

Wage Growth, Landholding, and Mechanization in Agriculture

Evidence from Indonesia

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Abstract

This paper uses farm panel data from Indonesia to examine dynamic patterns of land use, capital investments, and wages in agriculture. The empirical analysis shows that an increase in real wages has induced the substitution of labor by machines among relatively large farmers. Large farmers tend to increase the scale of operation by renting in more land when real wages

increase. Machines and land are complementary if the scale of operation is greater than a threshold size. In contrast, such a dynamic change was not observed among relatively small holders, which implies a divergence in the movement of the production frontier between Java and off-Java regions given that the majority of small farmers are concentrated in Java.

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1. Introduction

It has been increasingly recognized that rapidly-growing Asia is becoming a driving force of economic growth in the world, but also a growing concern in the global food economy due to its large share of grain imports in the world.³ Economic growth, urbanization and transformation of the economic structure in Asia have been the fastest in the world, which has induced increasing real wages not only in urban and non-agricultural sectors, but also in many parts of rural and agricultural sectors in Asia. Although the above transformation contributed to reducing poverty in the region, it also created a challenge to farming which depends on small-scale and family based operations. In this paper, I examine (i) how an increase in real wage induced a realization of scale economies and investments in machines substituting for labor, and (ii) potential differences between small and large farmers, using farm panel data from Indonesia.

Family labor tends to be more intensively used on smaller farms in the absence of efficient labor markets, which, in turn contributes to the inverse relationship between farm size and crop yield (Feder 1985; Berry and Cline 1979; Benjamin and Brandt 2002). In fact, Asian agriculture has been dominated by labor-intensive small farms mainly relying on family labor. However, such an inverse relationship could be altered with the fast economic growth, accompanying a rising wage rate, because labor-intensive production becomes costly. The wage growth may have significant effects on the efficiency of small-scale farming in Asia and potentially more generally in developing countries.

The following intuition shapes up the key hypothesis. An increase in real wages increases the production cost of the labor-intensive farming system and thereby decreases comparative advantage in agriculture based on the labor-intensive production methods widely observed in many parts of Asia. To restore comparative advantage, at least partially, farm size expansion and large-scale mechanization must

³ Low self-sufficiency is evident in Japan; the Republic of Korea; Taiwan, China; and more recently becoming a serious concern in China, where imports of certain commodities increased very rapidly. Though exporters such as Thailand, Brazil, and Argentina can enjoy such a trend, it is possible that the above trend observed in Asia will destabilize the supply-demand balance in the global food economy.

take place so as to save high-cost labor. However, the introduction of large-scale mechanization is difficult if farm size is constrained by some factors, such as total land endowment, population density and a relatively high value of non-agricultural land use, which all prevail in Java. All the above factors generate an advantage to large farmers. If expansion of farm size is easy for larger farmers, it may create a divergence in production efficiency and profitability between large and small farmers.

This paper shows evidence from Indonesia to support the proposition that wage growth in recent years led to an introduction of labor saving practices among relatively large farmers. That is, large farmers tend to acquire more land by renting in land when real wages increase, and they install machines if agricultural real wages increase. In contrast, small farmers seemed not to change their behavior. The empirical findings also show that land and machines are complementary among relatively large landholders. The above trend also divides the dynamics of farm production between Java and off-Java as land endowments are relatively large outside Java and small landholders are concentrated in Java.

As Otsuka (2013) elaborates in his paper, increasing real wages (and transformation of occupational structures in labor markets) challenge Asian agriculture in which the majority of farmers are smallholders, because of the increasing need (i) to reduce the labor force in agriculture (as the opportunity cost of farming increases), (ii) to increase the average farm size (to reduce labor use by introducing labor-saving production methods) and (iii) to generate enough income to retain parity with non-agricultural workers. If land markets and/or institutional mechanisms are imperfect, major inefficiencies in the allocation of farm land will be bound to arise. Otsuka, Liu and Yamauchi (2013) present evidence consistent with the above conjectures using cross-country panel data. Foster and Rosenzweig (2010, 2011) also show some evidence to support the second point in India.

