# ADOPTION OF AGRICULTURE MECHANIZATION ON PADDY FARMERS IN INDONESIA: DEMOGRAPHIC DETERMINANTS, INTERNET ACCESS INFLUENCE, AND THE IMPACT OF ADOPTION ON THE YIELD

**K Kadir[1], O R Prasetyo[2]**

[1,2]Statistics Indonesia; Directorate of Food Crops, Horticultura and Estate Crops Statistics
e-mail: kadirsst@bps.go.id

**Abstract**

This study aims to identify the demographic determinants of the agriculture mechanization adoption on paddy farmers in Indonesia and the impact of internet use by farmers on the probability of being adopters. Besides, it also analyses the difference in the average paddy yield cultivated by adopters and non-adopters to determine the adoption impact on agricultural productivity. We found that farmers' level of education and age significantly impacts the probability of being adopters. However, the magnitude of the age impact tends to be diminishing with the increase in age. The probability of being adopters is affected significantly by gender, region, and the farm scale. Male farmers tend to be more likely of being adopters than their female counterparts. Farmers in Java have a slightly higher probability of being adopters than farmers outside Java. Adopting agriculture mechanization also has a positive association with the farm scale, where the larger the farm scale, the more likely the farmers are to be adopters. Our study also found that internet use positively and significantly impacts the farmers' probability of being adopters. Moreover, our study also confirmed a strong indication that the mechanization adoption affects the paddy yield positively indicated by the higher paddy yield average of adopters than non-adopters. Therefore, boosting the adoption of mechanization must be done, for instance, by attracting young people with high education to get involved in agriculture and up-scaling the implementation of tools and agricultural machinery assistance facilitated by the government.

**Abstrak**

Penelitian ini bertujuan untuk mengidentifikasi determinan demografi adopsi mekanisasi pertanian pada petani padi di Indonesia dan dampak penggunaan internet oleh petani terhadap peluang menjadi adopter mekanisasi. Selain itu, penelitian ini juga menganalisis perbedaan rata-rata hasil panen padi yang diusahakan oleh adopter dan non-adopter untuk mengetahui pengaruh adopsi mekanisasi terhadap produktivitas pertanian. Kami menemukan bahwa tingkat pendidikan dan usia petani secara signifikan mempengaruhi kemungkinan menjadi adopter. Namun, besarnya dampak usia cenderung berkurang dengan bertambahnya usia. Probabilitas menjadi adopter dipengaruhi secara signifikan oleh jenis kelamin, wilayah, dan skala pertanian. Petani laki-laki cenderung lebih mungkin menjadi adopter disbanding petani perempuan. Petani di Jawa memiliki peluang yang sedikit lebih tinggi untuk menjadi adopter dibandingkan petani di luar Jawa. Adopsi mekanisasi pertanian juga memiliki hubungan positif dengan skala usaha tani, di mana semakin besar skala usaha tani maka semakin besar kemungkinan petani untuk menjadi adopter. Studi kami juga menemukan bahwa penggunaan internet berdampak positif dan signifikan terhadap kemungkinan petani mengadopsi mekanisasi. Selain itu, penelitian kami juga mengkonfirmasi indikasi kuat bahwa adopsi mekanisasi mempengaruhi produktivitas padi secara positif yang ditunjukkan oleh rata-rata hasil padi yang lebih tinggi pada petani yang mengadopsi mekanisasi dibanding yang tidak mengadopsi. Oleh karena itu, mendorong adopsi mekanisasi harus dilakukan, misalnya dengan menarik generasi muda berpendidikan tinggi untuk terlibat dalam pertanian dan meningkatkan implementasi bantuan alat dan mesin pertanian yang difasilitasi oleh pemerintah.

## INTRODUCTION

Indonesia faces a challenge of domestic food demand, especially rice, that continues to grow with the population growth. The rice consumption per capita of the country is still high, reaching around 112 kg per capita [1]. Without a considerable measure to enlarge its rice production capacity in response to this challenge, Indonesia will mostly rely on rice importation in the future. Technically, agricultural land expansion and boosting productivity are two ways to increase rice production capacity [2]. However, the paddy field conversion to non-agricultural uses happening quite massively in recent years makes the last measures the key to boosting the yield.

One way to increase farmers productivity is the adoption of agricultural mechanization. It can be defined as measures to increase agricultural production by applying implementations, tools, and agricultural machinery [3]. Food and Agriculture Organization (FAO) defines agricultural mechanization as measures to improve agricultural labour productivity by applying implementations, tools, and agricultural machinery [4]. It can be applied to pre-harvest, harvest, and post-harvest activities.

