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Comparing Technical and Allocative Efficiency between Family Farms and Agricultural Corporations: Evidence From Japan's Rice Sector

Is an agricultural corporation more efficient than a traditional family farm? This paper attempts to answer this question by examining the technical and allocative efficiency of family farms and agricultural corporations. To do so, it applies the stochastic production frontier method in panel data built on the family farms and agricultural corporations in the Japanese rice sector and focuses on comparing the technical and allocative efficiency of the two production forms at the same scale of operation. Results reveal that family farms have a significant advantage over agricultural corporations in technical efficiency at each level of scale of operation. In both production forms, as the scale of operation increases, the technical efficiency correspondingly rises. However, the disparity in technical efficiency diminishes between the two production forms as their land size increases. In contrast, the allocative efficiency of different factors differs between family farms and agricultural corporations at different scales of land size. Overall, family farms show superiority in the allocative efficiency of labour, and agricultural corporations exhibit superiority in the allocative efficiency of agricultural capital. Last, decomposition of total productivity progress (TFP) reveals that family farms have positive TFP change which is mainly attributable to a positive and large allocative component, while agricultural corporations undergo negative TFP change due to its negative and large allocative component. Moreover, the results intimate that technical progress and technical efficiency improvement are faster in agricultural corporations than in family farms.

Keywords: Agricultural corporation, family farm, technical efficiency, allocative efficiency

JEL classifications: D10, D22, D24, Q10

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Introduction

What is a corporation? Simply speaking, a corporation is a production organisation set up and operated by contracts. What is a family? A family is a unit held together and organised by blood or affection. It is widely believed and proven that a corporation is more efficient than a household or an individual in industrial production. That is why large factories inevitably replaced family workshops following the first Industrial Revolution. However, does this hold true in agricultural production? Is an agricultural corporation more efficient than a traditional family farm? To date, there is no definitive conclusion.

By 2013, there were more than 570 million farms worldwide, most of which were small and family operated. Family farms manage about 75% of the world's agricultural land (Lowder *et al.,* 2016). In other words, family farms remain the dominant form of agricultural production worldwide. The broad existence of family farms must have its rationale. Initially, the vulnerability of the agricultural production process makes it difficult to both supervise and assess the labour input involved in that process. In other words, family members, connected by blood or affection and share in the core profits of agricultural production, are thought to be more trustworthy than the mere employed. Secondly, agriculture depends heavily on land when compared to other industries, and with arable land usually owned or used by independent and dispersed farm households, it is highly challenging to concentrate land to achieve a large scale of business in agriculture. This is truest in the regions whose agricultural sector mainly consists of peasant households, such as Asian or African areas. Thirdly, it is more difficult to concentrate capital in the agricultural sector. That is, the nature of some agriculture's productive process is incompatible with the requirements of capitalist production and unattractive for capitalist penetration (Mann and Dickinson, 1978). Those theories explain the dominance of family farms in agriculture worldwide, namely, why it is difficult to develop agricultural corporations, yet fall short in providing evidence that family farmers are superior to agricultural corporations in production efficiency.

Peasant households had long been considered backward and inefficient until Schultz (1967) proposed his famous hypothesis that peasant households are poor but efficient. What has followed is years of debate on the efficiency of peasant households and a wave of empirical work designed to test his theory (e.g. Adams, 1986; Lipion, 1968; Popkin, 1980). Recently, researchers in this field are more interested in examining and comparing the production efficiency of family farms with different-sized operations and testing the hypothesis of the inverse farm size-productivity relationship, which states that small farms are more productive than larger farms (Carletto *et al.,* 2013; Charnes *et al.,* 1978; Chayanov 1991; Cornia 1985; Kagin *et al.,* 2016; Larson *et al.,* 2014; Sen, 1962; Schultz, 1980). Thus far, the issue of production efficiency of family farms has been systematically and elaborately examined. However, rare studies refer to the comparison of production efficiency between family farms and agricultural corporations. Hence, we have neither evidence nor a conclusion on which form of agricultural production holds the advantage in production efficiency.

The research question fuelling this paper is whether agricultural corporations have an advantage over family farms in terms of production efficiency. The key hypothesis put forward is that agricultural corporations are more efficient than family farms in production efficiency. This advantage, if it in fact exists, may stem from the fact that the former is established and operated by contract, while the latter is maintained and operated by blood relations. This implies that the former is more adept in flexibly adjusting the input of production factors, thus making its production efficiency higher than the latter. More importantly, taken together with the finding from the existing literature that operation size has an extremely significant effect on production efficiency (Fujie and Senda, 2022; Perdomo *et al.,* 2022), this paper focuses on estimating and comparing production efficiency between family farms and agricultural corporations of the same operation size to verify whether agricultural corporations are superior to family farms in terms of production efficiency.

More concretely, this paper builds a quantitative framework for measuring the technical and allocative efficiency (inefficiency) of agricultural production in family farms and agricultural corporations, respectively, via estimating the stochastic production frontier functions. An economic entity's production process may exhibit technical inefficiency, allocative inefficiency, or both. Technical inefficiency is defined as the unsuccessful minimisation of input usage to produce given outputs or the unsuccessful maximisation of outputs using given inputs. Allocative inefficiency is described as the failure to combine inputs in optimal proportions to minimise the production costs, namely, failure to equate the marginal rate of technical substitution (MRTS) between any two inputs to the ratio of corresponding input prices (Atkinson and Cornwell, 1994; Farrell, 1957; Kopp and Diewert, 1982; Zhang *et al.,* 2019). Obviously, the former inefficiency is price-independent, and the latter is price-related.

This paper enriches the existing literature on agricultural production efficiency analysis by including agricultural corporations in the analytical framework. It is the first attempt to evaluate technical and allocative efficiency for both family farms and agricultural corporations. It reveals that agricultural corporations do not retain an advantage over traditional family farms in production efficiency, but the disparity between the two forms of agricultural production diminishes as their operation size increases. These findings have rich policy implications for developing new forms of agricultural production. Exploring further methods of increasing the production efficiency of agricultural corporations should be a component of a new strategy of agricultural modernisation.

The rest of the paper is organised as follows. Section 2 describes the methodology of evaluating the technical and allocative efficiency and decomposing the TFP growth. Section 3 introduces the data adopted in this paper and groups the research objects. Section 4 reports the empirical results, while Section 5 concludes.

Methodology

Measurement of Technical Efficiency

The present paper identifies and compares the technical and allocative efficiency of family farms and agricultural corporations by estimating a stochastic production frontier model. Stochastic frontier models have been widely applied in the analyses of the efficiency of agricultural production (Aigner *et al.,* 1977; Battese and Coelli, 1992; Battese and Coelli, 1995; Meeusen and Julien 1977; Perdomo *et al.,* 2022; Zhang *et al.,* 2019).