Indonesia provides an interesting setting in which relatively abundant and scarce land endowments coexist. Land is immobile across islands, while labor is mobile. Demarcation between macro-regional

islands gives an ideal experimental ground, when real wages are increasing, to learn about differences in the consequence of wage growth between land abundant and scarce regions.

The key idea of this paper is related to an important line of thought in the literature. First, developing the concept of induced innovations proposed by Hicks (1932), Hayami and Ruttan (1985) introduced the idea of induced institutional changes in agriculture. An increase in real wages may induce a technical change to save labor, i.e., mechanization, but also could lead to an institutional arrangement that saves labor and/or reduces user costs of machines on farms even without land consolidation. For example, if machines can be rented relatively cheaply, small farmers may be able to effectively save labor by utilizing machines through rental markets.⁴ In this context, I examine whether changes in relative factor prices altered productivity if there exists a constraint on labor-capital substitutability imposed by the rigid initial land distribution. But it remains possible that (i) land reallocation could happen over time (but not captured by our data) and (ii) institutional arrangements such as emergence of machine rentals mitigate the efficiency cost attributed to the land market rigidities.

Indonesia has traditional harvest arrangements by traders who purchase products before harvest time (reducing price risk to farmers), or bring labor to farm yards to harvest, called *Ijon* and *Tebasan* respectively. Casual observation in the field suggest that machines are rarely brought to harvest in the practice of *Tebasan* concentrated in Java, which implies that an increase in labor costs has not been too high, i.e., there are still sufficient low-cost laborers available to farming. However, the empirical findings of this paper also point to the emerging phenomenon of large farmers outside Java having started scaling up their operations with mechanization. Therefore, it appears that Indonesian farming is reaching a crossroads, potentially resulting in divergences in efficiency across differently endowed regions.

⁴ This will be the case in some areas, e.g., lowland agriculture. However, it is more difficult in hilly areas including terraced rice production.

The current issue is not entirely new in the history of agricultural development. First, the British enclosure movement during its industrial revolution played a role in consolidating farm land to thus suppressing wages and releasing labor to non-agricultural industries. This example shows that labor cost and supply in the labor market could be critically related to landownership and land consolidations in rural areas at that time. Second, as Hayashi and Prescott (2006) recently illustrated in a calibration model, the family system governing land inheritance (maintaining small farms) could have reduced the supply of labor to non-agricultural sectors, which thus reduced the potential of industrial growth in prewar Japan.

Third, land reforms in developing countries have typically aimed to create small farmers by redistributing land own from landlords to tenants. Successful land reforms contributed to promoting equity as well as efficiency in agriculture but could impose a historical constraint on production efficiency when labor shortage becomes serious. While small farmers find it difficult to maintain family-labor intensive production, it is politically challenging to re-redistribute land to enlarge operational land sizes unless land markets including rental arrangements work perfectly.

The paper is organized as follows. Section 2 describes empirical strategy. Section 3 describes the panel data collected in 7 provinces in Indonesia, with two rounds in 2007 and 2010. The empirical findings are summarized in Section 4, followed by concluding remarks. The Appendix sketches a simple model that helps us to interpret the empirical findings.

2. Empirical Strategy

Theoretical predictions on land transaction, machine investment and farm profit are examined with farm panel data, described in the next section. Though the theory in the Appendix has a rich set of structural relationships, I take the initial approach using reduced forms in this paper. A change in real wage is the key factor assumed to impact two behavioral outcomes: land transactions and machine investment.

The analysis differentiates large and small farmers since the theory predicts scale advantage among large farmers when they face wage growth. Small farmers are predicted to increase their labor supply to non-agricultural work, and/or rent out their land to large farmers. In contrast, large farmers are likely to increase their operational size by purchasing or renting in land from smaller farmers, and to invest in machines to substitute for labor.

In the farm profit equation, the main issue is whether land and machines show complementarities, and if so, under what conditions. As in land and machine investments, large and small farmers are distinguished in order to identify their behavioral differences.