Ruslan [2] found that Indonesian farmers' adoption of agricultural mechanization resulted in a 16 per cent higher paddy yield. One channel through which agricultural mechanization increases productivity is by reducing the harvest losses. A pilot study conducted by Statistics Indonesia (BPS) and the Ministry of Agriculture pointed out that combined harvester assistance distributed to farmers increased the paddy yield significantly [2]. The crop-cutting survey results conducted by BPS show that the paddy yield cultivated by farmers adopting mechanization was higher than cultivated by non-adopters [5]. Unfortunately, the level of agricultural mechanization in Indonesia is still not optimal. As captured by the Intercensal of Agricultural Survey results in 2018, the proportion of non-adopters was still high, amounting to 36 per cent of the total paddy farmers in Indonesia.

Olaoye & Rotimi [6] stated that critical factors for the success of mechanization include socio-economic factors, supporting infrastructures, land conditions, skill, and technical services. Meanwhile, according to GC et al. [7], the adoption of agricultural mechanization has a strong connection with socio-economic and environmental factors and regulation mechanisms.

There are also plenty of studies analyzing the influence of demographic characteristics such as age, gender, and level of education on the adoption of agricultural mechanization [7–11]. Meanwhile, GC et al. [7] studied the impact of internet use on agricultural mechanization adoption in Nepal.

To the best of our knowledge, a study elaborating the results of a nationwide agricultural survey about the demographic determinants of agricultural mechanization adoption in the Indonesian context and the influence of internet use on the adoption is not yet conducted. Studies on agricultural mechanization adoption have only been conducted in the regional context, such as [12] in Talang Sari village, Banyuasin district. This study aims to fill the gap by analyzing the Intercensal of Agricultural Survey (SUTAS) results conducted by BPS nationwide in 2018. This study tries to identify the demographic determinants of agricultural mechanization adoption on paddy farmers in Indonesia and the influence of internet use on the probability of farmers being adopters. In addition, this study also analyzed the difference in the average paddy yield cultivated by adopters and non-adopters to figure out the indication of the adoption impact on agricultural productivity.

## METHODOLOGY

This study elaborated microdata of SUTAS conducted by BPS nationwide in 2018. The data contains 1,349,716 farmers sample cultivating paddy (dryland and wetland paddies) from May 2017 to April 2018. The survey is a household approach survey. A farmer in this study refers to the main farmer in a selected household with the highest production. The survey results show that the average number of farmers in each agricultural household was 1.2, meaning that the use of the main farmers is a good proxy for the total number of farmers. A logistic regression model was applied to the data to identify the demographic characteristics influencing the probability of a farmer adopting agricultural mechanization. A logistic model was chosen since the dependent variable in this study is a binary response variable [13]. The model is a choice model based on random utility [14] denoted as follows:

$$U_i = \alpha + \boldsymbol{x}_i'\boldsymbol{\beta} + \varepsilon_i \tag{1}$$

In this study, Equation (1) models the utility level of each farmer from adopting agricultural mechanization in paddy cultivation based on farmer characteristics ($\boldsymbol{x}_i'$). $\boldsymbol{x}_i'$ is a vector containing farmer characteristics such as age, gender, level of education, type of paddy variety, internet use, region, and harvested area during a year. $\boldsymbol{\beta}$ is a vector of parameters to be estimated, and $\varepsilon_i$ is an error component. The probability of a farmer being an adopter was estimated by taking into account the characteristics of each farmer. Fallowing [14], the logistic function of this study can be denoted as follows:

$$\begin{aligned} &Prob(Y = 1|X) \\ &= \frac{e^{\alpha + x_i'\beta}}{1 + e^{\alpha + x_i'\beta}} \\ &= \Lambda(\alpha + x_i'\beta) \end{aligned} \tag{2}$$

In Equation (2), $Y$ is a farmer choice or decesion to be an adopter, which is assigned 1 when a farmer is an adopter and zero otherwise. The choice of a farmer of being an adopter is the decision that maximizes the level of utility in Equation (1). The logit model specification employed in this study can be denoted as follows:

$$y_i = \alpha + \boldsymbol{x}_i'\boldsymbol{\beta} + \varepsilon_i \tag{3}$$

Where $y_i$ is a binary variable labelled 1 if a farmer is an adopter and 0 if a farmer is a non-adopter. $\boldsymbol{x}_i'$ is a vector of independent variable specified in Table 1.

