Changing Relationship between Farm Size and Productivity and Its Implications for Philippine Agriculture

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Short bio

Keijiro Otsuka is a professor of Development Economics at the Graduate School of Economics, Kobe University, and a Chief Senior Researcher at the Institute of Development Economies. He received a PhD in economics from the University of Chicago in 1979. He was a Chairman of the Board of Trustees of the International Rice Research Institute from 2004 to 2007 and President of the International Association of Agricultural Economists from 2009 to 2012. He received the Purple Ribbon Medal from the Japanese Government in 2010 and was selected as a member of the Japan Academy in 2018.

Abstract

No controversy in the history of agricultural economics is more perennial than the relationship between farm size and productivity. While the dominant view has been the inverse relationship (IR), particularly when the productivity is measured by gross value of output or physical yield per hectare, several studies found the positive and U-shaped relationships between farm size and productivity. Furthermore, there is evidence that IR has been weakened, particularly in rapidly-growing countries in Asia. This study's primary purpose is to identify causes for the different and changing relationships between farm size and productivity based on a literature review. The second purpose of this study is to review farm size changes over time among selected Asian countries to examine how farm size changes are related to the changing farm size-productivity relationship or the changing advantage of small vs. large farms. The third purpose is to draw policy implications of the changing farm size-productivity relationships for the future of Philippine agriculture.

Keywords: farm size-productivity relationship, advantage of small farms, mechanization, advantage of large farms, changing comparative advantage of agriculture

JEL codes: O13, Q12, Q15

1 Introduction

No controversy in the history of agricultural economics is more perennial than the relationship between farm size and productivity. From the days of Chayanov (1926) to the present, the dominant view has been the inverse relationship (IR) between farm size and productivity, particularly when it is measured by physical yield or gross value of production per hectare (e.g., Barrett, Bellemare, and Hou 2010; Larson et al. 2014; Delvaux, Riesgo, and Paloma 2020). Feder (1985) theoretically demonstrated that because large farms tend to use hired labor more intensively than small farms, and because hired workers do not work as hard as family workers, large farms tend to be less productive than small farms. Based on this IR, Lipton (2012) advocated redistributive land reform as it is supposed to be conducive to both efficiency and equity.

However, Otsuka (2007) argued that the IR is partly the consequence of the land reform programs that suppress land rental transactions between less productive large farmers and more productive small farmers. He points out that IR is found primarily in South Asia, where land reform programs were widely implemented, but not in Southeast Asia, where they were not implemented rigorously, except in the Philippines.[1] Otsuka (2013); Estudillo and Otsuka (2016); and Otsuka, Liu, and Yamauchi (2016a) also maintain that by nature, small farms in Asia employ labor-intensive production methods and since the wage rate has been rising sharply in many high-performing Asian countries, the production cost of small-scale farming has been rising. This results in the loss of comparative advantage of agriculture in this region. This argument suggests that IR has been weakened in Asia because small farms' labor-intensive production is no longer advantageous. Using cross-country data from 1980 to 2010, Otsuka, Liu, and Yamauchi (2013) confirmed that the efficiency of smallholder agriculture has been declining. Thus, Asia as a whole may become a major importer of food grains unless farm-size expansion and large-scale mechanization take place (Yamauchi, Huang, and Otsuka 2021).

According to a recent meta-regression analysis of roughly 1,000 cases by Delvaux, Riesgo, and Paloma (2020), strong IR tends to be found when the gross value of output or physical yield per hectare is used as a measure of productivity; weaker IR is generally found when the net value of output (i.e., the gross value of output minus cost of purchased inputs) is used; and the farm size-productivity relationship becomes unclear when profit

1 An exception is a study by Benjamin (1995), which found IR in Indonesia.

(i.e., the net value of output minus the imputed value of owned resources, including family labor) or total factor productivity is used.[2] Furthermore, several studies found a U-shaped relationship between farm size and productivity in Pakistan (Heltberg 1998), Brazil (Rada and Fuglie 2019), and China (Sheng, Ding, and Huang 2019). As will be discussed later, the positive relationship between farm size and productivity is also reported in high-wage economies.

If factor markets work efficiently, no difference in productivity should be found across farms of different sizes because resources are transferred from less productive to more productive farms through land renting or labor employment (Kevane 1996). Therefore, the existence of an IR, positive, or U-shaped relationship implies inefficiency of production due to market failures, which must be eradicated ideally by policy means.[3] To do so, we must have a clear understanding of the causes for these different types of relationship between farm size and productivity. The first purpose of this article is to identify causes for the different and changing relationships between farm size and productivity based on a literature review. I observed that an IR tends to be found in low-wage economies where farm size is small and labor-intensive farming methods are adopted. In contrast, a positive relationship tends to be found in high-wage economies where farm size is large, and large-scale mechanization takes place. The U-shaped relationship is found where small-scale farming and large-scale farming systems coexist.

The second purpose of this article is to review changes in farm size over time among selected Asian countries in order to examine how farm size is related to the comparative advantage of agriculture, which should be reflected in the food self-sufficiency ratio in these countries. I would like to show that food self-sufficiency declines with economic development accompanying wage growth unless significant farm-size expansion occurs (Otsuka 2013).

The third purpose of this article is to draw policy implications of the changing relationship between farm size and productivity for the future of Philippine agriculture, based on a review of rice farming systems in Central Luzon from 1966 to 2015. I assert that unless land reform policies are redirected towards farm-size expansion, the efficiency of

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2 I presume that since both profit per hectare and total factor productivity take into account the contribution of whole inputs to production, they are highly correlated.

3 I assume that soil quality is not different between farms of different sizes. See Section 2 for a discussion on the possible impacts of soil quality difference on the farm size-productivity relationship.

Philippine agriculture is bound to decline with economic development in the future.

This article is organized as follows. Section 2 examines the theoretical causes for the inverse, positive, and U-shaped relationships between farm size and productivity, and Section 3 reviews the empirical evidence. Section 4 considers the future of small farms in East Asia (i.e., Northeast and Southeast Asia). This is followed by Section 5, with a review of long-term changes in rice farming systems in Central Luzon and a re-examination of the impact of land reform programs in the Philippines. The last section considers appropriate land policies for efficient land use in the course of successful economic development.

2 Economics of Farm Size-Productivity Relationship

2.1 Conceptual framework

In order to grasp why differential productivity is observed across farms of different sizes, let us consider the following production function:

$$Q = F(A, L_f, L_h, X, K), \quad (1)$$

where Q is output; A is the land area or farm size; L_f is family labor; L_h is hired labor; X is purchased inputs, including fertilizer and pesticides; and K is capital service. Family labor and hired labor are not perfect substitutes and, as such, are treated as separate inputs. In fact, the former is primarily engaged in care-intensive tasks, such as land preparation, crop care, and supervision of hired workers, whereas the latter is engaged in simple tasks, such as transplanting, harvesting, and threshing (Otsuka, Chuma, and Hayami 1992; Hayami and Otsuka 1993). Otsuka, Chuma, and Hayami (1993) demonstrate that tenancy contract is chosen over labor contracts, wherever tenancy transaction is allowed. *This implies that the labor market does not work efficiently in spatially-dispersed and ecologically-diverse agricultural environments*.[4] It is also noteworthy that roughly 90 percent of farms in the world are family farms relying on family labor (Lowder, Skoet, and Raney 2016), which indicates the importance of family labor in the management of farms. Note that labor inputs are assumed to be measured in terms of labor time in Equation (1). Since family workers are motived to work harder than hired workers, the marginal product of family labor is higher than that of hired labor (i.e., $\partial Q/\partial L_f >$

4 I will provide the supportive evidence in the analysis of labor use data in Central Luzon in Section 5.

$\partial Q/\partial L_h > 0$) in the observable range of labor inputs.