In all the above estimations, first differences are taken to wipe out unobserved fixed error components, which could lead to bias in the cross-sectional estimation. The key explanatory variable in the first-differenced form is village-level real wage growth separately for agriculture and non-agriculture work (see details on the construction of the wage variables in Section 4.3). Labor can be imperfectly substitutable between agricultural and non-agricultural work due to differences in the required tasks, so I use the village-level wages for the two sectors in the land and machine investment equations.

3. Data

3.1 Household Survey

The data come from two rounds of household survey conducted in rural areas of Indonesia. The primary source of our data is the village and household level surveys that we conducted in 2007 and 2010 for 98 villages in seven provinces (Lampung, Central Java, East Java, West Nusa Tenggara, South Sulawesi, North Sulawesi, and South Kalimantan) under the Japan Bank for International Cooperation (JBIC) Study of Effects of Infrastructure on the Millennium Development Goals in Indonesia (IMDG). Figure 1 shows the locations of surveyed villages. In 2010, we revisited all of the 98 sample villages to

re-interview sample households and their splits after the 2007 survey. Out-migrants were tracked through either direct or phone interviews.

Figure 1 to be inserted

The 2007 survey was designed to overlap with villages in the 1994/95 PATANAS survey conducted by ICASEPS to build panel data on households. The 1994/95 PATANAS survey mainly focused on agricultural production activities in 48 villages chosen from different agro-climatic zones in seven provinces, though the sample also included households in fishery villages and laborer households. In 2007, we visited those villages to expand the scope of research as a general household survey under the IMDG survey.

In the 2007 round, we also added 51 new villages in the same seven provinces. These new villages were selected using the following criteria. First we chose the same districts where PATANAS villages are located. We listed villages that had received relatively large amounts of government infrastructure projects during the period 1995 to 2005, funded by either the Japan Bank for International Cooperation or the World Bank. Finally, the new villages were randomly sampled from the list.

In the revisited villages in 2007, we re-sampled 20 households per village from the 1994/95 sample (using a proportional sampling based on landholding size) and followed the split households. In the new villages, we sampled 24 households from two main hamlets in each village. Since one of the 48 villages in the 1994/95 PATANAS was not accessible for safety reasons in the 2007 survey (in West Nusa Tenggara province), we have the total of 98 villages that are available for various research objectives. (The 2010 survey followed sample households and their split households in all 98 villages.)

Some household members split from the 2007 original households to start their new households or to join other households. In the household-level panel analysis, for households that split between the two rounds of data collection in 2007 and 2010, we aggregated incomes of original household and split households by using the 2007 household unit as the base in the following way. We include new

households if an original household member became a new household head and lives in the same village (called split households). Household members who moved outside the original village or joined other households within the village (both called out-migrants) are excluded from our analysis.⁵ We aggregate incomes from both original and split households in 2010 to be comparable with the 2007 original households. The food price crisis of 2008-10 may be correlated with split (and migration) decisions, which raises an additional concern that supports the aggregation of incomes from the 2007 original household and its splits in the period 2007 – 2010.

3.2 Agricultural Production, Landholding and Machines

Agricultural production was recorded with detailed information but rather differently in the two rounds. In 2007, the survey collected information on outputs and inputs for each crop by crop season, using management units defined by irrigated and un-irrigated lands. The 2010 survey collected plot-level information for each crop and crop season. In the analysis, I use crop income deducting input costs, i.e., crop profit including family labor costs. The estimation uses the sample of farmers who had positive crop profits in the two rounds.

Machine investments in the period from 2007 to 2010 were captured in the 2010 survey. The analysis uses total values of investment such as tractors, threshers, etc., which function to substitute for farm labor.

Land is aggregated at the household level, but grouped into three types: self-cultivated own land, self-cultivated rented-in land and rented-out land. In the analysis, a focus is on the first type as the farm cultivation decision is the main issue of this paper. Whether owned or rented-in does not matter in the analysis.

⁵ Potential attrition-related bias in the current analysis is small since the dynamics of crop income is its focus, not household income in general, which includes non-agricultural employment and remittance incomes.