The confidence interval estimation of the average paddy yield for both adopters and non-adopters groups was constructed at

Table 1. Description of Independent Variables

| **Dependent variables: Agricultural mechanization adoption by a farmer. The reference category is non-adopter.** | |
|---|---|
| **Independent variables:** | |
| **Gender** | Reference category is female. |
| **Level of education** | Level of education is a categorical variable, which is constructed based on the highest education level completed. The reference category is the lowest education level (no education or not completing elementary education). |
| **Age** | It is farmers' age in years. |
| **Internet use** | It is a binary variable coded 1 if a farmer is an internet user and 0 otherwise. |
| **Region** | It is a binary variable coded 1 if a farmer is a Java resident and 0 if outside Java resident. |
| **Paddy variety** | It is the type of paddy variety cultivated by a farmer, a categorical variable consisting of three categories: dryland paddy, hybrid paddy, and inbred paddy. The reference category is dryland paddy. |
| **Farm scale** | It is represented by the total sum of paddy harvested area from May 2017 to April 2018. It is a binary variable coded 1 if the harvested area < 0.5 hectares (as a proxy for small scale farmer) and 0 otherwise. The reference category is the farmers with more than or equals to 0.5 hectares of harvested area. |
| **Yield** | Quantity of production from May 2017 to April 2018 measured in per unit of land area (qu/ha). |

5 percent significant levels to analyze whether agricultural mechanization could explain variation in paddy yield. The presence of a significant difference in the paddy yield between the two groups was confirmed by assessing whether there was an overlap in the confidence intervals or not. The difference in the yield distribution between the two groups was also analyzed by plotting the kernel density function of the paddy yield for each group. This study made use Epanechnikov kernel function [15] denoted as follows:

$$\hat{f}_k = \frac{1}{h}\sum_{i=1}^{n} K\left(\frac{x - X_i}{h}\right) \qquad (4)$$

where $h$ is the bandwidth that determines the number of values needed to estimate density at each point. This study set $h = 0.15$. The value assigned for $h$ is arbitrary to get a smooth kernel density curve. $x$ is a natural logarithmic of the paddy yield, and $n$ is the number of samples.

## DISCUSSION

### 1. Demographic characteristics of farmers

Demographically, most paddy farmers in Indonesia have a low education level (no education or not completing elementary education), are above 55 years old, are male, and are residents of Java Island. The proportion of farmers with no education and only completed elementary school reach 71 per cent. The proportion of paddy farmers completing education at least undergraduate (higher education) is very small, accounting for only less than 2 per cent of the total paddy farmers. Meanwhile, more than half of paddy farmers are above 50 years old. The proportion of above 55 years old farmers makes up about 40 per cent of the total paddy farmers, the highest among other age groups. The combination of the low level of education and old age can be the main obstacle for agricultural mechanization adoption.

Males dominate paddy farmers, making up 88.79 per cent of the total paddy farmers. It shows that paddy cultivation in Indonesia is a male phenomenon. However, a relatively significant proportion of the female farmers (11.24 per cent) shows the vital role they play in paddy cultivation. Moreover, although not farmers, many of them have a critical role in serving agricultural activities as labours and family workers in agriculture.

A high proportion of paddy farmers who are in the Java Islands, reaching around 60 per cent, indicates that paddy cultivation in Indonesia is slightly concentrated in the island. Interestingly, if we look at the paddy field distribution, the share of the two regions is almost the same [2]. It indicates that each farmer's average paddy field area in Java is smaller than outside Java.

Information on the average harvested area in Table 2 indicates that small scale farms dominate paddy cultivation in Indonesia. The average harvested areas of dryland paddy, hybrid paddy, and inbred paddy were 0.43 hectares, 0.58 hectares, and 0.62 hectares respectively. Meanwhile, one hectare of paddy field could only produce around 2 tons of dryland paddy and 4 tons of wetland paddy. However, these lower figures compared to the official ones published by BPS [5] tend to be underestimated. The yield presented in this study was computed by dividing the total production by the harvested area, and both information was obtained from farmers recall. Some studies [16] pointed out that information of areas and production outputs obtained from farmers recalling tend to be underestimated.

Most paddy farmers cultivated inbred paddy accounting for around 86 per cent of the total paddy farmers in Indonesia. Meanwhile, the proportion of paddy farmers cultivating hybrid paddy was very small, which was only 6.85 per cent of the total paddy farmers, whereas this type of paddy could produce more grains than other types of paddy potentially. It shows that there is plenty of room for boosting paddy yield by promoting the implementation of the hybrid varieties massively. When it comes to internet use, the proportion of paddy farmers using the internet was only around 11 per cent of the total 13 million paddy farmers.