For simplicity, assume that the production function is subject to constant returns to scale. Then, Equation (1) can be rewritten as:

$$q = f\left(l_f, l_h, x, k\right), \tag{2}$$

where lower-case letters show output or input per hectare, corresponding to capital letters in Equation (1). I assume that a farmer's profit maximization leads to the optimum input use functions in which input (or input per hectare) is a function of real wage, real rental price, and farm size. Farm size can be changed in the long run through market transactions, but it is assumed to be fixed in the short-run or due to the suppression of the land market.

Let us also assume that there are two types of technologies (i.e., labor-intensive and capital-intensive technologies). While it is optimal to choose labor-intensive technology in low-wage economies, it is optimum to choose capital-intensive technology in high-wage economies. First, let us consider the case of low-wage economies. Since the use of capital is negligible, let us assume that k is low and fixed or $k = 0$. The question is how optimum l_f, l_h, and x change when A changes. Since it is reasonable to assume that the endowment of family labor is largely fixed, L_f cannot increase proportionally with an increase in A, which implies that $\partial l_f/\partial A < 0$. Large farms must employ large numbers of hired workers, which implies that $\partial l_h/\partial A > 0$. Whether x increases with an increase in A is uncertain (i.e., $\partial x/\partial A \gtrless 0$), because x tends to decrease with an increase in A if family labor and purchased inputs are complements, but it will increase if larger farmers have better access to credit.

In this framework, IR is explained primarily by lower productivity of hired labor than family labor and the more extensive employment of hired labor per unit of land on larger farms. If the amount of purchased inputs per unit of land decreases with an increase in farm size (i.e., $\partial x/\partial A < 0$), the tendency of IR is strengthened. If the land market (whether land rental or land sales market) works efficiently, however, IR will be eradicated by the transaction of land from less to more efficient farmers. Therefore, IR can be explained by multiple market failures, or at least by failures in both labor and land markets (Kevane 1996).

Next, let us consider the case of high-wage economies, where the intensive use of capital service or mechanization is advantageous. The important point is that since the tractor is a substitute for family labor for land preparation, a tractor reduces the demand for family labor. On the other hand, hired workers can be employed for driving tractors.[5] In other words, the use of tractors reduces the productivity of family labor and increases that of hired labor so that the marginal product of family labor can be either higher than or lower than hired labor (i.e., $\partial q/\partial l_f \gtreqless \partial q/\partial l_h$). According to Deininger et al. (2018, p. 239), "family labor use was more efficient than hired labor in 1982 and 1999 but not in 2008" in India when farms were highly mechanized. Furthermore, the use of combine harvesters reduces both the demand for hired labor in harvesting and threshing and for family labor in supervision. Thus, we expect that $\partial l_f/\partial A < 0$ and $\partial l_h/\partial A < 0$, so that the use of both family and hired labor is lower on larger farms. Since labor inputs are no longer critically important, it is likely that x is determined primarily by credit access, which confers an advantage to large farms. Thus, we expect that $\partial x/\partial A > 0$. Finally, considering that capital input is an indivisible factor of production,[6] its use is more effective on larger farms, which means that $\partial k/\partial A > 0$.

Consequently, we expect to observe a positive relationship between farm size and yield per hectare due to the efficient use of capital and the application of larger amounts of purchased inputs. Like the case of IR, such a positive relationship will disappear if the land or labor market works efficiently.

2.2 Methodological issues

I implicitly assumed that soil quality is the same between small and large farms in the conceptual framework. Soil quality, however, tends to be higher on small farms, which may result in IR. According to Barrett, Bellemare, and Hou (2010), however, the difference in the soil quality explains only a small part of IR. The meta-analysis of Delvaux, Riesgo, and Paloma (2020) also point out that the inclusion of soil quality reduces IR but does not eradicate it.

Another possibility is the measurement error. Smallholders may overestimate output and underestimate farm size. According to Carletto, Savastano, and Zezza (2013), farm size that is actually measured instead of just being estimated by farmers strengthens IR rather than weakens it. That is, farmers seem to consistently overestimate the land size of small

5 If a farmer rents the tractor, the tractor owner usually sends a driver along with the tractor.

6 If the machine rental market is developed, machine service can be a divisible input. Yet, larger machines can be used more efficiently on larger farms.

plots and underestimate large ones. On the other hand, Desiere and Jolliffe (2018) report that IR is strong when self-reported production data are used, but it disappears when crop-cut estimates are used. While it is not clear how generalizable this finding is, it seems safe to assume that the measurement errors of output do not entirely cause IR until further supporting evidence is provided by additional studies.

Some authors argue that since the yield or gross value of output per hectare does not show production efficiency, profit per hectare or total factor productivity (TFP) should be used to discuss the issue of production efficiency associated with farm size (Muyanga and Jayne 2019; Rada and Fuglie 2019; Delvaux, Riesgo, and Paloma 2020).[7] While I agree that the gross value of output or yield per hectare is not an appropriate measure of production efficiency at the farm level, I *strongly* disagree that one should examine only the profit per hectare or TFP. Figure 1 illustrates this point. Acknowledging the findings of Delvaux, Riesgo, and Paloma's (2020) meta-analysis, Figure 1 shows strong IR for the gross value of production per hectare, less strong yet significant IR is drawn for the net value of production, and a less clear relationship is shown between farm size and profit per hectare. The source of the problem is that labor cost includes the imputed cost of family labor, which is unpaid. Imputation usually uses the prevailing market wage rate, but it can be questioned whether it is really an appropriate shadow price of family labor. In other words, the estimated profit, which is obtained by deducting estimated family labor cost as well as imputed costs of using other family-owned resources from the net value of production, is subject to errors. If TFP is used, the estimations of factor shares and amount of labor input (which is usually simply the sum of family and hired labor time) are subject to errors because family labor and hired labor are not perfect substitutes. Therefore, it is risky to rely only on estimated profit or TFP when one analyzes the relationship between farm size and productivity.

---Figure 1 about here---

It must be clearly understood that it is more relevant to analyze the gross value of production, the net value of production, and profit per hectare simultaneously. Indeed, the fact that the gross value of output and the net value of output (which can be measured accurately, at least in theory) differ between small and large farms provides clear indications that resources are misallocated between farms, even though the extent of misallocation cannot be immediately ascertained. It is also desirable to examine the

7 The estimated profit is supposed to show return to land and management efficiency, aside from errors of imputing family labor cost.

robustness of estimated profit and TFP by changing the assumed shadow wages of family labor.