Table 1 shows the average farm size (self-cultivated own and rented-in) for the whole sample as well as for each province. The second column shows the average land size in the sample of farmers who had non-negative crop incomes in both years. It is clear in the table that farm size is smaller in the Java provinces than outside Java. The average farm size is less than 0.5 ha in the Java provinces (Column 2), in contrast to non-Java where the average farm size is above 1 ha.⁶ If we use the sample of farmers who had non-negative crop incomes in both sample years, the average size increases marginally, except for North Sulawesi in our sample. In the analysis below, I check whether small/marginal and larger farmers behave differently by using 0.6 ha as the threshold size (i.e., many of the farmers in our Java sample fall below 0.6 ha due to skewed landholding distributions).

3.3 Labor Markets and Wages

Village-level wages for both agricultural and non-agricultural works are estimated from individual-level employment data in 2007 and 2010. Both rounds used the identical module to record job type, wage rate, number of days worked, duration, contract type, etc. for each individual employment experience in the past year. Individual frequently had several employment spells in the previous year and this method was applied to both agricultural and non-agricultural employment.

The data processing followed a few steps. First, we computed the daily wage for agriculture and the monthly wage for non-agricultural work at the individual level. Second, the distribution of the household-level average wages was obtained. Third, we compared the average wages at the village level – both agriculture and non-agriculture – between 2007 and 2010. The analysis uses growth rate of the village-average wages by sector. Yamauchi (2011) used these household-level wage data to show that road infrastructure projects increased non-agricultural wages by connecting workers to employment opportunities outside the village (also increasing speed of transportation).

⁶ In addition to the observed difference in farm size, it is possible that soil quality significantly differs between Java and non-Java islands.

4. Empirical Results

This section summarizes the empirical results. Table 2 shows estimation results on land transactions.

Table 2 to be inserted

Columns 1 and 2 show results for large farmers (cultivating more than 0.6 ha).⁷ Column 1 uses total cultivated land including both owned and rented-in, while Column 2 only uses rented-in land. Several findings emerge. First, real wage growth is not significant in explaining changes in total cultivated land in 2007-2010. Second, if we only focus on changes in rented-in land, we find that real non-agricultural wage growth significantly increased land rentals. The effect of agricultural wage growth is marginally insignificant. Therefore, for relatively large farmers (in the Indonesian context), wage growth significantly increased land acquisition, either purchasing or renting in.

Note that the effect of non-agricultural wage growth can be a result of (i) increased labor supply of relatively small farmers, thus making more farm land available to larger farmers, and (ii) increased labor costs, which shifts from non-agricultural to agricultural sectors. The above interpretation is consistent with the finding that rented-in land increases with increased non-agricultural wages.

The case of relatively small farmers is reported in Columns 3 and 4. The number of farmers in this category is quite large, implying that the majority of farmers in Indonesia are operating on small farm

⁷ I have experimented different values around 0.5 to 1.0 ha. It is concluded in a preliminary analysis that the threshold of 0.6 ha (or around that value) seems to divide farm behavior well in the sample. Incidentally, that is the average farm size in Java in our sample.

land. In contrast to the results for larger farmers, wage growth is insignificant in both columns. Land transactions are very small and are not responding to increased labor costs.⁸

Table 3 to be inserted

Table 3 shows results on machine investments.⁹ The sample was again split into two groups based on initial farm size in 2007. In Column 1, we find that an increase in the real agricultural wage induces machine investments among relatively large farmers. However, this is not observed among relatively small farmers (Column 2). Therefore, we can conclude that larger farmers tend to not only expand their operation but also to invest in machines to substitute for labor when real agricultural wage increases.