An agricultural management entity is technically inefficient when it operates beneath its stochastic production frontier. Thus, the production technology of an agricultural corporation can be characterised by a production function of the form:

$$y = a_0 \prod_{i=1}^{n} x_i^{a_i} e^{v-u}, \tag{1}$$

where y is the agricultural output of the agricultural management entities, the x_i are the inputs to the production process, a_0 and a_i are parameters, v is a random error term that captures random variation in output due to factors outside the control, which is distributed as $N(0,\sigma_v^2)$, and u is a non-negative disturbance and reflects technical inefficiency, which is distributed as $N^+(0,\sigma_u^2)$.

The log-linear form of this production function can be written as:

$$\ln y = \ln a_0 + \sum_{i=1}^{n} a_i \ln x_i + v - u. \tag{2}$$

Obviously, $\ln y$ is bounded from above by the stochastic production frontier:

$$\ln a_0 + \sum_{i=1}^{n} a_i \ln x_i + v, \tag{3}$$

with technical efficiency relative to the frontier given by u percent.

The log-linear form of this production defined in Equation 2 is used to estimate technical efficiency. In fact, besides the production system approach, a form of stochastic cost frontier is also widely used to identify and measure technical and allocative efficiencies (Kumbhakar, 1997; Mosheim and Lovell, 2009). However, Kumbhakar and Wang (2006) point out that the estimates of a cost frontier function can be easily biased without the cost of allocative inefficiency being included explicitly. Here, we do not adopt the form of a cost system approach mainly for another reason. To make the technical efficiency comparison between family farms and agricultural corporations meaningful, we must put them at the same production or cost frontier. However, this condition cannot be satisfied in the estimation of cost frontier because family farms and agricultural corporations do not encounter the same factor markets. In other words, they face systematically different prices of production factors. This point is of great importance. Put simply, an agricultural corporation might be identified as being more technically efficient in the estimates of the cost frontier model, but such technical efficiency is due to lower prices of input factors rather than the input factors being less in quantity. Intuitively, in terms of technical efficiency, we only want to observe which production form can use less input to produce the same output or which can produce more output using the same amount of input. Therefore, the production system approach is better suited to such an objective.

Measurement of Allocative Efficiency

As stated previously, allocative inefficiency is defined as the degree of failure to combine inputs in optimal proportions to minimise the production costs: in other words, failure to equate the marginal rate of technical substitution between any two inputs to the ratio of corresponding input prices. Thus, by adding the first-order conditions for cost minimisation into the production function defined as Equation 1, we will have:

$$\frac{f_j}{f_1} = \frac{p_j}{p_1} e^{\xi_j}, \tag{4}$$

where f_j represents the first derivation of the production function for input j, p_j is the price for input j, and ξ_j is interpreted as the allocative inefficiency for the input pair $(j,1)$. x_1 is the numeraire. The sign ξ_j shows whether input j is over- or underused relative to numeraire input 1. A positive sign means input j is underused relative to input 1, while a negative sign means input j is overused relative to input 1.

Equation 4 can also be rewritten as:

$$\frac{\partial \ln y}{\partial \ln x_j} \div \frac{\partial \ln y}{\partial \ln x_1} \equiv \frac{s_j}{s_1} = \frac{p_j \cdot x_j}{p_1 \cdot x_1} e^{\xi_j} = \frac{a_j}{a_1}, \tag{5}$$

where s_j is cost share of input j, which is defined as $s_j = p_j \cdot x_j / c$ and $c = \sum_j p_j \cdot x_j$. Taking logs for Equation 5 yields:

$$\ln(a_j/a_1) - \ln(p_j/p_1) - \ln x_j + \ln x_1 = \xi_j \tag{6}$$

Due to the linear homogeneity in input prices, only relative inefficiency can be estimated using Equation 6. In the following analysis, we choose land as the numeraire to estimate relative allocative inefficiency.[1]

TFP Decomposition

To examine the technical and efficiency changes, this paper decomposes the TFP growth in family farms and agricultural corporations, respectively. There are various approaches used to decompose TFP, including parametric estimation of production or cost functions, non-parametric indices, exact index numbers, and non-parametric methods using linear programming (Bauer, 1990; Kalirajan *et al.,* 1996; Kumbhakar *et al.,* 2015). Following the above method of estimating technical and allocative efficiency, we use the parametric estimation of the production function to decompose the TFP. The production function has been defined as Equation 1. Meanwhile, TFP change, which measures the productivity change, can be expressed in the form of:

$$T\dot{F}P = \dot{y} - \sum_j s_j \dot{x}_j. \tag{7}$$

Differentiating Equation 1 totally and combing it with Equation 7, we will have:

$$\begin{aligned} T\dot{F}P &= TC - \frac{\partial u}{\partial t} + \sum_j \left(\frac{f_j x_j}{f} - s_j\right) \dot{x}_j = \\ &(RTS-1)\sum_j \lambda_j \dot{x}_j + TC + TEC + \\ &+ \sum_j (\lambda_j - s_j)\dot{x}_j, \end{aligned} \tag{8}$$

where $TC = \frac{\partial \ln f(\cdot)}{\partial t}$, is the measure of technical change; $TEC = -\frac{\partial u}{\partial t}$, is the measure of technical efficiency change; and $RTS = \sum_j \frac{\partial \ln y}{\partial \ln x_j} = \sum_j \frac{\partial \ln f(\cdot)}{\partial \ln x_j} = \sum_j f_j(\cdot) x_j \equiv \sum_j \epsilon_j$, is the measure of returns to scale. ϵ_j is the input elasticity defined as the production frontier. $\lambda_j = f_j x_j / \sum_k f_k x_k = \epsilon_j / RTS$.

In this way, we can decompose TFP into scale components, $(RTS-1)\sum_j \lambda_j \dot{x}_j$, technical progress, TC, technical efficiency change, TEC, and change in allocative efficiency, $\sum_j (\lambda_j - s_j)\dot{x}_j$.

Data and Grouping

Data

This paper adopts the aggregate data from the Statistical Survey on Farm Management and Economy (Statistics code: 00500201) conducted by the Ministry of Agriculture, Forestry, and Fisheries of Japan. This survey is conducted on and summarises family farmers and agricultural corporations of different sizes. Japan's Statistical Survey on Farm Management and Economy divides family farms into ten grades and agricultural corporations into four grades according to their operating land scale, as shown in Figure 1. It reports the averages of various inputs and outputs of family farms and agricultural corporations on different operating land sizes each year. Taking into account the fact that production techniques and outputs vary greatly across different agricultural product sectors, we choose single rice farming entities, the family farms and agricultural corporations in which more than 80 percent of their total agricultural sales is rice, as research objects. Our observation period spanned 2004 to 2016. Hence, this paper adopts a panel data set with 14 observations for 13 years.

To facilitate the quantitative analysis, a rich set of data on Japanese family farms and agricultural corporations is compiled. In Japan, the decreasing birth rate and ageing population are becoming problematic for its agriculture. The number of peasant households in Japan has plummeted from 1.98 million in 2005 to 0.99 million in 2021, while the average age of agricultural workers has soared to 62.3 years. In such context, a countermeasure put forward by the Japanese government has been vigorously to develop agricultural production corporations.[2] The number of agricultural corporations in Japan has more than doubled from 13.9 thousand in 2005 to 31.6 thousand in 2021 (Table 1).