3 A Review of Empirical Evidence

Numerous empirical studies have found stable IR of yield or gross value of output per hectare (see Lipton 2012 for a survey of earlier studies). Selected recent studies include Barrett, Bellemare, and Hou (2010) on Madagascar; Li et al. (2013) on China around the turn of the century; Carletto, Savastano, and Zezza (2013) on Uganda; Larson et al. (2014) on Malawi, Tanzania, Kenya, and Uganda; Wang et al. (2015) on India; and Rada and Fuglie (2019) on Malawi, Tanzania, Uganda, and Bangladesh. Consistent with the conceptual framework, IR is found in low wage-economies, such as those in sub-Saharan Africa, South Asia, and China during the early years.[8] Li et al. (2013) did not find any relationship when TFP is used. Larson et al. (2014) also observed IR for family labor per hectare and a positive relationship for hired labor per hectare.

More recent studies found the weakening tendency of IR in several Asian countries, many of which experienced high economic growth and rising wage rates. While Wang et al. (2016) discovered declining IR in China, Deininger et al. (2018) report similar tendencies in India. Furthermore, Gautum and Ahmed (2019) and Liu et al. (2020) also found similar phenomena in Bangladesh and Vietnam, respectively. These studies commonly report on farm-size expansion and progress of mechanization, particularly through renting of machinery services,[9] which would lead to the lessened advantage of intensive family labor use on small farms. This is consistent with Otsuka, Liu, and Yamauchi's (2013) finding from the cross-country regression that labor-saving mechanization has taken place significantly in countries where farm size is large.

Earlier, Hayami and Kawagoe (1986) found the emergence of scale economies in rice farming in Japan since the mid-1960s when riding tractors were introduced. This suggests the emergence of a positive relationship between farm size and productivity in this country. Later, Kawasaki (2010) confirmed that the cost of rice production increases less than proportionally with an increase in output, implying the emergence of the positive relationship in Japan. Rada and Fuglie (2019) report the positive relationship between

8 IR is found in sub-Saharan Africa even though land rental transactions have gradually become active (Holden, Otsuka, and Deininger 2013; Holden, Otsuka, and Place 2009).

9 In Vietnam, land consolidation has also taken place, which facilitates mechanization (Nguyen and Warr 2020).

farm size and TFP in Australia and the USA. This is also found in emerging economies, such as China (Wang et al. 2015) and Indonesia (Yamauchi 2016), as well as some areas in Vietnam where farm size is relatively large, farm size is expanding through land renting, and mechanization is taking place through machine renting (Liu et al. 2020). The upward sloping curve portrays the positive relationship between farm size and productivity in Figure 2.

---Figure 2 about here---

There are several studies that found a U-shaped relationship between farm size and productivity. Heltberg (1998) was the first to report the U-shaped relationship between farm size and net output per hectare in Pakistan, where smallholders and significantly large farmers coexist.[10] Later such relationships were reported in Brazil (Rada and Fuglie 2019) and in China (Sheng, Ding, and Huang 2019), where small farms adopting labor-intensive production methods and large farms using large machinery coexist. The dotted curve illustrates such a relationship in Figure 2. Somewhat surprisingly, a U-shaped relationship between cultivated area and profit per hectare or TFP was reported in Kenya by Muyanga and Jayne (2019), where the bottom of the U-shape was around 5 hectares. According to them, large farms have newly emerged and used highly mechanized farming systems, in contrast to smallholder farmers who rely on labor-intensive production methods.[11]

To sum up, the traditional labor-intensive farming system tends to be subject to IR, whereas capital-intensive mechanized farming systems are subject to a positive farm size-productivity relationship. When both farming systems coexist, a U-shaped relationship between farm size and productivity is likely to be observed.

4 Future of Small Farms in East Asia

As shown, small farms in East Asia have been losing the advantage of using family labor, as the wage rate has been rising, and mechanization has been taking place. If so, farm size should increase to prevent the loss of comparative advantage in agriculture; otherwise, food self-sufficiency will decline in this region. The issues of changes in farm size and

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10 As far as profit per hectare is concerned, he found a positive relationship.

11 I have some reservations about their findings because half of the land owned by large farms is unused but their study excludes such land and focuses only on the cultivated area. I believe that the entire land should be considered if the production efficiency is analyzed. It is also unclear how the cost of using owned large machinery is reckoned.

grain self-sufficiency are examined in this section.

4.1 Changing farm size in East Asia

Figure 3 shows the changing operational farm size in six selected East Asian countries: Japan, the Republic of Korea, China, Indonesia, the Philippines, and Thailand. The average farm size was small in the early 1960s, ranging from 1 hectare in Japan and Indonesia, 2 hectares in the Republic of Korea, to 3.5 hectares in the Philippines and Thailand. It has declined in subsequent periods in all these countries except in Japan because of rapid population growth and limited area expansion in rural areas. This is consistent with the generally declining farm size in developing countries (Lowder, Skoet, and Raney 2016). The decrease in farm size is particularly pronounced in the Philippines partly because of rapid population growth and partly because of the failure of growth in the nonfarm sectors, which can absorb rural labor. If this trend in farm-size reduction continues and the economy sustains a fairly high growth rate, the agricultural sector's inefficiency can be a major constraint to further economic growth. Although farm size increased in Japan, reaching three hectares in recent years, it is far below the average farm size in Europe and North America, where farms larger than 100 hectares are common. Considering the high wage rate in this country, it is obvious that Japanese agriculture is losing its comparative advantage.

---Figure 3 about here---

The average farm size in China is tiny. However, it increased from 0.57 hectare in 2003 to 0.79 hectare in 2013 (Huang and Ding 2016), amounting to a 0.22-hectare increase per decade. Since the wage rate has been rising sharply in the last few decades and a positive relationship between farm size and productivity has emerged in this country, retaining small farms could result in increased cost of domestic production and massive import of food. In fact, China is already a major importer of soybean. There is a possibility that China will import massive amounts of other grains unless farm-size expansion and large-scale mechanization take place.

Declining farm size in the Philippines, Thailand, and Indonesia; slowly increasing farm size in China; and increasing but still small farm size in Japan cannot be compatible with rising wage rates and the actual or possible emergence of a positive relationship between farm size and productivity, suggesting that agriculture in these countries is losing or will lose its comparative advantage (Otsuka, Liu, and Yamauchi 2016a, 2016b).

4.2 Changing grain self-sufficiency in East Asia

Figure 4 shows changes in grain self-sufficiency ratio, which is calculated by dividing domestic production of rice, wheat, maize, and soybean by the sum of domestic production and net imports of the above four crops. Since production, consumption, and trade are evaluated simply by weight, the self-sufficiency ratio is a rough measure of agriculture's comparative advantage. It is also affected by the distortionary agricultural policies of various governments. Thus, it should be interpreted with caution, even though its large changes over time and large differences across countries indicate underlying changes and differences in comparative advantage.

---Figure 4 about here---

The estimated grain self-sufficiency ratio in Japan has declined rapidly since 1961, attesting to the sharply declining comparative advantage of agriculture in this country. The self-sufficiency ratio has also declined significantly in the Republic of Korea, almost in parallel with that of Japan. Farm sizes in Korea are slightly smaller than in Japan, and wage rates have increased continuously, similar to Japan. There seems to be little doubt that one of the fundamental causes of the lost comparative advantage in these two Northeast Asian countries is the preservation of labor-intensive small-scale agriculture amid high and rising wages. This is consistent with the cross-country regression analysis findings by Otsuka, Liu, and Yamauchi (2013) that in Asia, the grain self-sufficiency ratio decreased when GDP per capita exceeded a threshold level.