## 2. Agricultural mechanization by farmer characteristics

In general, the adoption rate of agricultural mechanization in paddy cultivation in Indonesia is relatively high. It is reflected by the proportion of adopters reaching around 63.62 per cent of the total farmers (Table 2). However, the non-adopters still make up a significant portion of the total paddy farmers, amounting to 36.38 per cent. It shows that a consistent effort to promote the adoption of mechanization in paddy cultivation should be a national agricultural strategy in boosting paddy productivity. Generally, the level of adoption is larger in Java than outside Java. In Java, the adopters

Table 2. Paddy Farmers Characteristics in Indonesia

| Farmer characteristics | Proportion (%) | Average |
|---|---|---|
| 1. Yield (quintal/hectare) | | |
| Dryland | - | 21.14 |
| Wetland hybrid paddy | - | 43.22 |
| Wetland inbred paddy | - | 42.48 |
| 2. Harvested area (hectares) | | |
| Dryland | - | 0.43 |
| Wetland hybrid paddy | - | 0.58 |
| Wetland inbred paddy | - | 0.62 |
| 3. Age groups (years) | | - |
| < 30 | 3.31 | - |
| 30-34 | 5.76 | - |
| 35-39 | 9.69 | |
| 40-44 | 12.12 | - |
| 45-49 | 14.41 | - |
| 50-54 | 14.81 | - |
| 55+ | 39.89 | - |
| 4. Level of education completed | | |
| No school/not completed elementary school | 25.21 | - |
| Elementary school | 44.96 | - |
| Junior high school | 14.73 | - |
| Senior high school | 12.44 | - |
| Diploma 1/Diploma 2 | 0.32 | - |
| Diploma 3 | 0.3 | - |
| Diploma 4/Undergraduate | 1.93 | - |
| Master's/Doctoral degree | 0.00 | - |
| 5. Gender | | |
| Male | 88.76 | - |
| Female | 11.24 | - |
| 6. Regions | | |
| Java | 60.17 | - |
| Outside Java | 39.83 | - |
| 7. Type of variety cultivated | | |
| Dryland | 6.99 | - |
| Wetland hybrid paddy | 6.85 | - |
| Wetland inbred paddy | 86.16 | - |
| 8. Internet use | | |
| User | 10.81 | - |
| Non-user | 89.19 | - |
| 9. Agricultural mechanization adoption | | |
| Adopter | 63.62 | |
| Non-adopter | 36.38 | |

*Source: authors calculation from the results of SUTAS 2018*

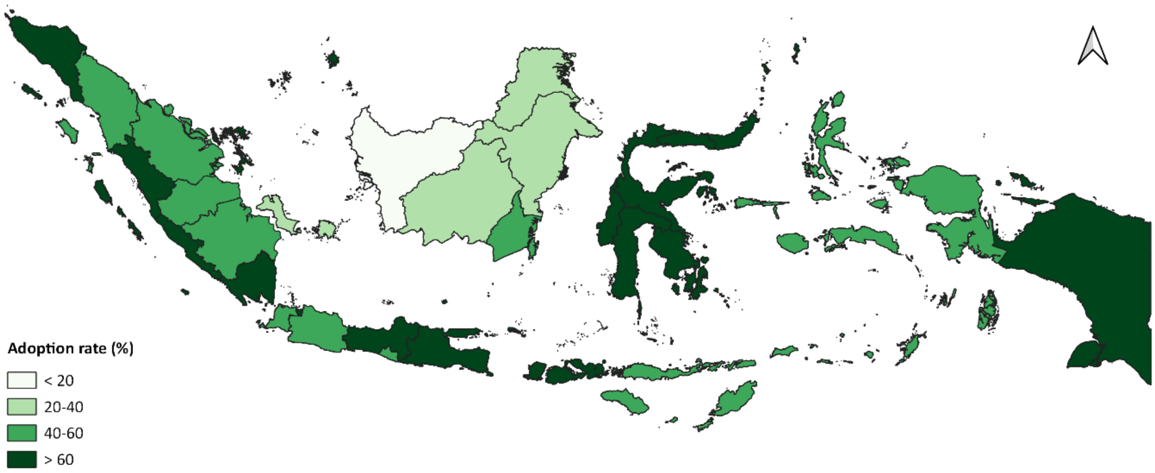


Figure 1. Distribution of Agricultural Mechanization Adoption by Province

accounted for 65.30 per cent of the total paddy farmers, while outside, the proportion is slightly lower at 61.08 per cent. These figures show that the adoption level of mechanization in the two regions is not much different. It could be explained since the access to mechanization is almost the same for the two regions. The agricultural tools and machinery assistance facilitated by the government also reached farmers outside Java equally.

