value for the year weighted by the harvested area is used. For cost items, the average values in 2017 are used in the estimation for 2017. The average values in 2017 are also used in the estimation for 2015, except for the fuel cost, for which 1.12 times the cost in 2017 is used to reflect the change in fuel price between the two years. These assumptions are made not only because the cost data from 2015 are not available, but also to examine the net effect of the change in the fee level. Imputed wage of family labor is regarded as cost when estimating IRR, but it is not included in the cost when calculating income. In fact, family labor input is small on average and, hence, whether the imputed wage of family labor is included in the cost or not, does not affect the result significantly. Cost and revenue items expressed as Cambodian riels (KHR) are converted into USD using the annual average of exchange rate for the respective

years (USD 1.0 was equal to KHR 4,067.8 in 2015 and KHR 4,050.5 in 2017).

The income of a custom harvester is estimated for three cases according to how the purchase of the combine harvester was financed: (1) no money was borrowed; (2) 65 percent of the purchase price of the combine harvester was borrowed; and (3) 100 percent of the purchase price was borrowed. Sixty-five percent is the average rate of dependence on loans from financial institutions for 12 cases of purchasing a brand-new, first combine harvester in 2016 and 2017. For (2) and (3), a loan is assumed to be taken from a financial institution with a monthly interest rate of 1.27 percent, which was the average interest rate of the loans taken from financial institutions by the surveyed custom harvesters in 2016. This means that, for (2) and (3), income is net of interest payments. IRR is estimated only for case (1).

The estimated values for income and IRR are shown in Table 9. Based on the fee level in 2017 (USD 79 or KHR 318,000 per hectare), a custom harvester is estimated to earn USD 4.20 per hectare of operation, USD 14.30 per operating day, and USD 815.00 per year, if he/she can finance the investment without borrowing money. This income level is not low given that the daily wage of agricultural hired workers is around USD 5.00. However, the income level is not high given the size of investment involved. IRR is only 2.7 percent per annum, indicating that the custom-harvesting business would not be a worthwhile investment where the monthly loan interest rate is about 1.2 percent. This implies that a custom harvester would lose money due to interest payments if he/she takes a large loan from a financial institution to fund the investment. The borrower would be unable to repay the loan and could lose the land used as collateral.

It may be noted that profitability is low because the custom-harvesting fee has decreased. As shown in Table 9, based on the 2015 fee level of USD 102 or KHR 414,000 per hectare, IRR would be as high as 20.1 percent. The estimated income of a custom harvester without interest payment is USD 25 per hectare of operation, USD 85 per operating day and USD 4,832 per year.

<sup>15</sup> Concretely, the sales price of the combine harvester is regressed on the purchase price, (the logarithm of) the period of use (in months), a dummy variable (based on the reasons for selling) taking the value of 1 if the combine harvester was already broken and 0 if it was sold for other reasons, and dummy variables representing the districts of residence of custom harvesters.

**Table 9. Estimated income and internal rate of return**

	2015	2017
<b>Fee (USD/ha) (A)</b>	102	79
<b>Area harvested (ha)</b>		
Per year (B)	193	193
Per operating day (C)	3.4	3.4
<b>Cost</b>		
Variable cost (USD/ha) (D) <sup>a</sup>	34	32
Fixed cost (USD/year) (E) <sup>b</sup>	8,174	8,139
<b>Income (without interest payment)</b>		
Per area harvested (USD/ha) (F = A – D – E/B)	25.1	4.2
Per operating day (USD/day) (G = F × C)	84.7	14.3
Per year (USD/year) (H = F × B)	4,832	815
<b>Income (net of interest payment) (USD/year) by the rate of dependence on loan<sup>c</sup></b>		
65%	2,437	–1,580
100%	1,152	–2,865
Internal rate of return (IRR) (% per annum)	20.1	2.7

<sup>a</sup> Variable cost includes fuel cost, wage of hired workers, cost of meal for workers, and cost of transporting combine harvesters to rice fields. Imputed wage for family labor is not included in the cost shown in this table.

<sup>b</sup> Fixed cost includes cost of oil, repair and depreciation of the combine harvester.

<sup>c</sup> Loan interest rate is assumed to be 1.27 percent per month. The rate of dependence is defined as the ratio of the amount borrowed to the price of the combine harvester.

The income level would still be as high as USD 1,152 per year net of interest payment even with 100 percent loan financing for the investment.

These results of our analysis suggest that many newcomers started their custom-harvesting business in 2015 and 2016 by taking large loans from financial institutions because the business appeared very lucrative at that time, thanks to the high fee level. Seen from another perspective, the decline in the interest rate since 2016 is also considered to have increased the number of new entrants who relied heavily on loans for investments. For example, if the interest rate is 1.57 percent, which is the average rate for 2009–2014, and the investment is wholly financed by a loan from a

financial institution, the annual income net of interest payment is merely USD 274. The decrease in the interest rate therefore has boosted the attractiveness of the custom-harvesting business.