[1] The estimation results will not be affected by choice of the input used as the numeraire. Thus, the choice of determining the numeraire can be arbitrary (Kumbhakar *et al.*, 2015; Khataza *et al.*, 2019).

[2] Agricultural corporations are defined as operating entities that engage in agriculture and are registered as legal persons in Japan. That is to say, the process of setting up, managing, and disbanding or abolishing agricultural corporations must satisfy the conditions of legal persons (enterprise counting and taxing system, etc.). Refer to Appendix 1 for the classification of Japan's agricultural corporations.

Table 1: Composition of Agricultural Management Entities in Japan, in Thousand and Percentage, 2005-2021.

Year	Number of Agricultural Management Entities				% of Corporation
	Total	Individual	Organisation		
			Total	Corporation	
2005	2,009.4	1,981.3	28.1	13.9	0.69
2006	1,935.8	–	–	–	–
2007	1,867.0	–	–	–	–
2008	1,804.1	–	–	–	–
2009	1,753.2	–	–	–	–
2010	1,679.1	1,648.1	31.0	17.1	1.02
2011	1,617.6	1,586.1	31.5	–	–
2012	1,563.9	1,532.7	31.2	17.8	1.14
2013	1,514.1	1,482.4	31.7	18.2	1.20
2014	1,471.2	1,439.1	32.1	18.9	1.28
2015	1,377.3	1,344.3	33.0	22.8	1.66
2016	1,318.4	1,284.4	34.0	23.8	1.81
2017	1,258.0	1,223.1	34.9	24.8	1.97
2018	1,220.5	1,185.0	35.5	25.5	2.09
2019	1,188.8	1,152.8	36.0	26.1	2.20
2020	1,075.7	1,037.3	38.4	30.7	2.85
2021	1,030.9	991.4	39.5	31.6	3.07

Source: Data are from the database of the Ministry of Agriculture, Forestry, and Fisheries of Japan

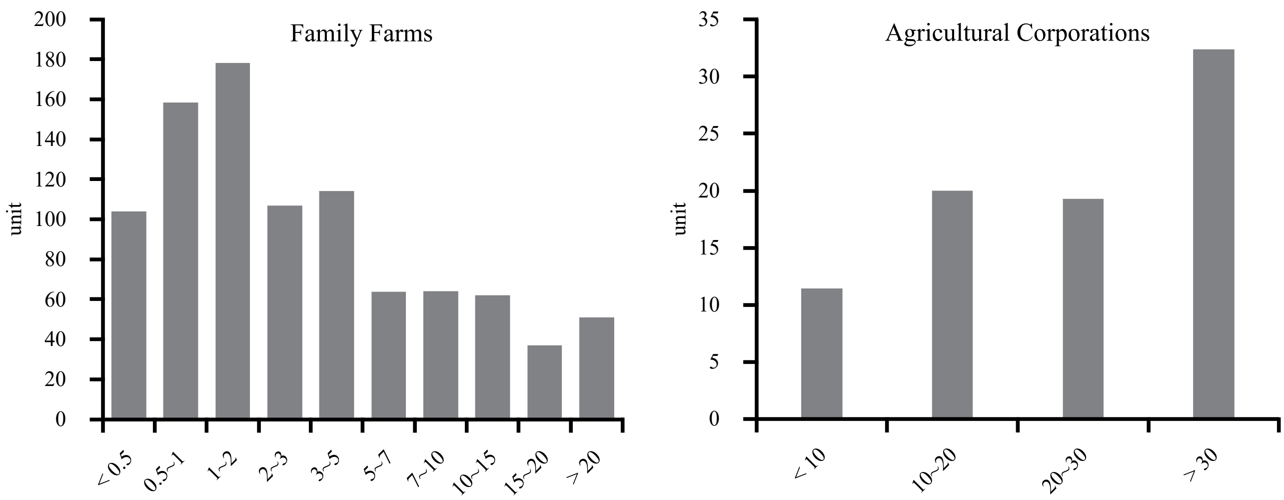

Figure 1: Distribution of Rice Family Farms and Rice Agricultural Corporations in Land Size.

Source: Japan's Statistical Survey on Farm Management and Economy

Figure 1 displays the average number of single rice farming family farms and single rice farming agricultural corporations at each level of land size from 2004 to 2016.[3] Japan's Statistical Survey on Farm Management and Economy divides family farms into ten grades and agricultural corporations into four grades according to their operating land scale, as shown in Figure 1. The operating land scale of the majority of rice family farms is under 2 hectares, while that of most rice farming agricultural corporations is above 10 hectares. As mentioned above, it is crucial to compare family farms and agricultural corporations of the same operation size on the grounds that even though we can empirically prove that agricultural corporations produce rice more (or less) efficiently than family farms, it is hard to say whether and to what extent the gulf between them is due to the difference in operation form or merely the variation in operating land scale. To address this problem, we split family farms and agricultural corporations into four groups according to their operating land scale and compare the technical and allocative efficiency between the two forms of agricultural production within each group.

[3] Single rice farming entities refer to family farms and agricultural corporations in which more than 80 percent of their total agricultural sales is rice.

Table 2: Description of Variables and Data Sources.

Variable	Unit	Description	Source
Output			
Rice Output	kg	Annual gross rice output per household/corporation	Statistical Survey on Farm Management and Economy (Statistics code: 00500201)
Input			
Labour Input	hour	Labour hours input in rice production per household/corporation consisting of hours input of family members and employed workers	Statistical Survey on Farm Management and Economy (Statistics code: 00500201)
Agricultural Fixed Assets	1000 yen	Fixed assets relative to rice production owned by per household/corporation	Statistical Survey on Farm Management and Economy (Statistics code: 00500201)
Cultivated Land	hectare	Area of land sown with rice per household/corporation consisting of owned land and rented land	Statistical Survey on Farm Management and Economy (Statistics code: 00500201)
Other Costs	1000 yen	Costs consisting of expenses in seedlings, fertiliser, agricultural chemicals, relative materials and fuel, and power	Statistical Survey on Farm Management and Economy (Statistics code: 00500201)
Price Index			
Price Index of Fixed Assets	100	Price index of agricultural implements (2015=100)	Statistical Survey on Prices in Agriculture (Statistics code: 00500204)
Price Index of Other Costs	100	Price index of other materials for agricultural production (2015=100)	Statistical Survey on Prices in Agriculture (Statistics code: 00500204)
Factor Price			
Labour Wage	yen/hour	Average wage weighted by household labour input and employment labour input	Calculated from the Statistical Survey on Farm Management and Economy (Statistics code: 00500201)
Rate of Interest	%	Interest rate of borrowing	Calculated from the Statistical Survey on Farm Management and Economy (Statistics code: 00500201)
Land Rent	yen/10ha	Average land rent weighted by owned land and rented land	Calculated from the Statistical Survey on Farm Management and Economy (Statistics code: 00500201)
Others			
Ratio of Employed Labour	%	Percentage of hours input of employed labour in total hours input	Calculated from the Statistical Survey on Farm Management and Economy (Statistics code: 00500201)
Ratio of Borrowed Land	%	Percentage of borrowed land area in the total cultivated land area	Calculated from the Statistical Survey on Farm Management and Economy (Statistics code: 00500201)