Table 4 to be inserted

Table 4 summarizes the results on estimate of a profit function.¹⁰ The dependent is the growth of crop income (after deducting all costs except family labor) taking the difference in log crop incomes between 2007 and 2010. Thus, negative income observations were dropped from the sample. The first three columns use all farmers with positive crop incomes in both years. Three results emerge. First, self-cultivated land, both owned and rent-in, has significant positive effects on crop profit (Column 1). Second, machine investment also has a marginally significant effect on crop profit (Column 2). Third, if we include the interaction term between cultivated land and machine investment (Column 3), the effects of land and machine investment remain robust, and the interaction has a positive effect on crop profit, but this is marginally insignificant.

⁸ In Indonesia, rice production rather stagnated in 2009 and 2010, which resulted in an increase of rice imports, and the negative production shock could be a reason for smaller rent-in among small holders but since the survey captured the crop year of 2009/10, the decision on land rentals should have been made at the end of the crop year 2008/09 and moreover the observations of negative crop incomes were excluded in the above analysis, such a possibility is quite small.

⁹ The survey did not capture details of machine rentals.

¹⁰ In the preliminary analysis, per-ha profit did not show good results, which implies that productivity was not affected by machines and landholding size.

Next, the sample is split into two groups. Column 4 shows results for relatively large farmers. In this group, we find that land acquisition and machine investments are complementary, mutually augmenting crop profit. Though the above complementarities are supported, the marginal effects of land and machines become insignificant. That is, a combination of land and machines as an investment package is profitable for this group of farmers who have relatively large land endowments. Among relatively small farmers (Column 5), the land-machine complementarity was not significant. Though an increase in either land or machines augments crop profit, they are not complementary.

5. Conclusions

This paper showed evidence that an increase in real wages has been inducing the substitution of labor by machines among relatively large farmers in Indonesia. They also tend to increase the scale of operation by renting in more land when real wages increase. The empirical results also show that machine investments and land are complementary if the scale of operation is greater than a threshold around 0.6 ha. In contrast, such a dynamic change was not observed among relatively small holders.

In the context of Indonesia, the above findings can be directly translated into a divergence in production frontier between Java and off-Java regions as the majority of small farmers are concentrated in Java. The findings lead to a prediction that agriculture in favorably endowed off-Java islands can stay on the frontier by promoting mechanization on the basis of the initial scale advantage, while small farmers in Java tend to be trapped in high-cost agriculture due to rigidity of land markets in the future.

Appendix: Simple Model

In this section, I describe a simple model. To identify potential efficiency gain, we compare two institutional regimes: (i) the individual decision problem and (ii) the coordination problem. In (ii), I briefly discuss political economy issues.

The individual problem is defined as follows. Farm profit Π_i is the maximum over two alternative activities.

$$\Pi_i = \max \left\{ \begin{array}{l} \max_{\{L_i^F(h), L_i(h), A_i\}} F(g(L_i^F(h), L_i(h)) + M, A_i) + w(h)[T - L_i^F(h) - \sigma L_i(h)] \\ \quad - pI(M > 0) - r^m(A_i - A_{0i}), \\ \max_{\{L_i^F(h), L_i(h), A_i\}} F(g(L_i^F(h), L_i(h)), A_i) + w(h)[T - L_i^F(h) - \sigma L_i(h)] - r^m(A_i - A_{0i}) \end{array} \right\}$$

where $F(\cdot)$ is the production function, A_i is the area of land used for farming (A_{0i} is the initial size of land owned), M is machine, $(L_i^F(h), L_i(h))$ are family and hired labor (resp), h is human capital, $w(h)$ is the wage rate determined in the competitive labor market (therefore, exogenous to the household), $\sigma > 1$ is the exogenous additional cost of hired labor including a supervision cost margin (i.e., $\sigma w(h)$ is the wage for hired labor), T is per-family time endowment, r^m is market land (rental) price, and p is the unit price of machine (we do not exclude renting-in of machines). M may be zero or a positive number (fixed investment). For simplicity, we assume out leisure (therefore, they supply all time endowed). In the above, we assume that due to an increase in real wages and machine's indivisibility, land and machine turn out to be complementary. Note that land market rigidity can be captured by relatively high land price.