On the other hand, the surge in the number of new entrants to the custom-harvesting business has driven down the harvesting fee level and, hence, drastically reduced the profitability of the business. In this sense, there has been excessive entry into the custom-harvesting business. The increasing number of new entrants was encouraged by the availability of large loans from financial institutions. As is suggested by the theoretical discussion under the section on theoretical model, financial institutions might have failed to carefully consider the possibility of excessive entries because loans had been secured by collateral. This argument is also supported by the fact that 24 out of 36 loans taken from financial institutions by the custom harvesters surveyed were provided by only three financial institutions, of which, one institution gave 14 loans and each of the other two institutions provided five loans. Those institutions continued to supply funds for the custom-harvesting business even though they could have anticipated the surge in the number of new entrants to the business, and its consequent effect on profitability of the business. In short, imprudent lending by some financial institutions might have caused excessive entries into the custom-harvesting business.<sup>16</sup>

The substantial decline in the profitability leads the author to predict a decline in the number of new entrants to the custom-harvesting business, and an increase in the number of those who will exit. In fact, during the survey in Takeo, one respondent cited the case of another custom harvester who reportedly quit the business because

<sup>16</sup> The effect of government policy is out of the scope of this study. But it is unlikely that government policy has caused the aggressive lending behavior of the financial institutions, because the Cambodian government has imposed regulations on all financial institutions regarding credit risk management, such as credit grading and a loan loss provision, which seem strict enough by international standards. There is also no special treatment by the government to any financial institution, including the three financial institutions that provided loans to the custom harvesters surveyed.



of low profitability. One can also reasonably predict that owing to low profitability, an increasing number of custom harvesters will end up unable to repay their loans from financial institutions, and lose their land to foreclosure.

## CONCLUSION

In recent years, the use of combine harvesters on a custom-hiring basis has become popular in rice farming in Cambodia. Using data on 30 custom harvesters in Takeo province, this study examined the increasing number of newcomers entering the custom-harvesting business in recent years, from the standpoint of the profitability of the business and of factors affecting financing of investments in combine harvesters. It also investigated the effects of the increase in the supply of custom-harvesting services on the custom harvesters themselves. The major findings are summarized below.

First, custom harvesters are mostly land-rich, and many of them had taken out large loans from financial institutions to buy their first combine harvester to start their business. Taking out a large loan was facilitated by the upsurge in the price of land, which was used as loan collateral. Loan financing of the investment was facilitated by the improved conditions of formal credit, as manifested by a decrease in the interest rate and increase in the repayment period.

Second, custom harvesters tend to prefer brand-new combine harvesters to used ones and replace their combine harvesters as frequently as once every two years on average, to avoid breakdown. Frequent replacement has been made possible by the demand for used combine harvesters in the secondhand market serving Vietnamese farmers.

Third, as the surge in the number of new entrants to the business has intensified competition among custom harvesters, the fee level has declined since 2015–2016, and custom harvesters are forced to search for clients in increasingly remote areas. Fourth, the profitability of the custom-harvesting business was estimated to be very high at least in 2015 because of high fees, which appeared to

induce many newcomers to enter the business even by obtaining large loans from financial institutions. Declining interest rates further encouraged new entrants. By 2017, however, profitability was estimated to be very low owing to the decline in the fee level and an accompanying decline in the number of clients per individual custom-harvesting business. By then, investment in the business had become largely unattractive.

Finally, by making ample loan funds available to custom harvesters, financial institutions played a key role in the rapid diffusion of combine harvesters. However, they also attracted excessive entry into the business as they continued to provide loans to new entrants secured by collateral, failing to give adequate consideration to the resulting declining prospects in the custom-harvesting service market.

At least two policy implications may be drawn from these findings. First, to promote agricultural mechanization, governments of developing countries need not provide extraordinary financial support to farmers for mechanization, as long as farmers have good access to credit and investment in mechanization services generates visibly high returns. In Cambodia, credit to farmers is also generally provided by private financial institutions without government subsidies, suggesting that governments can better focus on creating an environment for private financial institutions to expand loan availability to farmers with favorable terms.

Second, governments could play some role in curbing excessive investment in farm machines, especially as encouraged by excessively relaxed lending by financial institutions.

The findings of this study are based on a relatively small sample of custom harvesters in one province of Cambodia. Further studies are required to confirm whether they hold true for the custom-harvesting business in other provinces of Cambodia in general. This study has examined rice farm mechanization from the point of view of a business analysis on provision of custom machine harvesting services. To round up the picture, separate research also needs to be undertaken on the effect of the diffusion of combine harvesters on rice farming and the rural economy in Cambodia.

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