Thailand has been a net exporter of grains as its self-sufficiency ratio exceeds unity. However, its self-sufficiency ratio has been declining and has fallen to slightly above the self-sufficient level in the 2010s. Although the average farm size in Thailand is fairly large by Asian standards (see Figure 3), it seems that it is not large enough to maintain its comparative advantage in agriculture.

Self-sufficiency ratios were close to unity in the 1960s to the mid-1980s but had been slightly declining in the other three countries (i.e., the Philippines, Indonesia, and China). The declining trend of self-sufficiency ratio since the mid-1980s in the Philippines is consistent with the sharply declining farm size in this country. Slightly declining self-sufficiency ratios in Indonesia and China are worrisome, as these are large, populous countries. Moreover, the average farm size in these two countries is even lower than in

Japan and in the Republic of Korea. If these countries become gigantic importers of grains, world grain prices will significantly shoot up, adversely affecting the well-being of consumers throughout the world, particularly the poor consumers. These possibilities cannot be denied unless farm size increases significantly, and large-scale mechanization takes place (Yamauchi, Huang, and Otsuka 2021).

5 Changes in Rice Farming in Central Luzon

I would like to examine long-term changes in farm size, labor use, and mechanization using the rice farming data collected by the Central Luzon Survey, carried out more or less every four years from 1966 to 2015 (Moya et al. 2015). This data set is valuable; not only significant changes in paddy yield but also dramatic changes in family and hired labor and machine use are reported. According to Estudillo and Otsuka (1999), who used the same survey data, mild IR seems to have been observed in this region from 1966 to 1994.[12] Needless to say, Central Luzon is an advanced rice-growing region in the Philippines and is regarded as its rice bowl. Similar changes seem to have taken place in other rice-growing areas in this country (Mataia et al. 2020).

As shown in Table 1, farm size in Central Luzon has been largely unchanged at around two hectares from 1966 to 2015, except for a brief period in 1970 and 1974. Paddy yield increased from 2.3 tons per hectare in 1966 to 4.1 tons per hectare in 1982, owing to the Green Revolution. Yield has been largely unchanged from 1982 to 2015, even though there were fluctuations in yield due mainly to climate variations. High-yielding hybrid varieties were introduced around 2010, but their adoption rates remained very low in Central Luzon. It is interesting to observe substantial changes in total labor used per hectare; it increased from 1966–1970 to 1974–1982, gradually decreased until 1999, and drastically declined toward 2015 after some increases in 2008–2011. In the following subsections, what happened to the use of family and hired labor separately and mechanization in rice farming in Central Luzon during the last five decades is explored.

---Table 1 about here---

12 A part of the reason could be the provision of credit with relatively low interest rates by traders to small farmers.

5.1 Changing labor use by family and hired labor

Figure 5 shows changes in the family and hired labor used per hectare of care-intensive activities (i.e., land preparation and crop care) and other activities (e.g., crop establishment, harvesting, and threshing). Several important observations can be made. First, traditionally in the 1960s and 1970s, family labor was used for care-intensive activities significantly more than hired labor. As pointed out by Otsuka, Chuma, and Hayami (1992) and Hayami and Otsuka (1993), the hired labor market does not seem to work for care-intensive tasks because proper care and judgment are required in these activities. Clearly, family labor and hired labor are not perfect substitutes. Second, the use of hired labor has been dominant in other activities (simple tasks that do not require much care and judgment) and remained relatively stable from 1966 to 2010. Thus, it seems clear that the hired labor market works for these activities. Family labor is used primarily for supervision, which accounts for a small portion of these activities. It must be pointed out that the dominant use of family labor for care-intensive activities and that of hired labor for other activities are observed throughout rice farming areas in Asia (David and Otsuka 1994). Third, family labor use in care-intensive activities began decreasing in the late 1970s: from 24.1 days per hectare in 1966 to a mere 7.5 days per hectare in 2015. Thus, the advantage of small farms arising from the intensive use of family labor, if any, must have eroded over time. This finding is consistent with the weakening IR in Asia discussed in the previous section. Fourth, all of a sudden, hired labor use dropped in 2011 to 2015. It appears that the increasing wage rate in the Philippines induced the introduction of hired labor-saving technology.

I would like to postulate the hypothesis that drastic changes in family and hired labor use can be explained mainly by mechanization, some of which save on family labor and others save on hired labor. I will examine the validity of this hypothesis in the next sub-section.

5.2 Mechanization in Central Luzon

Threshing was traditionally carried out by large threshing machines, called *tilyadora*, which were used to measure the quantity of paddy produced by share tenants (Hayami and Kikuchi 1982). The adoption rate of tilyadora was 87 percent in 1966 and 74 percent in 1970. As share tenancy declined due to the implementation of land reform (Otsuka 1991), the adoption rate decreased to 44 percent in 1974 and 31 percent in 1979. Such changes are consistent with low hired labor use in 1966 and 1970 and its increase in 1974 and 1979 (see Figure 5) because the tilyadora can replace hired labor. Small threshers were almost completely adopted by 1986, and, thereafter hired labor use had been fairly stable from 1986 to 2011.

---Figure 5 about here---

Decreasing family labor use for care-intensive activities since 1974 can be explained primarily by the increasing adoption of power tillers, as well as the gradually increasing adoption of riding tractors and rotavators (see Figure 6). In fact, family labor use in land preparation significantly decreased over time. The use of animals or water buffalos decreased but did not become negligible because they were used for plowing the edge of paddy fields. In contrast, hired labor use in land preparation increased from about 2 days per hectare in 1966 and 1970 to 7.6 days per hectare in 2011 and 2015. This can be explained by the fact that most farmers rent power tillers and tractors along with their drivers, who are also hired workers. Thus, family labor has been substituted for by tractors and hired labor. It is no wonder that the advantage of small farms arising from intensive family labor use no longer exists once tractors were introduced. This is similar to the case of postwar Japan reported earlier.

---Figure 6 about here---

Another major mechanization was the introduction of combine-harvesters. No farmer had adopted this machine in Central Luzon until 2011, but its adoption rate jumped to 45 percent in 2015. As a result, hired labor use in other activities (i.e., harvesting and threshing) precipitously declined from 2011 to 2015 (see Figure 5). It is likely that as the adoption rate of combine-harvesters increased, hired labor use declined further. There seems to be no question that combine-harvester save on hired labor. This suggests that the disadvantage of large farms associated with the supervision of hired labor decreases with the adoption of combine-harvesters.

To sum up, it is reasonable to conclude that while tractorization reduces the advantages of small farms, the introduction of combine-harvesters reduces the disadvantage of large farms. This implies that the optimum farm size increases with the increased adoption of agricultural machinery.

5.3 Need for redesigning land reform in the Philippines

If IR is observed and small farms are more efficient than large farms, the question is why inefficient large farms do not lease out their land to smaller farmers. In India and the

Philippines, the redistributive land reform program, known as the land-to-the-tiller program, applied to tenant-cultivated land with the exemption of owner-cultivated land using hired labor (Otsuka 2007). Thus, landlords were motivated to evict tenants in order to undertake owner cultivation using hired labor. As a consequence, the land (rental) market cannot allocate land from inefficient farms to efficient farms. Such a policy, which suppresses the land rental market's function, is responsible for both inefficient land allocation and inequitable income distribution.