If we look at it in more detail at the provincial level, the adoption rate varies between provinces both in Java and outside Java (Figure 1). It could be caused by the variation of agricultural conditions, such as the type of land and farmers' capacity to adopt mechanization, between provinces. In Java, the adoption rate ranges from 40 to 60 per cent and more than 60 per cent. The Special Capital Region of Jakarta has the highest proportion of adopters reaching 85.29 per cent of the total farmers. It might be because most farmers in Jakarta have already become members of farmer groups, allowing them to have wider access to mechanization, mainly through government assistance. However, it should also be noted that the number of farmers in Jakarta is relatively small. In outside Java, the proportion of adopters also varies between provinces. Interestingly, the proportion of adopters in Papua and all provinces of Sulawesi is more than 60 per cent of the total paddy farmers. It might happen since the two regions have been the focus of the government agricultural tools and machinery assistance in recent years to improve the level of mechanization in Indonesia. Meanwhile, the agricultural adoption in Kalimantan is relatively lower than in other parts of Indonesia. It could be caused by the land condition in the island dominated by swamp and dryland that does not have a good suit with the types of agricultural mechanization available. Therefore, the island should be one of the main focuses to improve the adoption in Indonesia. It can be done by applying mechanization tools that are suitable for the land condition of the island. However, the application needs serious and well-planned research and development.

Mechanization adoption has a strong association with farmers age. The most considerable fraction of adopters are farmers who are above 45 years old (Table 3). It indicates no resistance to the agricultural mechanization adoption among old farmers (old block) in Indonesia. It seems that farmers experience plays a vital role in this acceptance. Moreover, the role of farmers groups and extension services also influences the acceptance of old farmers to agricultural mechanization.

The level of education also has a positive association with the adoption of agricultural mechanization. The higher the level of education, the more likely farmers adopt mechanization in paddy cultivation. It is reflected by the increase of adopters proportion with the level of education. This tendency anticipates the estimation results of the logistic regression model that possibly will confirm the positive impact of education on the farmers' probability of being adopters.

From the gender perspective, the proportion of adopters is higher for male farmers (64.15 per cent) than female farmers (59.44 per cent). Meanwhile, the type of paddy variety cultivated by farmers also determines the adoption. The highest proportion of adopters cultivated inbred paddy (67.36 per cent), following by farmers cultivating hybrid paddy (58.99 per cent) and dryland paddy (22.04 per cent). In that regard, the adoption level in dryland paddy farmers is still low, in which the proportion of non-adopters reaches 77.96 per cent.

Internet use also has a positive association with the possibility of farmers being adopters in paddy cultivation. It is confirmed by the higher proportion of adopters among the internet users (70.63 per cent) than non-users (62.77 per cent). It also anticipates the estimation results of logistic regression models that will confirm

Table 3. Distribution of Agricultural Mechanization Adoption in Paddy Farmers by Farmers Characteristics in Indonesia (%)

| Farmers characteristics | Adopters | Non-adopters |
|---|---|---|
| 1. Age groups (years) | | |
| < 30 | 58.74 | 41.26 |
| 30-34 | 60.68 | 39.32 |
| 35-39 | 61.74 | 38.26 |
| 40-44 | 62.75 | 37.25 |
| 45-49 | 63.37 | 36.63 |
| 50-54 | 64.08 | 35.92 |
| 55+ | 65.09 | 34.91 |
| 2. Level of education completed | | |
| No school/not completed elementary school | 61.54 | 38.46 |
| Elementary school | 61.61 | 38.39 |
| Junior high school | 65.98 | 34.02 |
| Senior high school | 70.56 | 29.44 |
| Diploma 1/Diploma 2 | 69.48 | 30.52 |
| Diploma 3 | 74.01 | 25.99 |
| Diploma 4/Undergraduate | 72.01 | 27.99 |
| Master’s/Doctoral degree | 71.45 | 28.55 |
| 3. Gender | | |
| Male | 64.15 | 35.85 |
| Female | 59.44 | 40.56 |
| 4. Regions | | |
| Java | 65.30 | 34.70 |
| Outside Java | 61.08 | 38.92 |
| 5. Type of variety cultivated | | |
| Dryland | 22.04 | 77.96 |
| Wetland hybrid paddy | 58.99 | 41.01 |
| Wetland inbred paddy | 67.36 | 32.64 |
| 6. Internet use | | |
| User | 70.63 | 29.37 |
| Non-user | 62.77 | 37.23 |
| 7. Farm scale | | |
| Small scale (harvested area <0.5 ha/year) | 58.10 | 41.90 |
| Not small-scale (harvested area >= 0.5 ha/year) | 63.73 | 36.27 |

*Source: authors calculation from the results of SUTAS 2018*

a positive impact of internet use on the probability of farmers of being adopters.