In the above, assume that $g(L_i^F(h), L_i(h))$ is a composite labor input, which is perfectly substitutable with machine M . Family labor may not be perfectly substitutable with hired labor, and this point is reflected by the margin σ in wages; shadow prices diverge between family and hired labor. In small farms,

family labor has advantage ($\sigma > 1$). The incentive to introduce machinery depends on three factors: (i) wages $w(h)$ and σ , (ii) farm size, A_i , and (iii) machine price, p .

The coordination problem is defined below. Assume, for simplicity, that coordination fails unless the solution on land allocation is beneficial to each differently-endowed farmer. Without loss of generality, suppose that A_{01} is relatively large. Farmer 1 rents land from a subset of farmers in the village:

$$\begin{aligned} \max_{L_1^F(h), L_1(h), M, A_1} \Pi_1^m &= F\left(g\left(L_1^F(h), L_1(h)\right) + M, A_1\right) + w(h)[T - L_1^F(h) - \sigma L_1(h)] \\ &\quad - pI(M > 0) - r(A_1 - A_{01}) \\ y_i^m &= rA_{0i} + w(h)T, \quad i \in n^* \end{aligned}$$

where $A_1 = \sum_{i \in n^*} A_{0i}$. Farmer 1 rents in with rent r (contract) and n^* is the group of farmers who join the reallocation contract (renting out the whole plot). If they do not join the contract, they operate their farm themselves. The set $\{i \in n^*\}$ is endogenous. Note that as $w(h)$ and r increase, small farmers tend to rent out their lands, and larger farmers to rent in (as they do not have to rent in a large amount of land in order to break even with mechanization).

The proposed land reallocation is supported if

$$\begin{aligned} \Pi_1^{m*} &\geq \Pi_1^* \\ y_i^m &= rA_i + w(h)T \geq \Pi_i^*, \quad i \in n^* \end{aligned}$$

where Π_1^{m*} and Π_1^* denote farm profits in the coordinated allocation and individual allocation cases, respectively. In the above setting, the entry condition for smaller farmers also incorporates farm profitability on their own farms, where they can potentially rent in machines. Strategic complementarities arise only from (collective or decentralized) land reallocation decisions.

Some implications are discussed briefly. Suppose that $\{A_i\}_{i=1}^n$ are historically given. An increase in $w(h)$ promotes renting-out of land from small farmers (becoming wage earners), if market or rental prices of machines and land rent are both sufficiently high. If family time endowment for $i = 1$ tends to be smaller than total labor used, an increase in $w(h)$ decreases π_1^m . Note also that shadow prices of family and hired labor differ by the margin of σ . On the other hand, if $A = \sum_{i=1}^n A_i$ is large, the per-land unit cost of machine can approach zero (thus, we can ignore the term). Therefore, the introduction of machine creates scale economies. Due to scale economies, the social planner's profit can be greater than the sum of uncoordinated individual farm profits.

Some remarks follow. First, accumulation of human capital potentially plays an important role in the above dynamics. Since human capital (education) augments wages (assume that $w'(h) > 0$), education policy h also affects the transition. Second, an increase in r can deter the above mentioned transition by increasing rental costs for $i = 1$. When non-agricultural land use has high returns, an increase in r means that small farmers sell or rent out their land, and farmer 1 will buy or rent in to equalize marginal product of land and land price, which implies reduction of agricultural land (A will change).

Similarly, it is easy to introduce transaction costs in creating the above contractual arrangement. If there is a transaction cost that deters land reallocation, it is also possible to construct multiple equilibria: small farm traps and high-productivity equilibria. In an inefficient equilibrium, land reallocation is difficult, keeping many small holders. In an efficient equilibrium, land can be consolidated among large farmers, and small farmers enjoy relatively high-wage non-farm work.

References

Benjamin, D. and L. Brandt, 2002, Property Rights, Labour Markets, and Efficiency in a Transition Economy: The Case of Rural China, *Canadian Journal of Economics*, 35: 689-716.