Setting a ceiling over which land is transferred to tenants also distorts land allocation (Adamopoulos and Restuccia 2014). In the Comprehensive Agrarian Reform Program (CARP) of the Philippines, the ceiling of 5 hectares is set for non-rice and non-corn land and 7 hectares for rice and corn land (Adriano 1991). This is detrimental to the efficiency of land allocation when a positive relationship emerges between farm size and productivity. Thus, in all likelihood, the positive relationship will be observed in the Philippines in view of the large-scale mechanization of land preparation and harvesting and threshing. Because of the failure of the CARP to generate an effective land rental market, the land is inefficiently allocated in the Philippines even at present (Michler and Shively 2015).

In the face of the changing relationship between farm size and productivity, it is critical to recognize the role of land rental markets in reallocating land from the less productive to the more productive farms. It should not be government law but the market that ought to determine the desirable allocation of land. The Philippines is no exception, and if the land market continues to be distorted, increasingly large and serious inefficiencies will arise because of inefficient land resource allocation in this country.

6 Concluding Remarks

The world has been changing rapidly, and so has agriculture throughout the world. Otsuka and Fan (2021) observe rapid growth in labor productivity in agriculture in all major regions of the world due to rapid mechanization. According to this study, such changes would have increased the advantage of large farms and decreased the advantage of small farms. Nonetheless, if the small farms are preserved, as in Japan and the Republic of Korea, the comparative advantage of agriculture will be lost, and, consequently, food self-sufficiency will decline.

I do not simply advocate the dominance of large farms, like Collier and Dercon (2014) and Adamopoulos and Restuccia (2014). When wage rates are low, and land is scarce, efficient farms are likely to be small family farms. Thus, Larson, Muraoka, and Otsuka (2016) advocate promoting agricultural development based on smallholder farms in sub-Saharan Africa. Such smallholder-based development can potentially lead to a full-fledged Green Revolution in sub-Saharan Africa, judging from the Green Revolution experience in Asia (Otsuka and Larson 2013, 2016). It is critically important to recognize that such development is both efficient and equitable.

As the economy develops, the potential problem is that the wage rate increases, which tends to induce mechanization. For effective mechanization, farm-size expansion must take place. In the adjustment process of farm-size expansion, the positive relationship between farm size and productivity tends to emerge. If the government wants to maintain or even strengthen comparative advantage in agriculture, land transfer from less productive small farms to more productive large farms must be promoted. This policy is diametrically opposite to the policy, which was desirable when the economy was poor. This policy shift is a significant challenge for policymakers who are interested in sustainable economic development.

How can the government implement efficient land policy in the course of economic development? The critical point is that the efficient allocation of land should be achieved by the land market, particularly by the land rental market. A land ceiling in the transfer of land from land-rich to land-poor farmers may be set, but it must be lifted once land redistribution has been completed. Similarly, the exemption of owner-cultivation from the implementation of land reform must be abolished to facilitate land renting. It must be clearly understood that the land market ought to play the vital role of transferring land rights from less productive to more productive farmers. Its suppression leads to potentially devastating consequences on the efficiency of agriculture, as has happened in Japan and the Republic of Korea. This is particularly the case in the Philippines and India, where, historically, the redistributive land reform programs were extensively implemented in favor of small farms.

References

Adamopoulos, T., and D. Restuccia. 2014. "The Size Distribution of Farms and International Productivity Differences." *American Economic Review* 104(6): 1667–97.

Adriano, L.S. 1991. "A General Assessment of the Comprehensive Agrarian Reform Program." *Philippine Institute for Development Studies Working Paper* No. 91-13.

Barrett, C.B., M.F. Bellemare, and J.Y. Hou. 2010. "Reconsidering Conventional Explanations of the Inverse Productivity-Size Relationship." *World Development* 38(1): 88–97.

Benjamin, D. 1995. "Can Observed Land Quality Explain the Inverse Productivity Relationship?" *Journal of Development Economics* 46(1): 51–84.

Carletto, C., S. Savastano, and A. Zezza. 2013. "Fact or Artifact: The Impact of Measurement Errors on the Farm Size-Productivity Relationship." *Journal of Development Economics* 103: 254–61.

Chayanov, A.V. 1926. *The Theory of Peasant Economy*. Madison, WI: University of Wisconsin Press.

Collier, P., and S. Dercon. 2014. "African Agriculture in 50 Years: Smallholders in a Rapidly Changing World." *World Development* 63: 92–101.

David, C.C., and K. Otsuka (eds.). 1994. *Modern Rice Technology and Income Distribution in Asia*. Boulder, CO: Lynne Rienner.

Deininger, K., S. Jin, Y. Liu, and S.K. Singh. 2018. "Can Labor-Market Imperfections Explain Changes in the Inverse Farm Size-Productivity Relationship? Longitudinal Evidence from Rural India." *Land Economics* 94(2): 239–58.

Delvaux, P.A.G, L. Riesgo, and S.G. Paloma. 2020. "Are Small Farms More Performant than Larger Ones in Developing Countries?" *Science Advances* 6(41): eabb8235.

Desiere, S., and D. Jolliffe. 2018. "Land Productivity and Plot Size: Is Measurement Error Driving the Inverse Relationship?" *Journal of Development Economics* 130: 84–98.

Estudillo, J.P., and K. Otsuka. 1999. "Green Revolution, Human Capital, and Off-Farm Employment: Changing Sources of Income among Farm Households in Central Luzon, 1966–94." *Economic Development and Cultural Change* 47(3): 497–523

———. 2016. *Moving out of Poverty: An Inquiry into Inclusive Growth in Asia.* London, UK: Routledge.

Feder, G. 1985. "The Relations between Farm Size and Farm Productivity: The Role of Family Labor, Supervision, and Credit Constraints." *Journal of Development Economics* 18(2–3): 297–313.

Food and Agriculture Organization of the United Nations (FAO). 2010. *World Census of Agriculture*.

Food and Agriculture Organization of the United Nations (FAO). 2020. *FAOSTAT*. http://www.fao.org/faostat/en/.

Gautum, M., and M. Ahmed. 2019. "Too Small to Be Beautiful? The Farm Size and Productivity Relationship in Bangladesh." *Food Policy* 84: 165–75.

Hayami, Y., and T. Kawagoe. 1986. "Farm Mechanization, Scale Economies, and Polarization: The Japanese Experience." *Journal of Development Economics* 31(2): 221–39.

Hayami, Y., and M. Kikuchi. 1982. *Asian Village Economy at the Crossroads.* Baltimore, MD: Johns Hopkins University Press.

Hayami, Y., and K. Otsuka. 1993. *The Economics of Contract Choice: An Agrarian Perspective*. Oxford: Clarendon Press.

Heltberg, R. 1998. "Rural Market Imperfections and the Farm Size-Productivity Relationship: Evidence from Pakistan." *World Development* 26(10): 1807–26.

Holden, S., K. Otsuka, and K. Deininger. 2013. *Land Tenure Reforms in Asia and Africa: Assessing Impacts on Poverty and Natural Resource Management.* Hampshire, UK: Palgrave Macmillan.