Farm scale also has a positive association with farmers possibility to adopt mechanization in paddy cultivation. The higher the scale, the higher proportion of adopters. The proportion of adopters is higher for farmers with a harvested area equals to and larger than 0.5 hectares in a year (63.73 per cent) than farmers with less than 0.5 hectares of harvested area (58.10 per cent).

### 3. Demographic determinants of agricultural mechanization adoption

The estimation results (Table 4) pointed out that the probability of paddy farmers being adopters is affected significantly by farmers demographic characteristics, namely gender, age, level of education, and regions (Java and outside Java). Besides demographic variables, other variables in the model specification (internet use, type of paddy variety, and farm-scale) also significantly impact the farmers' probability of being adopters. However, the value of Pseudo $R^2$ is only 0,0749, which strongly indicates that all variables in the model are not optimal simultaneously in explaining the variation of the farmers' probability of being adopters. Therefore, the potential of omitted variable bias should be taken into account. It could be explained since the adoption of agricultural mechanization is influenced by many other factors, as previously described, that were not included in the model specification. This is the limitation of our study that elaborated the results of SUTAS 2018.

The probability of male farmers of being adopters is 1.3 times higher than female farmers. Meanwhile, the age of farmers has a positive and significant impact on the farmers' probability of being adopters. It confirms no resistance to agricultural mechanization among old farmers (old-block) in Indonesia. However, the negative sign of the quadratic term of age variable, which is also statistically significant at 5 per cent, shows that the magnitude of the impact follows an inverted-U pattern. It means that the magnitude of the age impact tends to be diminishing with the increase in age, as shown by the plot of age marginal effects in Figure 2.

As expected, education also affects the farmers' probability of being adopters positively and statistically significant. In general, the higher the education level, the larger the farmers' probability of being adopters are. A paddy farmer who completed education at least Diploma 3 has a 1.4 higher probability of being adopters than a farmer with no education or not completing elementary education. Unfortunately, paddy farmers in Indonesia dominantly have a low level of education as previously described, where around 71 per cent of the paddy farmers only completed elementary education and lower, which seems one of the main obstacles for agriculture mechanization adoption in paddy cultivation in Indonesia.

Internet use has a positive and significant impact on farmers' probability of adopting agriculture mechanization in paddy cultivation. A paddy farmer who is an internet user has a 1.2 times higher likelihood to be an adopter than a non-user. It seems because internet use provides farmers with more access to information related to mechanization and cultivation techniques. This access allows farmers to increase their knowledge and insight, particularly about the type, application, impacts, and the benefit of agriculture mechanization in increasing productivity. Internet use also reflects farmers acceptance of innovation and technology.

As anticipated, farmers cultivating wetland paddy have a higher probability of being adopters than farmers cultivating dryland paddy. The model estimation results show that farmers cultivating wetland hybrid paddy and inbred paddy have around 6 times and 9 times higher probability respectively of being adopters than farmers cultivating dryland paddy. It could be explained by the low level of mechanization among farmers cultivating dryland paddy.

When the region impacts farmers' probability of being adopters, farmers in Java have a slightly higher probability of being adopters than farmers outside Java. However, it can be seen that the magnitude of the impact is relatively weak, indicated by the value of the odds ratio that is close to one. It seems since the categorization of farmers regions into Java and outside Java is not sensitive enough in capturing the variation of the adoption between provinces, as presented in Figure 1. More specific categorization, for instance, by the main island would give a better estimation in explaining the effect of farmer location.

As anticipated, the farm-scale has a strong and positive association with farmers probability of being adopters—the probability of being adopters increases with the farm scale. Non-small scale farmers have a 1.3 times higher probability of being adopters than small-scale farmers. It could be understood since labour productivity does matter in paddy cultivation, especially for large scale cultivations. In that regard, agricultural mechanization allows farmers