- Berry R. and W. Cline 1979. *Agrarian Structure and Productivity in Developing Countries*, Baltimore: Johns Hopkins University Press.
- Feder, G. 1985. The Relation Between Farm Size and Farm Productivity, *Journal of Development Economics*, 18:297–313.
- Foster, A.D. and M.R. Rosenzweig, 2010, Is There Surplus Labor in Rural India? Yale University.
-----, 2011, Are Indian Farms Too Small? Mechanization, Agency Costs and Farm Efficiency, Brown University.
- Hayami, Y., and V.W. Ruttan, 1985, *Agricultural development: An international perspective*, Johns Hopkins University.
- Hayashi, F. and E.C. Prescott, 2008, The Depressing Effect of Agricultural Institutions on the Prewar Japanese Economy, *Journal of Political Economy* 116, 573-632.
- Hicks, J.R., 1932, *The Theory of Wages*, London: Macmillan.
- Otsuka, K. 2013, Food Insecurity, Income Inequality, and the Changing Comparative Advantage in World Agriculture, *Agricultural Economics*, 44: 7-18.
- Otsuka, K., Y. Liu and F. Yamauchi, 2013, Factor Endowments, Wage Growth, and Changing Food Self-Sufficiency: Evidence from Country-Level Panel Data, *American Journal of Agricultural Economics*, 95: 1252-1258.
- Yamauchi, F., 2011, Spatial Connectivity, Labor Markets and Returns to Human Capital: Evidence from Rural Indonesia, Manuscript, International Food Policy Research Institute, Washington D.C.
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Figure 1 Locations of surveyed villages

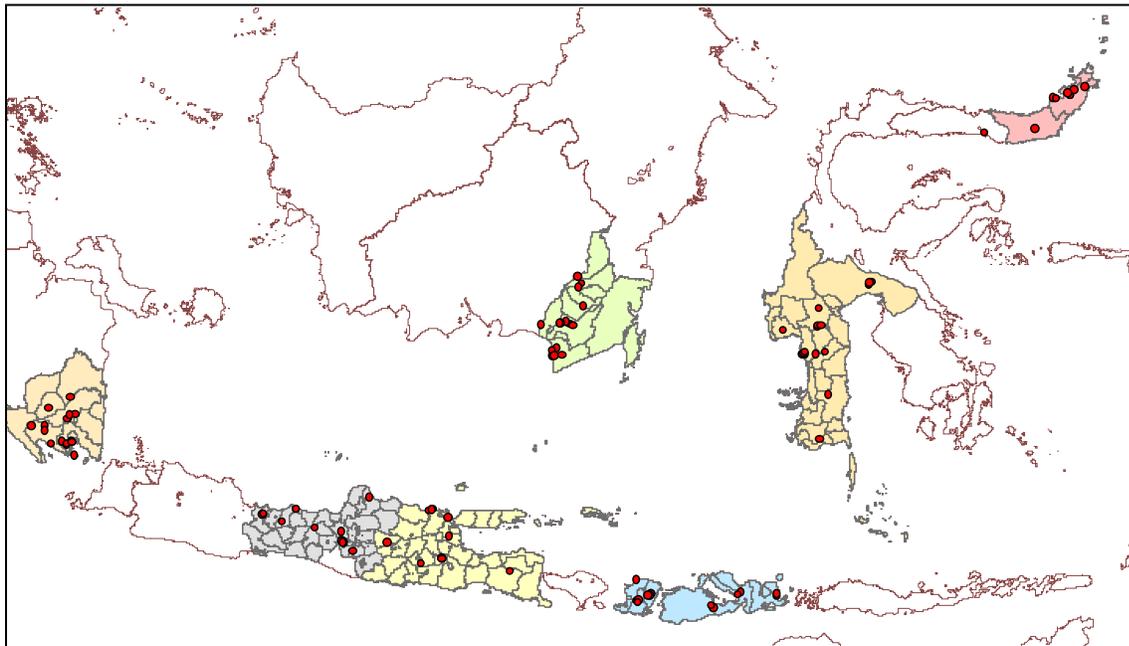


Table 1 Average land size (ha) in 2007

		Crop income>0 in2007 and 2010
All sample provinces	1.088 (1.429)	1.170 (1.417)
Lampung	1.324 (1.256)	1.342 (1.213)
Central Java	0.366 (0.448)	0.401 (0.535)
East Java	0.519 (1.499)	0.471 (0.410)
NTB	1.005 (1.125)	1.120 (1.271)
South Kalimantan	1.249 (1.264)	1.267 (1.024)
South Sulawesi	1.063 (1.068)	1.111 (1.098)
North Sulawesi	1.626 (2.472)	2.201(2.816)

Numbers in parentheses are standard deviations.