Source: Own composition

Table 2 describes each of the variables used in the estimation and its data sources. To estimate the stochastic production frontier model, we choose gross rice output (in kgs) as the output variable. For input variables, we select labour input (in hours), agricultural fixed assets (in thousand Japanese yen), the area of arable land (in hectares), and other costs (in thousand Japanese yen), which consists of expenses in seedlings, fertiliser, agricultural chemicals, various relative materials and fuel, and power. Note that labour input includes both family labour input and hired labour input, and land input combines owned land and rented land. Agricultural fixed assets and other costs are deflated to the prices of 2015. The relevant data on the price index are from the Statistical Survey on Prices in Agriculture (Statistics code: 00500204) published by the Ministry of Agriculture, Forestry and Fisheries of Japan. Labour wage is calculated by dividing total labour cost by labour hours. Land rent is calculated by dividing the total cost of land rent by the area of borrowed land. Agricultural capital price is calculated by dividing debt interest by total debt.[4]

Grouping

It is well-known that land size plays a crucial role in assessing and explaining the performance of family farms (Chayanov, 1991; Hall and LeVeen, 1978; Helfand and Levine, 2004; Henneberry *et al.,* 1991; Khataza *et al.,* 2019; Mottaleb and Mohanty, 2015; Weersink and Tauer, 1991;

[4] The database of Management Statistics by Farming Type does not cover the relative data for calculating the input prices for single rice farming family farms. Hence, we use the database of Agricultural Production Costs, which also belongs to the Statistical Survey on Farm Management and Economy (Statistics code: 00500201), to calculate the input prices for single rice farming family farms.

Table 3: Division of Operating Land Size.

Form	Hectare	Group
Family Farms	<0.5	1
	0.5-1	
	1-2	
	2-3	
	3-5	
	5-7	
	7-10	2
	10-15	3
	15-20	
	>20	4
Agricultural Corporations	<10	2
	10-20	3
	20-30	4
	>30	

Source: Own composition

Wolf and Sumner, 2001). To eliminate the effect of land size on assessing economic efficiency and to obtain as accurate as possible comparison results of production efficiency between family farms and agricultural corporations, we split family farms and agricultural corporations into four groups according to their operating land scale. As shown in Table 3, we classify family farms whose operating land scale is under 7 hectares as group one and classify family farms between 7 and 10 hectares and agricultural corporations under 10 hectares as group two. Note there is neither subdivision for the agricultural corporations under 10 hectares nor a group one, as the average operating land scale of agricultural corporations under 10 hectares is over 7 hectares. Thus, we classify agricultural corporations under 10 hectares separately from family farms under 7 hectares. The family farms and agricultural corporations between 10 and 20 hectares are classified as group three, and family farms and agricultural corporations above 20 as group four. In such a way, the operating scale of family farms and agricultural corporations differs little within each group. Hence, in the following analysis, we will be intent on comparing the technical and allocative efficiency of family farms and agricultural corporations within each group.

The summaries and comparison of variables between family farms and agricultural corporations within each group are reported in Table 4. Variations in the quantity of each input factor are insignificant between family farms and agricultural corporations within each group, suggesting our division is reasonable. Also prominent is that within each group the amount of labour input hours, agricultural fixed assets, cultivated land, and others expended in rice production by agricultural corporations is higher than that of family farms. But in terms of output levels, agricultural corporations do not always produce more rice than family farms. Only in group four (above 20 ha) is the average rice output of agricultural corporations greater than that of family farms. This might forebode that our hypothesis that agricultural corporations are more efficient than family farmers in agricultural production may be challenged.

It is worth mentioning the difference in factor prices paid by agricultural corporations and family farmers in each group. In group two (7-10 ha) and group three (10-20 ha), the average labour wage of family farms is higher than that of agricultural corporations. The situation in group four (above 20 ha) is the opposite. In all groups, the average interest rate (capital price) and land rent of agricultural corporations are lower than those of family farms. This implies that compared with traditional family farms, agricultural corporations tend to have more market power in the factors market and thus can obtain production factors at a lower price, especially in the capital and land rent markets.

Results

Estimates of Technical Efficiency

Initially, we estimated the production frontier aggregately for family farms and agricultural corporations. The parametric estimates for the frontier production function appear in Table 5. Model 1 shows the results with family farms and corporations estimated aggregately. For reference, we also estimate their production frontier separately and report the estimation results. Models 2 and 3 include

Table 4: Intra-group Comparison of Mean Values of Variables.

	< 7 ha	7-10 ha		10-20 ha		>20 ha	
	Family Farms	Family Farms	Corporations	Family Farms	Corporations	Family Farms	Corporations
Rice Output	12,714	42,840	34,929	76,932	68,911	137,323	173,230
Labour Input	642	1,752	1,927	2,631	3,287	4,131	6,768
Agricultural Fixed Assets	2,496	6,538	10,572	11,441	13,391	20,294	23,127
Cultivated Land	313	1,044	1,226	1,802	2,044	3,139	4,591
Other Costs	687	2,209	2,802	3,820	4,165	7,036	10,092
Labour Wage	1,417	1,489	1,183	1,538	1,260	1,512	1,686
Rate of Interest	3.87	3.61	0.45	3.48	0.80	3.42	0.74
Land Rent	16,136	17,772	11,034	16,992	12,354	16,976	13,507
Ratio of Employed Labour	6.01	8.95	18.68	13.34	26.01	23.49	36.79
Ratio of Borrowed Land	22.96	52.06	87.32	52.98	97.72	62.47	94.39

Source: Own composition

the results with family farms and corporations estimated separately. All the estimated coefficients are statistically significant in the three models except capital, whose coefficient is insignificant in Model 1 and Model 3. The estimated coefficient of ln capital is negative in Model 3. This is mainly because agricultural capital is over-invested to some extent in agricultural corporations, and thus as capital inputs increase, output first rises and then falls. That is, rice output and capital inputs show an inverted U-shaped relationship in agricultural corporations. For that reason, we add the square of the ln Capital into Model 3 and re-estimate the stochastic frontier production of agricultural corporations, shown in Model 4.

The return to scale is 0.772, 0.759, 0.902, and 1.05 in the four models, respectively. According to the results of the Wald test, the former two are significantly less than 1, but the last two are not markedly different from 1. The estimated parameter σ_u is much greater than that of σ_v, suggesting deviations from the production frontier are primarily due to technical inefficiency. The null hypothesis that there does not exist an inefficiency component is rejected, thus justifying the use of the stochastic frontier approach.