Table 4. Estimation Results of Logistic Regression

| **Independent variable: mechanization adoption** | **Regression coefficient** | **Odds ratio** |
|---|---|---|
| Gender (male) | 0.2125***<br>(0.0069) | 1.2839***<br>(0.0074) |
| Age | 0.0157***<br>(0.0010) | 1.0159***<br>(0.0010) |
| Age square/100 | -0.0083***<br>(0.0010) | 0.9917***<br>(0.0010) |
| Education level | | |
| Elementary school | 0.0472***<br>(0.0048) | 1.0483***<br>(0.0050) |
| Junior high school | 0.2070***<br>(0.0063) | 1.2300***<br>(0.0078) |
| Senior high school | 0.3259***<br>(0.0067) | 1.3853***<br>(0.0092) |
| Diploma 1/Diploma 2 | 0.2084***<br>(0.0318) | 1.2318***<br>(0.0392) |
| Diploma 3 | 0.3816***<br>(0.0330) | 1.4646***<br>(0.0483) |
| Diploma 4/Undergraduate | 0.3653***<br>(0.0144) | 1.4410***<br>(0.0208) |
| Master's/Doctoral degree | 0.3686***<br>(0.0651) | 1.4458***<br>(0.0941) |
| Type of paddy variety | | |
| Wetland hybrid paddy | 1.8326***<br>(0.0095) | 6.2498***<br>(0.0596) |
| Wetland inbred paddy | 2.1426***<br>(0.0071) | 8.5211***<br>(0.0608) |
| Region (Java) | 0.0737***<br>(0.0041) | 1.0765***<br>(0.0044) |
| Small-scale | 0.2745***<br>(0.0109) | 1.3159***<br>(0.0143) |
| Internet use | 0.2125***<br>(0.0069) | 1.2367***<br>(0.0085) |
| Constant | -3.1389***<br>(0.0318) | 0.0433***<br>(0.0014) |
| Prob > Chi2 = 0.0000<br>Pseudo $R^2$ = 0.0749 | | |

*Note: Number of observation is 1.349.716; *** statistically significant at $\alpha$ = 1 %; robust standard error is presented in the parantheses* to increase their labour efficiency by reducing labour costs in cultivation activities. In other words, the adoption of mechanization in large-scale farms is more profitable and has a more notable impact than in small-scale farms that generally only need limited labour inputs.

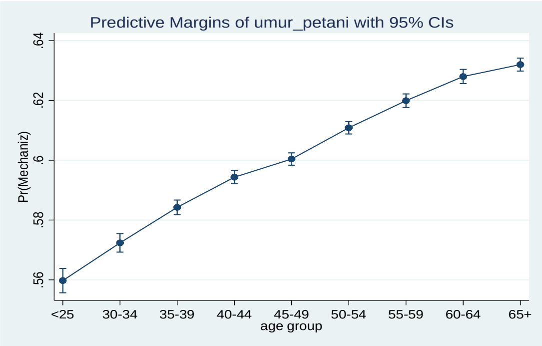


Figure 2. The plot of age group marginal effects

## 4. Mechanization and paddy yield

The estimation of the confidence interval of paddy yield mean at 5 per cent significance level (Table 5) and Kernel Density Function of paddy yield distribution (Figure 3) for adopters and non-adopters clearly pointed out that the difference in the yield between the two groups is statistically significant. It is consistent for all varieties of paddy (see Figure A1-A3). The paddy yield distribution of adopters is slight to the right of the paddy yield distribution of non-adopters. It strongly indicates that the adoption of mechanization in paddy cultivation can increase the paddy yield. It could happen, among others, through the reduction of paddy losses during harvest.

However, a follow-up study is needed to confirm that the difference in the yield between the two groups is due to the impact of the adoption of mechanization. In that regard, the study should use a Cobb-Douglas production function as a theoretical and practical standard in estimating the production function [17,18]. The regression model should include production inputs and capital (land) variables in the model specification. In this conceptual framework, the mechanization adoption enters the model specification through an explained part, total factor productivity (TFP).

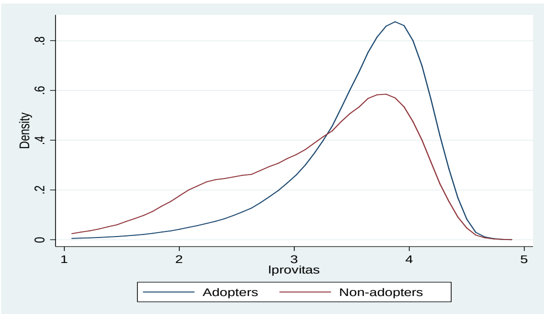


Figure 3. Kernel Density Distribution of the Paddy Yield

Table 5. Paddy Yield of Adopters and Non-adopters by Paddy Variety (qu/ha)

| Type of variety | Adopters | Non-adopters |
|---|---|---|
| Dryland paddy | | |
| - Mean | 27.91 | 19.23 |
| - Confidence interval ($\alpha$ = 5%) | 27.62-28.20 | 19.09-19.37 |
| Hybrid wetland paddy | | |
| - Mean | 44.28 | 41.70 |
| - Confidence interval ($\alpha$ = 5%) | 44.02-44.54 | 41.33-42.08 |
| Inbreed wetland paddy | | |
| - Mean | 44.59 | 38.12 |
| - Confidence interval ($\alpha$ = 5%) | 44.53-44.65 | 38.03-38.21 |
| Paddy (total) | | |
| - Mean | 44.17 | 35.57 |
| - Confidence interval ($\alpha$ = 5%) | 44.11-44.22 | 35.48-35.65 |