Table 2 Land transactions

Sample: Dependent: change in	farm land >0.6 ha in 2007		farm land <=0.6 ha in 2007	
	land self-cultivated Total	land self-cultivated Rent-in	land self-cultivated Total	land self-cultivated Rent-in
Real wage growth: Non-agriculture	-0.0265 (0.35)	0.0546 (2.46)	0.1745 (1.79)	0.0521 (0.69)
Real wage growth: Agriculture	0.0130 (0.15)	0.0988 (6.39)	0.0254 (0.34)	-0.0034 (1.75)
Years of schooling (age 20-55; 2007)	-0.0405 (1.33)	-0.0448 (2.81)	0.0104 (0.92)	0.0074 (0.43)
Age (age 20-55; 2007)	-0.0269 (1.48)	-0.0191 (1.97)	-0.0099 (1.61)	0.0007 (0.13)
Female (age 20-55; 2007)	0.0827 (0.12)	-0.0494 (0.23)	-0.2305 (0.79)	-0.0220 (0.30)
Number of hh members (age 20-55; 2007)	0.1341 (1.62)	0.0403 (0.76)	0.0098 (0.19)	-0.0139 (0.28)
Province fixed effects	yes	yes	yes	yes
R squared (within)	0.0175	0.0332	0.0169	0.0038
Number of observations	451	451	457	457

Numbers in parentheses are absolute t values using robust standard errors.

Table 3 Machine investment

Sample:	farm land >0.6 ha in 2007	farm land <=0.6 ha in 2007
Dependent: Machine investment in 2007-2010		
Real wage growth: Non-agriculture	-916665.7 (1.34)	67337.9 (0.79)
Real wage growth: Agriculture	242615.3 (2.07)	-286772 (1.64)
Years of schooling (age 20-55; 2007)	71005.84 (1.74)	-22880.74 (0.68)
Age (age 20-55; 2007)	18699.46 (0.93)	-27631.53 (1.38)
Female (age 20-55; 2007)	-39647.67 (0.20)	115027.2 (1.65)
Number of hh members (age 20-55; 2007)	57216.69 (0.20)	125728.6 (1.37)
Farm land (self-cultivated) 2007	100105.8 (1.12)	494300.6 (1.36)
Farm land (self-cultivated) 2007 not owned	-63682.54 (0.29)	253248.2 (2.62)
Province fixed effects	yes	yes
R squared (within)	0.0385	0.0294
Numbers of observations	451	451

Numbers in parentheses are absolute t values using robust standard errors.

Table 4 Crop income

Sample:				Large farmers	Small farmers
Dependent: Crop income growth (difference in log)				>0.6 ha	<=0.6 ha
Change in self-cultivated farm land		0.3002	0.2809	0.1351	0.5788
		(2.66)	(2.45)	(1.11)	(3.15)
Change in self-cultivated farm land owned	0.2747				
	(2.70)				
Change in self-cultivated farm land not own	0.3318				
	(1.81)				
Machine investment		3.46E-08	4.38E-08	9.33E-09	9.73E-08
		(1.63)	(1.76)	(0.38)	(2.43)
Change in self-cultivated farm land * Machine inv			3.35E-08	4.90E-08	-7.29E-08
			(1.52)	(2.58)	(1.48)
Village fixed effects	yes	yes	yes	yes	yes
R squared (within)	0.0188	0.0201	0.0214	0.0126	0.0476
Number of observations	968	967	967	476	491

Numbers in parentheses are absolute t values using robust standard errors.