In Model 1, the estimated coefficients of ln Labour, ln Capital, and ln Land are 0.154, 0.021, and 0.300, respectively. In Model 2, the estimated coefficients of ln Labour, ln Capital, and ln Land are 0.127, 0.110, and 0.215, respectively. In Model 3, they are 0.120, -0.037, 0.502, and 0.317, respectively. After including the square of the lnCapital, the coefficient of lnCapital becomes 0.133, while minor deviations are observed in the other coefficients. These results echo those of the existing literature. Ajibefun *et al.* (2002) estimated the translog stochastic frontier production function of Japanese rice farms for 1984-1994. According to their estimation results, the coefficients of lnLabour, lnCapital, and lnLand are 0.191, 0.210, and 0.163, respectively. Considering their chosen paper period, the estimates appear to reflect the situation of family farms. Hence, in comparing their results with ours from Model 2, we can see that the coefficient of lnCapital is smaller than theirs by almost twice, and variations in the other coefficients are minimal.

Table 6 summarises the technical efficiency estimated from the stochastic frontier models. The first and the second columns are estimated from Model 1. The third column comes from Model 2, and the fourth column is derived from Model. 4. For comparison, the efficiency scores from the Data Envelopment Method (DEA) are included in the last columns.[5]

Table 5: Parametric Estimates of the Stochastic Frontier Production Function.

	Aggregated	Family Farms	Corporations	
	Model 1	**Model 2**	**Model 3**	**Model 4**
ln Labour	0.154***	0.127*	0.120*	0.120*
	(0.045)	(0.070)	(0.064)	(0.065)
ln Capital	0.021	0.110***	−0.037	0.133
	(0.022)	(0.037)	(0.032)	(0.560)
ln Land	0.300***	0.215**	0.502***	0.483***
	(0.079)	(0.104)	(0.130)	(0.147)
ln Others	0.297***	0.308***	0.317***	0.320***
	(0.065)	(0.078)	(0.123)	(0.125)
ln Capital * ln Capital	–	–	–	−0.009
	–	–	–	(0.029)
sigma u	0.434	0.493	0.176	0.183
sigma v	0.043	0.040	0.047	0.047
Observations	182	130	52	52

Note: Models 1-4 use Modified-LSDV time-varying fixed-effect estimators. Standard errors are reported in parentheses. Significant levels are * 0.10, ** 0.05, *** 0.01
Source: Own calculations

Table 6: Technical Efficiency Estimations.

Group	Aggregated		Separated		DEA	
	Family Farms	**Corporations**	**Family Farms**	**Corporations**	**Family Farms**	**Corporations**
<7 ha	0.446	–	0.433	–	0.890	–
7-10 ha	0.707	0.504	0.712	0.640	0.899	0.657
10-20 ha	0.847	0.689	0.855	0.818	0.930	0.758
>20 ha	0.988	0.922	1.000	0.982	0.958	0.900
Average	0.607	0.759	0.602	0.856	0.906	0.804

Source: Own calculations

5 The method of DEA refers to Appendix 2. For related literature, refer to Liu *et al.* (2015), Mao and Koo (1997), and Sarac *et al.* (2022).

Let us view the estimated technical efficiency from the stochastic frontier production function. There are some interesting findings. First, technical efficiency is higher in family farms than in agricultural corporations, whether estimated aggregately or separately. For example, according to the estimation results from aggregated estimation, the average technical efficiency of family farms is 0.446 in farm sizes below 7 hectares (group one). It means that family farms in this group, on average, produce around half of their maximum potential output due to technical inefficiency. In farm sizes between 7-10 hectares (group two), technical efficiency is 0.707 in family farms and 0.504 in agricultural corporations. In group three, between 10-20 hectares in size, it is 0.847 in family farms and 0.689 in agricultural corporations. In farm sizes above 20 hectares (group four), technical efficiency is 0.988 in family farms and 0.922 in agricultural corporations. Second, the disparity in technical efficiency between the two production forms diminishes as farm size increases. According to the results from the aggregated estimation, the gap in technical efficiency between the two is 0.20 in group two (7-10 ha), 0.16 in group three (10-20 ha), and 0.07 in group four (above 20 ha). As for the results from the separated estimation, the gap in technical efficiency between the two is 0.07, 0.04, and 0.02 in the three groups, respectively, displaying the same law. Lastly, technical efficiency rises with farm size increases, whether in family farms or agricultural corporations. In other words, the larger the entity's land scale is, the larger its technical efficiency is. This rule applies to family farms and agricultural corporations.

The findings from the DEA method are comparable, except that the relative level of technical efficiency in agricultural corporations is much lower. For example, based on parametric estimation of the frontier production function, the technical efficiency of agricultural corporations between 7-10 hectares is larger than that of family farms below 7 hectares. However, based on the DEA method, the technical efficiencies of agricultural corporations sized between 7-10 hectares and 10-20 hectares are smaller than that of family farms below 7 hectares.

In short, our results confirm that family farms are more technically efficient than agricultural corporations at the same level of operating land scale. However, Fujie and Senda (2022) adopt DEA to estimate and compare the production efficiency between family farms and agricultural corporations in the Japanese rice sector. They argue there is no significant difference in efficiency between corporate farms and family farms on average. But they also point out that the efficiency of family management significantly exceeds the efficiency of corporate management at the medium- and large-scale operations, confirming the superiority of family farms in the medium- and large-scale groups. However, they use agricultural gross income rather than rice output as the output variable in estimates, which involves the effect of the rice sale price. The same problem arises in the paper of Dong (2022), whose results show that agricultural corporations exhibit higher production efficiency than family farms in Japanese agriculture. Taking the effect of the rice sale price difference between the two production forms into account, we have reason to believe that our estimates and results are more reliable and reflect the reality of agriculture in Japan.

Moreover, importantly, our estimations show that rice production's technical efficiency rises as farm size increases. This finding seems incongruous with the hypothesis of the inverse farm size-productivity relationship, which depicts that small farms are more productive than larger farms and has been widely discussed and verified in existing literature (Carletto *et al.,* 2013; Charnes *et al.,* 1978; Chayanov, 1991; Cornia, 1985; Kagin *et al.,* 2016; Larson *et al.,* 2014; Schultz, 1967; Sen, 1962). However, there are two notable differences between those studies and our findings. Firstly, productivity is not equal to production efficiency. Many measurements have been used to represent productivity, and the most often used is the net value or net weight of output per unit of cultivated land (Carletto *et al.,* 2013; Kagin *et al.,* 2016; Muyanga and Jayne, 2019). Secondly, those studies supporting the inverse farm size-productivity relationship mainly examine smallholder farms between zero and 10 hectares or so. However, division is crucial in verifying such a relationship. Muyanga and Jayne (2019) examined farms in Kenya with a broader range of farm sizes (≤ 5ha, 5-20ha, >20ha) and detected a U-shaped relationship between farm size and farm productivity. Specifically, they found that the inverse relationship hypothesis holds true on farms between zero and 3 hectares, the relationship between farm size and productivity is relatively flat between 3 and 5 hectares, and a strong positive relationship between farm size and productivity emerges within the 5 to 7 hectares range of farm sizes. Hence, we can see how much the distribution and grouping of samples affect the verifying results of the hypothesis.

How about the relationship between land productivity and farm size for the two forms in our paper? Figure 2 shows the relationship between land productivity and farm size. Unlike the hypothesis of the inverse farm size-productivity relationship, the relationship between land productivity and farm size is more like an inverse U-shape in both family farms and agricultural corporations. That is to say, land productivity first increases and then decreases as farm size expands and similarly, land productivity is greater in family farms than in agricultural corporations at a similar farm size.