Holden, S., K. Otsuka, and F. Place. 2009. *The Emergence of Land Markets in Africa: Assessing the Impacts on Poverty, Equity, and Efficiency.* Baltimore, MD: Resources for the Future.

Huang, J., and J. Ding. 2016. "Institutional Innovation and Policy Support to Facilitate Small-Scale Framing Transformation." *Agricultural Economics* 47(S1): 227–27.

IRRI (International Rice Research Institute). 2016. *Central Luzon Loop Survey 2015–16*. Los Baños, Laguna, Philippines: International Rice Research Institute.

Japan Ministry of Agriculture, Forestry, and Fisheries. Various years. *The Statistical Yearbook of MAFF*. http://www.maff.go.jp/e/data/stat/index.html

Kawasaki, K. 2010. “The Costs and Benefits of Land Fragmentation of Rice Farms in Japan.” *Australian Journal of Agricultural and Resource Economics* 54(4): 509–26.

Kevane, M. 1996. “Agrarian Structure and Agricultural Practice: Typology and Application to Western Sudan.” *American Journal of Agricultural Economics* 78(1): 236–45.

Larson, D.F., R. Muraoka, and K. Otsuka. 2016. “Why African Rural Development Strategies Must Depend on Small Farms.” *Global Food Security* 10: 39–51.

Larson, D.F., K. Otsuka, T. Matsumoto, and T. Killic. 2014. “Should African Rural Development Strategy Depend on Smallholder Farmers? An Exploration of the Inverse-Productivity Hypothesis.” *Agricultural Economics* 45(3): 355–67.

Li, G., Z. Feng, L. You, and L. Fan. 2013. “Re-examining the Inverse Relationship between Farm Size and Efficiency: The Empirical Evidence in China.” *China Agricultural Economic Review* 5(4): 473–88.

Lipton, M. 2012. *Land Reform in Developing Countries: Property Rights and Property Wrongs*. London, UK: Routledge.

Liu, Y., C. Barrett, T. Pham, W. Violette. 2020. “The Intertemporal Evolution of Agriculture and Labor over a Rapid Structural Transformation: Lessons from Vietnam.” *Food Policy* 94: 101913.

Lowder, S.K., J. Skoet, and T. Raney. 2016. “The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide.” *World Development* 87: 16–29.

Mataia, A.B., J.C. Beltran, R.G. Manalili, B.M. Catudan, N.M. Francisco, and A.C. Flores. 2020. “Rice Value Chain Analysis in the Philippines: Value Addition, Constraints, and Upgrading Strategies.” *Asian Journal of Agriculture and Development* 17(2): 19–41.

Michler, J.D., and G.E. Shively. 2015. “Land Tenure, Tenure Security, and Farm Efficiency: Panel Evidence from the Philippines.” *Journal of Agricultural Economics* 66(1): 155–69.

Moya, P., K. Kajisa, R. Barker, S. Mohanty, F. Gascon, and M.R.S. Valentin. 2015. *Changes in Rice Farming in the Philippines: Insights from Five Decades of a Household Survey.* Los Baños, Laguna, Philippines: International Rice Research Institute.

Muyanga, M., and T.S. Jayne. 2019. “Revisiting the Farm Size-Productivity Relationship Based on a Relatively Wide Range of Farm Sizes: Evidence from Kenya.” *American Journal of Agricultural Economics* 101(4): 1140-63.

Nguyen, H.Q., and Peter Warr. 2020. “Land Consolidation as a Technical Change: Economic Impacts in Rural Vietnam.” *World Development* 127: 104750.

Otsuka, K. 1991. “Determinants and Consequences of Land Reform Implementation in the Philippines.” *Journal of Development Economics* 35(2): 339–55.

———. 2007. “Efficiency and Equity Effects of Land Markets.” In *Handbook of Agricultural Economics, Volume 3*, edited by R. Evenson and P. Pingali, pp. 2672–703. Amsterdam: North-Holland.

———. 2013. “Food Insecurity, Income Inequality, and the Changing Comparative Advantage in World Agriculture.” *Agricultural Economics* 44(S1): 7–11.

Otsuka, K., and S. Fan (eds.). 2021. *Agricultural Development: New Perspectives in a Changing World*, edited by K. Otsuka and S. Fan. Washington, DC: International Food Policy Research Institute.

Otsuka, K., and D. Larson (eds.). 2013. *An African Green Revolution: Finding Ways to Boost Productivity on Small Farms*. Dordrecht, Netherlands: Springer.

———. 2016. *In Pursuit of an African Green Revolution: Views from Rice and Maize Farmers’ Fields*. Dordrecht, Netherlands: Springer.

Otsuka, K., H. Chuma, and Y. Hayami. 1992. “Land and Labor Contracts in Agrarian Economies: Theories and Facts.” *Journal of Economic Literature* 30(4):1965–2018.

———. 1993. “Permanent Labor and Land Tenancy Contracts in Agrarian Economies: An Integrated Analysis.” *Economica* 60(237): 57–77.

Otsuka, K., Y. Liu, and F. Yamauchi. 2013. “Factor Endowments, Wage Growth, Changing Food Self-Sufficiency: Evidence from Country-Level Panel Data.” *American Journal of Agricultural Economics* 95(5): 1252–58.

———. 2016a. “The Future of Small Farms in Asia.” *Development Policy Review* 34(3): 441–61.

———. 2016b. "Growing Advantage of Large Farms in Asia and its Implications for Global Food Security." *Global Food Security* 11: 5–10.

Rada, N.E., and K.O. Fuglie. 2019. "New Perspectives on Farm Size and Productivity." *Food Policy* 84: 147–52.

Sheng, Y., J. Ding, and J. Huang. 2019. "The Relationship between Farm Size and Productivity in Agriculture: Evidence from Maize Production in Northern China." *American Journal of Agricultural Economics* 101(3): 790–806.

Wang, J., K.Z. Chen, S.D. Gupta, and Z. Huang. 2015. "Is Small Still Beautiful? A Comparative Study of Rice Farm Size and Productivity in China and India." *China Agricultural Economics Review* 7(3): 484–509.

Wang, X., F. Yamauchi, K. Otsuka, and J. Huang. 2016. "Wage Growth, Landholding, and Mechanization in Chinese Agriculture." *World Development* 86(10): 30–45.

Yamauchi, F. 2016. "Rising Real Wages, Mechanization, and Growing Advantage of Larger Farms: Evidence from Indonesia." *Food Policy* 58: 62–69.

Yamauchi, F., J. Huang, and K. Otsuka. 2021. "Changing Farm Size and Agricultural Development in East Asia." In *Agricultural Development: New Perspectives in a Changing World*, edited by K. Otsuka and S. Fan, pp. 79–110. Washington, D.C.: International Food Policy Research Institute.