*Source: authors calculation from the results of SUTAS 2018*

## CONCLUSION

This study aims to analyze the demographic determinants of the adoption of agricultural mechanization on paddy farmers in Indonesia and the influence of internet access on the farmers' probability of being adopters. Besides, it also analyzes the difference in the paddy yield between the adopters and non-adopters to figure out an indication that the adoption of mechanization in paddy cultivation could increase the yield.

Our analysis found that gender, age, education, region of farmers, type of variety, scale of the farm, and internet use have a statistically significant impact on the farmers' probability of being adopters. Farmers who are male, well-educated, residents of Java, non-small-scale, and cultivate wetland paddy are more likely to be adopters than female, less-educated residents outside Java, small-scale, and cultivate dryland paddy. The study also confirmed the positive impact of internet use on the farmers' probability of being adopters. Therefore, the improvement in internet access in rural areas and farmers could boost mechanization in paddy cultivation.

Our study also found a strong indication of the positive impact of mechanization adoption on the yield. The study results point out that the average paddy yield of adopters is significantly larger than non-adopters. However, a follow-up study based on a sound conceptual framework is needed. The study should use a Cobb-Douglass production function as the theoretical base to well-captured the impact of the adoption on the paddy yield.

In conclusion, our study confirms the importance of farmers capacity, particularly the level of education and farm-scale for the adoption of mechanization by farmers. Therefore, improving farmers capacity by attracting young people with high education to get involved in agriculture could boost the mechanization in Indonesia. Moreover, our study also shows that boosting the adoption of mechanization could be a game-changer for improving paddy yield in Indonesia. It can be done by up-scaling the implementation of tools and agricultural machinery assistance facilitated by the government, particularly for an area with a relatively low level of mechanization.

## APPENDICES

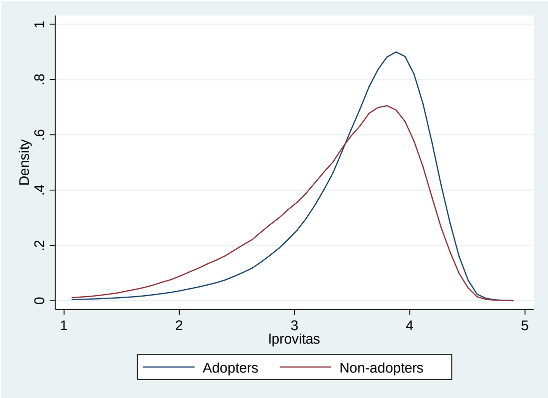


Figure A1. Kernel Density Distribution of the Paddy Yield

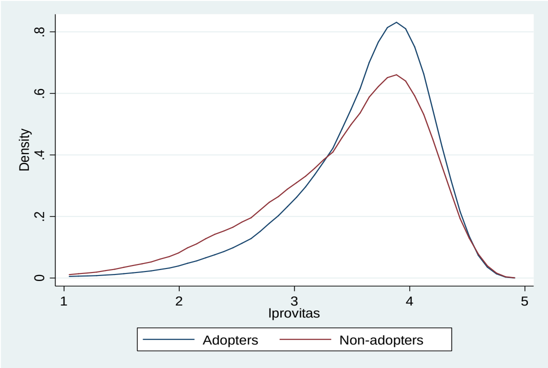


Figure A2. Kernel Density Distribution of the Wetland Hybrid Paddy Yield

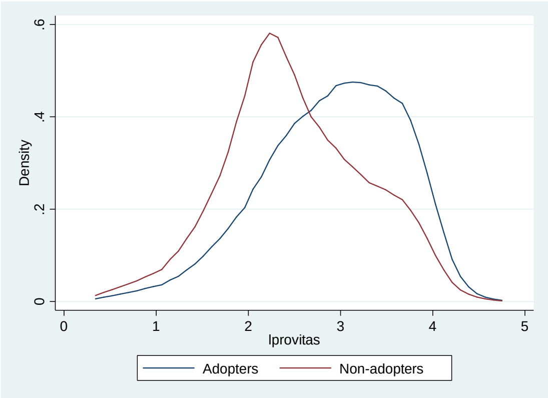


Figure A3. Kernel Density Distribution of the Dryland Paddy Yield

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