Estimates of Allocative Efficiency

In the following analysis, we mainly use the estimated results of the stochastic frontier production function from Model 1 to examine the allocative efficiency of family farms and agricultural corporations. There is no relative data for calculating the prices of seedlings, fertiliser, and others for agricultural corporations in the statistics of such a period. Hence, we only consider the three inputs of labour, capital, and land when estimating allocative efficiency in this section. The prices of the three input factors are summarised in Table 4. Note that for both family farms and agricultural corporations, the wage of family labour and the rent of self-owned land are included when calculating the input prices.

An estimation of allocative inefficiency is reported in Table 7.[6] With land as the numeraire, we find that labour and capital are overused in both family farms and agricultural corporations. This phenomenon is mainly due to a serious shortage of arable land in Japan and thus the high relative price of arable land to labour and capital, shown in Table 4. Both family farms and agricultural corporations try to fully utilise farmland by devoting more resources to other factors in production.

In terms of labour, the absolute value of family farms is less than that of agricultural corporations, suggesting the allocative inefficiency of labour is larger in agricultural corporations. Namely, the overuse of labour is more serious in agricultural corporations. As farm size increases, allocative inefficiency improves in family farms. This is because as operating land size expands, the ratio of employed labour used in family farms increases, shown in Table 4. Apparently, a family farm with a high ratio of employed labour can adjust labour input more elastically, such as responding to labour wage change, than a family farm full of family labour. Nevertheless, such a rule is not applicable to agricultural corporations. Even though the ratio of employed labour in agricultural corporations also rises as their operating land size expands, the allocative inefficiency of labour in agricultural corporations rises rather than decreases as operating land size expands. This difference between the two production types is probably due to the fact that employment contracts in family farms are usually for a short period, while employment contracts in agricultural corporations are usually for a long period, which results in family farms performing better in adjusting labour input when responding to the change in labour wage than agricultural corporations do on average. It is important to note that the allocative inefficiency is highest in family farms below 7 hectares, suggesting the biggest challenge for an agricultural management entity full of family labour is adjusting relative labour input in response to changes in labour wage. Our findings further support the existing conclusion on the advantages of family farms in using labour. For example, Kostov *et al.* (2019) verified the superiority of family farms relative to agricultural corporations in the organisational efficiency of family labour by examining family and corporate farms of EU Member States. However, our results document that the superiority of family farms might be more embodied in the distribution of family labour and employed labour according to labour wage. The situation is reversed when it comes to capital. The allocative inefficiency of capital is larger in family farms, as the overuse of capital is much more severe in family farms. Over-investment in the Japanese rice sector has been elaborated on and proven in existing literature (e.g. Hara and Hitoshi, 2008). The disparity of allocative inefficiency of capital between family farms and agricultural corporations is mainly due to the distinguished ability to acquire loans from financial institutions and invest in agricultural capital. Exactly, agricultural corporations are more likely to obtain low-interest loans than family farms. The lending interest rate they obtain is much lower than that for family farms, as shown in Table 6. It implies that agricultural corporations can obtain more credit when increased agricultural capital is required. They need not invest in precautionary agricultural capital since they can obtain credit more easily than family farms. Therefore, agricultural corporations have a higher ability to adjust agricultural capital in response to changes in capital price.

TFP Decomposition

By applying the data into Equation 8, we can decompose and compare TFP for family farms and agricultural corporations, respectively.[7] Changes in inputs and RTS of family farms and agricultural corporations are reported in Table 8. Labour input and agricultural capital used per management entity declined in family farms from 2004 to 2016. The situation in agricultural corporations is basically the same, except that labour input increases in agricultural corporations below 20 hectares. Regarding land, the area of arable land used increases in family farms below 20 hectares but declines in those above 20 hectares. The situation in agricultural corporations is the opposite. The area of arable land used declines in agricultural corporations below 20 hectares but increases in those above 20 hectares. These findings confirm our conclusion on allocative efficiency above. Namely, labour and capital are both overused relative to land in family farms and agricultural corporations. Thus, both family farms and agricultural corporations tend to reduce these two factors' input and expand the area of arable land.

Table 7: Allocative Inefficiency Estimations.

Group	ξ_l		ξ_k	
	Family Farms	Corporations	Family Farms	Corporations
<7 ha	-1.419	-	-3.039	-
7-10 ha	-1.090	-1.302	-2.488	-0.940
10-20 ha	-1.025	-1.307	-2.507	-1.370
>20 ha	-0.899	-1.384	-2.487	-0.844
Average	-1.250	-1.344	-2.822	-0.999

Source: Own calculations

[6] The values of the coefficients of lnLabour, lnCapital, and lnLand used to estimate the allocative inefficiency are 0.15, 0.12, and 0.30. The value of the coefficient of lnCapital adopts the mean value of the coefficient of lnCapital from Model 2 and that from Model 4, considering the estimated value is far smaller in Model 1.

[7] Considering the data of separate prices of fertiliser for the two entity types are unavailable, we also only consider the three inputs of labour, capital, and land in decomposing TFP, similar in the estimates of allocative efficiency. The re-estimation of the translog stochastic frontier production function for TFP decomposition is reported in Appendix 3.

Table 8 shows that RTS is greater than 1 (increasing return to scale) except in agricultural corporations above 20 hectares. This finding seems contradictory to what we found in Table 5. Such inconsistency occurs mainly because we only consider labour, capital, and land in decomposing TFP and exclude other factors. However, we can see that RTS decreases as farm size increases. It declines from 1.22 in farm size below 7 hectares (group 1) to 1.04 for those above 20 hectares (group 4) in family farms. In agricultural corporations, it declines from 1.11 to 0.91. These data are in line with our expectations.

Based on Table 8, we decompose TFP for family farms and agricultural corporations, respectively. The results of the decomposition of TFP are summarised in Table 9. The scale component is -0.16 in family farms and -0.22 in agricultural corporations on average. Recall Table 8, the negative scale component is mainly driven by the declining input. Technical change is, on average, -0.28 in family farms and 0.26 in agricultural corporations, suggesting technical progress is faster in agricultural corporations than in family farms. In addition, as farm size increases, technical progress becomes faster accordingly, regardless of the type.

Technical efficiency change, TEC, is 0.33 in family farms and 0.75 in agricultural corporations. It reveals that even though family farms show a larger technical efficiency than agricultural corporations, as concluded in Section 4, the improvement in technical efficiency is more rapid in the latter. As to allocative efficiency, the previous analysis reveals that family farms show superiority in the allocative efficiency of labour, and agricultural corporations show superiority in the allocative efficiency of agricultural capital. However, the change in allocative efficiency is positive in family farms but negative in agricultural corporations. This phenomenon might be due to average prices of most input factors being higher in family farms than in agricultural corporations, as shown in Table 4.