Table 1. Average farm size (ha), paddy yield (ton/ha), and labor use (person-days/ha) during the wet season in Central Luzon, 1966–2015

Year	No. of Sample Farms	Farm Size (ha)	Paddy Yield (ton/ha)	Labor Use (person-days/ha)
1966	95	2.1	2.3	69
1970	62	2.5	2.5	68
1974	59	2.6	2.0	85
1979	148	1.9	3.6	82
1982	135	1.8	4.1	83
1986	120	1.8	3.5	71
1990	108	1.8	3.5	74
1994	100	1.7	4.1	71
1999	85	1.6	3.5	60
2003	116	1.9	4.3	61
2008	107	1.8	4.5	66
2011	95	1.9	3.9	71
2015	89	1.8	3.8	46

Source: Moya et al. (2015) and International Rice Research Institute (2016)

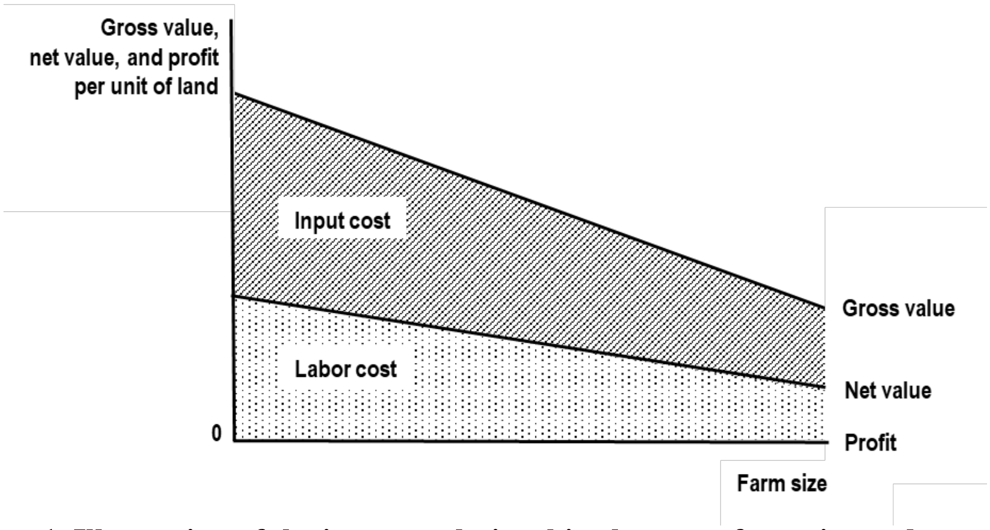

Figure 1. Illustration of the inverse relationships between farm size and productivity, measured by gross value of production, net value of production, and profit per unit of land

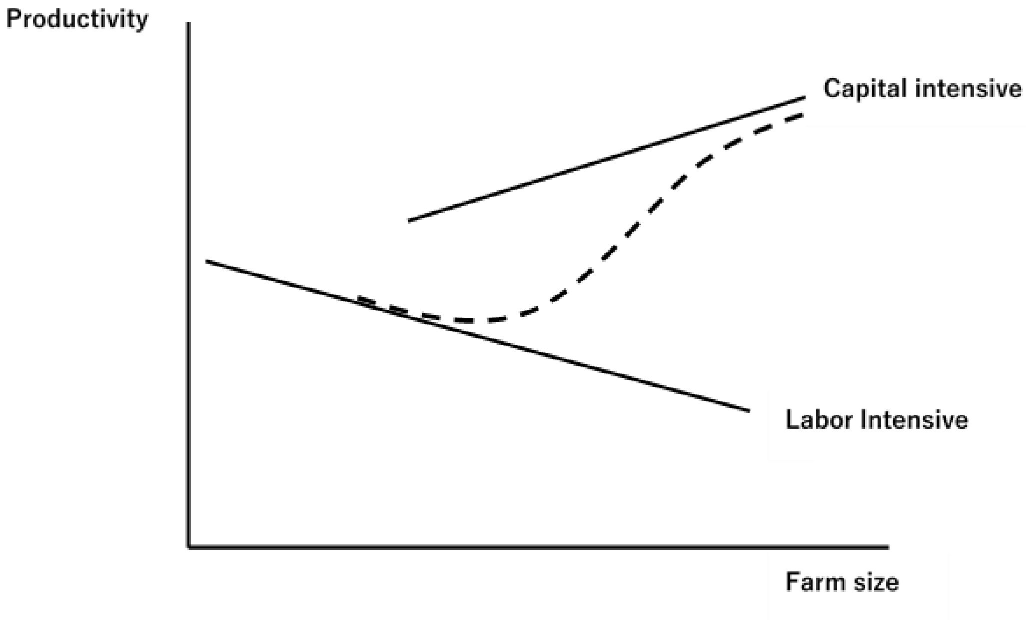

Figure 2. Conceptual relationships between farm size and productivity under labor- and capital-intensive farming systems

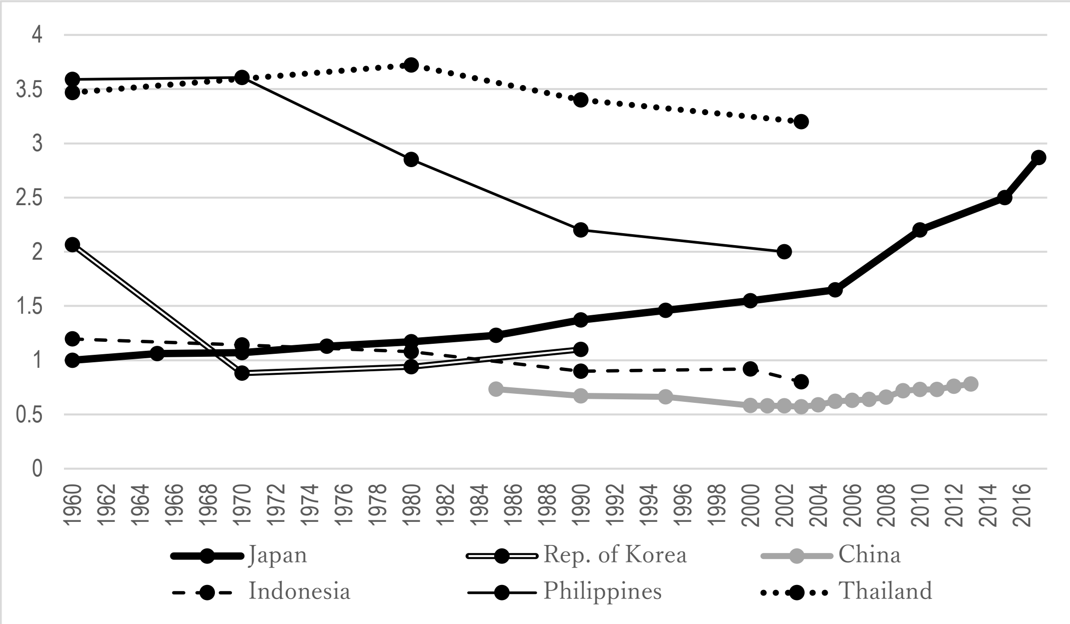

Figure 3. Changes in average farm size (ha) in selected East Asian countries

Sources: FAO (2010); Huang and Ding (2016) for China; Ministry of Agriculture, Forestry, and Fisheries (various years) for Japan