Consequently, family farms are sensitive to changes in input prices and are incentivised to improve their allocative efficiency. Furthermore, the allocative efficiency component is the largest contributor to each TFP of family farms and agricultural corporations. Hence, this drives TFP positively in family farms but negatively in agricultural corporations. Besides, it is important to note that TFP increases in agricultural corporations as farm size increases, which also suggests that the larger the agricultural corporation is, the better it is. Importantly, our findings from TFP decomposition deepen our understanding of the relationship between TFP change and operation size by involving agricultural corporations. Much existing literature confirms that the driving factors behind the TFP growth of family farms of different operation sizes are different (Rahmatullah and Kuroda, 2005; Fan and Chan, 2005; Hu, 1995; Kuroda, 1989). Our findings reveal this rule is also applicable to agricultural corporations.

Table 8: Changes in Inputs and RTS.

%, unit

		Family Farms	Corporations
< 7 ha	% Growth of Labour	-0.52	–
	% Growth of Capital	-3.11	–
	% Growth of Land	0.84	–
	RTS	1.22	–
7-10 ha	% Growth of Labour	-1.27	0.87
	% Growth of Capital	-2.21	-1.49
	% Growth of Land	1.77	-0.43
	RTS	1.10	1.11
10-20 ha	% Growth of Labour	-0.27	0.15
	% Growth of Capital	-2.54	-3.21
	% Growth of Land	1.31	-1.06
	RTS	1.08	1.01
>20 ha	% Growth of Labour	-0.18	-1.17
	% Growth of Capital	-3.74	-3.95
	% Growth of Land	-0.09	0.41
	RTS	1.04	0.91
Average	% Growth of Labour	-0.51	-0.33
	% Growth of Capital	-2.97	-3.15
	% Growth of Land	0.93	-0.16
	RTS	1.16	0.98

Source: Own calculations

Table 9: Decomposition of TFP.

%

		Family Farms	Corporations
< 7 ha	TFP	1.19	-
	Scale	-0.13	-
	TC	-0.55	-
	TEC	0.23	-
	Allocative	1.73	-
7-10 ha	TFP	0.04	-15.98
	Scale	-0.23	-1.80
	TC	-0.08	0.01
	TEC	-0.01	-0.34
	Allocative	0.37	-13.85
10-20 ha	TFP	-0.37	-8.63
	Scale	-0.21	-0.39
	TC	0.13	0.20
	TEC	0.69	0.81
	Allocative	-0.97	-9.24
>20 ha	TFP	0.60	-5.05
	Scale	-0.18	0.66
	TC	0.34	0.42
	TEC	0.51	1.27
	Allocative	-0.07	-7.40
Average	TFP	0.69	-8.68
	Scale	-0.16	-0.22
	TC	-0.28	0.26
	TEC	0.33	0.75
	Allocative	0.85	-9.47

Source: Own calculations

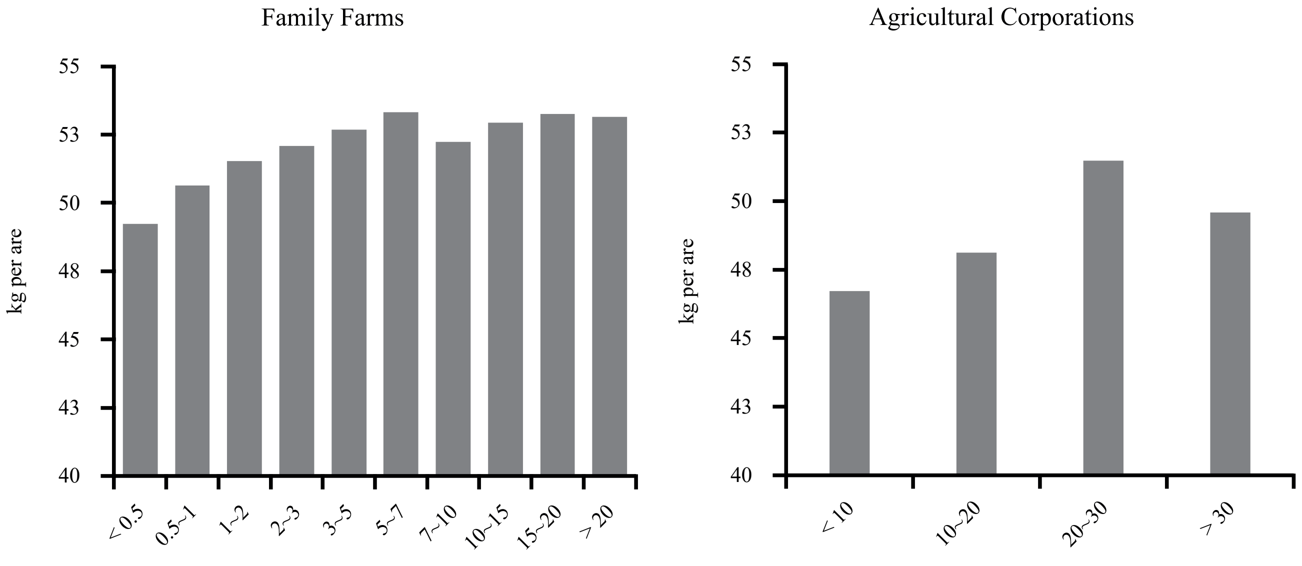

Figure 2: Farm Size and Land Productivity.

Source: Own calculations

Conclusions

This paper attempts to answer the question of whether an agricultural corporation is more efficient than a traditional family farm, a subject which is both important and forward-looking. As an extension and development of the existing theory on the production efficiency of family farms, this paper provides crucial evidence for assessing and comparing production efficiency between traditional family farms and agricultural corporations systematically.

Our analysis found that family farms have a significant advantage over agricultural corporations in technical efficiency at each level of operation scale. It reveals that the family farm can utilise input factors to maximise output more efficiently than agricultural corporations in rice production. Moreover, the results show that larger operation scale is accompanied by higher technical efficiency in both family farms and agricultural corporations. The disparity in technical efficiency between the two forms diminishes as farm size increases. This implies that once farm size becomes large enough and exceeds a certain degree, the advantage of family farms may vanish. Those findings differ from the existing studies (Dong, 2022; Fujie and Senda, 2022), which argue that there is no significant difference in technical efficiency between the two production forms or that agricultural corporations are superior to traditional family farms in technical efficiency. Unlike recent studies, we chose rice output weight as the output variable to eliminate the effect of rice sale prices on the measurement of technical efficiency and adopted the stochastic production frontier method, which is more flexible and adaptable in form than the DEA method. Hence, our estimation results are more reasonable and credible.

The findings in allocative efficiency are more complicated. In fact, allocative efficiency varies from family farms to agricultural corporations, as well as across different input factors and across land scales. Overall, family farms exhibit superiority in the allocative efficiency of labour, and agricultural corporations show superiority in the allocative efficiency of agricultural capital. Both labour and capital relative to land are overused in family farms and agricultural corporations. This can be put down to the severe shortage of agricultural land in Japan, which makes the relative of land much higher than the prices of other inputs.