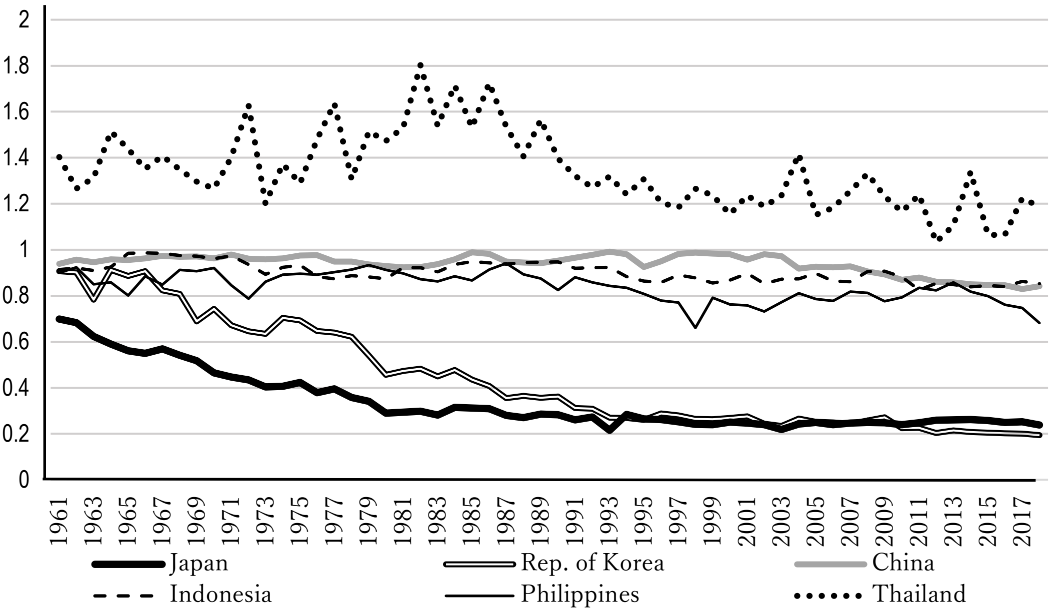

Figure 4. Changes in grain self-sufficiency ratio in selected East Asian countries

Note: Domestic production of rice, wheat, maize, and soybean divided by domestic production plus net imports of the above four crops in terms of weight

Source: FAOSTAT (2020)

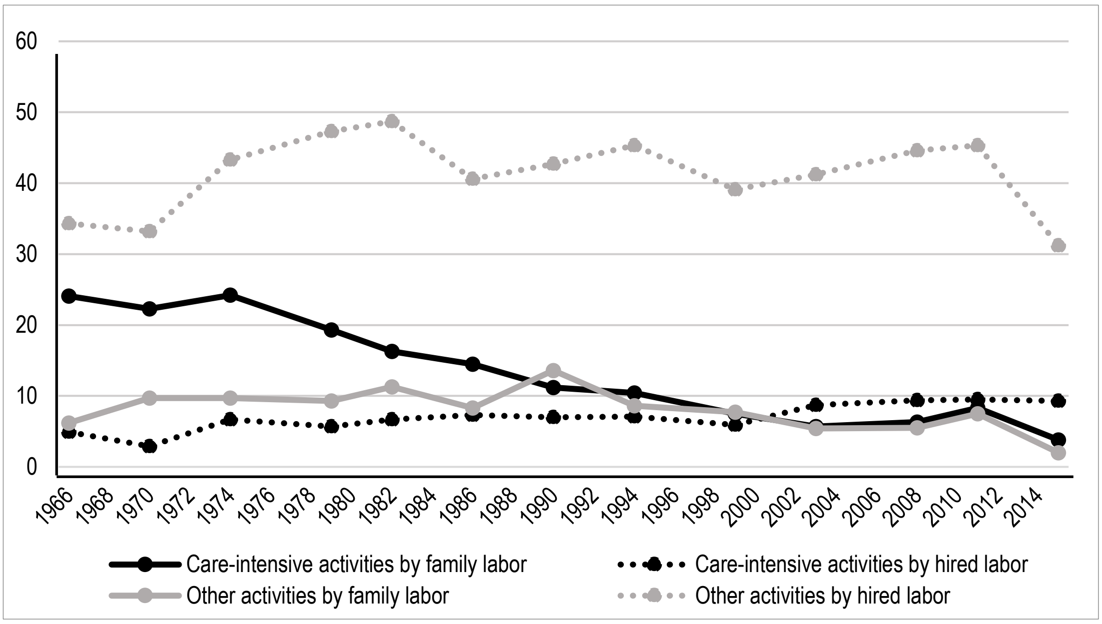

Figure 5. Changes in family and hired labor use (person-days/ha) for care-intensive and other activities during the wet season in Central Luzon, 1966–2015

Source: Moya et al. (2015) and International Rice Research Institute (2016)

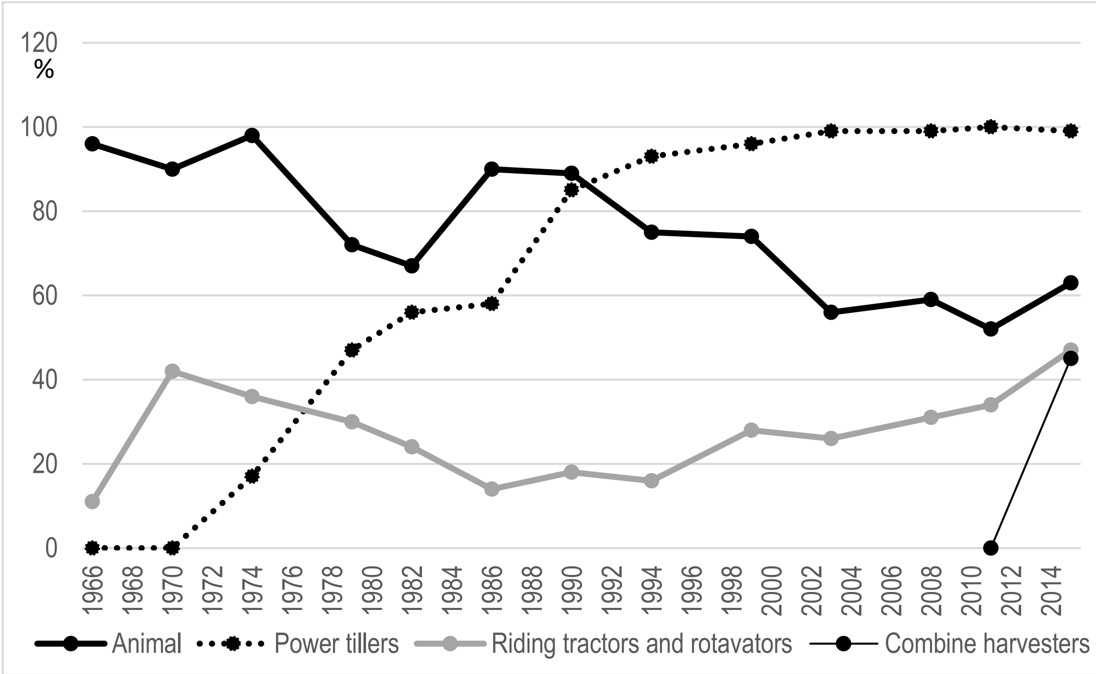

Figure 6. Tractorization in land preparation and the use of combine harvesters during the wet season in Central Luzon, 1966–2015

Source: Moya et al. (2015) and International Rice Research Institute (2016)