Based on the analysis of technical and allocative efficiency, we decomposed TFP to examine the changes in TFP and in each of its components. Overall, family farms have positive TFP change, which is mainly contributed by a positive and large allocative component. In contrast, agricultural corporations experience negative TFP change which is largely driven by its negative and large allocative component. Separately, technical progress and efficiency improvement are faster in agricultural corporations than in family farms. By contrast, family farms are superior to agricultural corporations in scale effect and allocative efficiency improvement.

Reviewing what we have learned thus far, we can draw a conclusion and discuss the reasons behind it. Firstly, overall, family farms are more technically efficient than agricultural corporations at the same level of operation land scale. There are two possible explanations as to why this is the case. For one, we have seen that prices of most input factors, mainly referring to labour and land, are higher for family farms than for agricultural corporations. That makes family farms use input factors more carefully and sparingly. For another, the ratio of employed labour and the ratio of borrowed land are both lower in family farms relative to agricultural corporations of the same operation size. This makes agricultural production more stable in family farms and makes it easier to plan various inputs during the production process and, thus, more possible to maximise agricultural output. More than that, we also see that as farm size increases, the disparity in technical efficiency between the two forms narrows. A probable reason is that as farm size increases, the ratios of employed labour and borrowed land rise in family farms, therefore, diminishing their advantage in technical efficiency.

Secondly, the superiority of family farms and agricultural corporations in allocative efficiency varies across input factors. Simply speaking, family farms are better at utilising labour, while agricultural corporations are better at utilising capital. A likely explanation is that employment in family farms is more flexible than in agricultural corporations and that agricultural corporations have better access to credit. Lastly, family farms perform better in improving allocative efficiency, and agricultural corporations are better equipped to improve technical efficiency and progress. This reveals traditional family farms are more sensitive to changes in the prices of input than agricultural corporations, and the latter has a stronger ability for technical innovation. Hence, our hypothesis that agricultural corporations are more efficient than family farms in production efficiency is mostly rejected in this paper.

The work provides some interesting insight and suggestions for developing agricultural production entities. First, we have proven that, on average, family farms are superior to agricultural corporations in technical efficiency. That being so, the replacement of family farms with agricultural corporations will generate net welfare loss unless we can reverse this problem. Accordingly, future studies must figure out which factors result in lower technical efficiency in agricultural corporations. Secondly, irrespective of the analysis of technical and allocative efficiency or the analysis of decomposing TFP, the golden rule shown is that the larger an agricultural corporation is, the better it is. In other words, the superiority of agricultural corporations is primarily embodied when their scales are large enough. Hence, the key is to develop agricultural corporations of large land scale.

Finally, we would like to address the limitations of this paper. Although we have proven that traditional family farms exceed agricultural corporations in production efficiency, we must respect the rapid rise of agricultural corporations in Japan. Our findings do not attempt to provide reasons for this movement in Japanese agriculture. Rather, the theme requires more in-depth examination via future studies. A reasonable argument is that agricultural corporations have a remarkable advantage over traditional family farms in maintaining higher rice sale prices and lower input factors prices. However, this supposition needs further systematic verification and discussion, which we plan to undertake as a follow-up.

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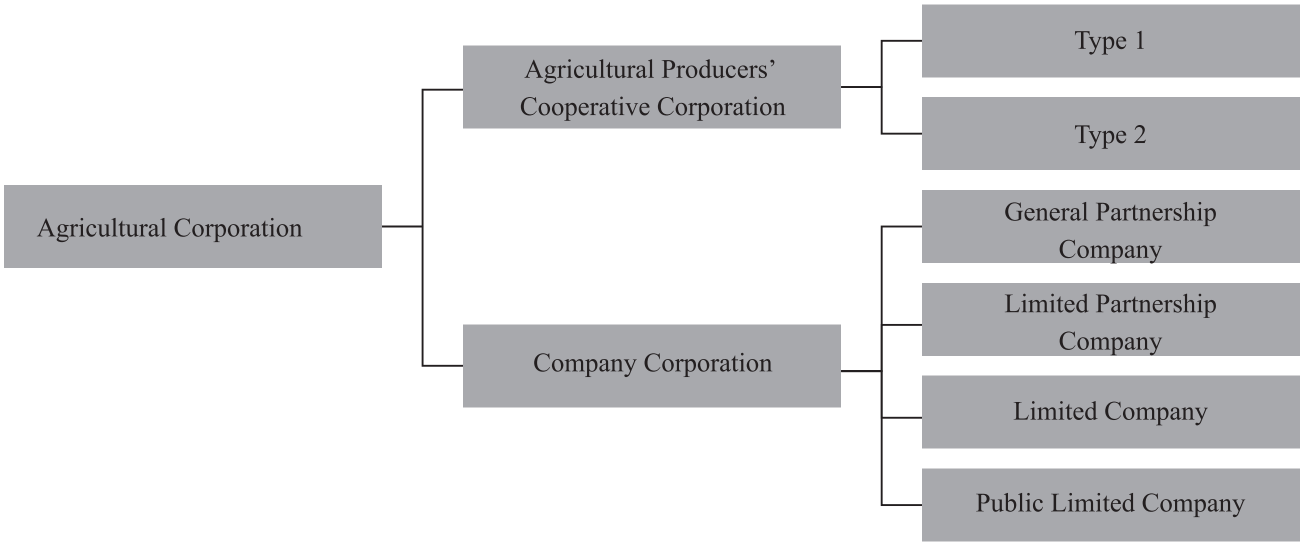
Appendix

Appendix 1: Types of Agricultural Corporations in Japan



Source: Own composition

Appendix 2: DEA Method

Data Envelopment Analysis (DEA) was initially proposed by Charnes (1978) measuring to assess the operational efficiency of the decision-making unit (DMU) in public programs in order to improve the planning and control of these activities. This method is widely used in measuring operational efficiency and technical change in many fields, including agriculture. In this method, the efficiency of any DMU is obtained as the maximum ratio of weighted outputs to weighted inputs subject to the condition that the similar ratios for each DMU be no more than unity. In more precise form, it can be expressed as:

$$\max_{v,u} \theta = \frac{u_1 y_{1i} + u_2 y_{2i} + \cdots + u_m y_{mi}}{v_1 x_{1i} + v_2 x_{2i} + \cdots + v_n x_{ni}} \quad \text{(B-1)}$$

subject to

$$\frac{u_1 y_{1j} + u_2 y_{2j} + \cdots + u_m y_{mj}}{v_1 x_{1j} + v_2 x_{2j} + \cdots + v_n x_{nj}} \leq 1 \; (j = 1, \cdots, t) \quad \text{(B-2)}$$

$$u_p \geq 0 \; (p = 1, \cdots, m) \quad \text{(B-3)}$$

$$v_q \geq 0 \; (q = 1, \cdots, n) \quad \text{(B-4)}$$

where y_{qi} and x_{qi} are the known outputs and inputs of the ith DMU, p denotes the category of outputs, and q denotes the category of inputs. u_p and v_q are the variable weights of each output and input, which are called virtual multipliers and are to be determined by the solution to this problem. θ_i is the measured efficiency for the ith DMU. The output-oriented DEA model is used with the variable returns to scale (VRS). The output variable is gross rice output (in kgs), and the input variables are labour input in agricultural production activity (in hours), the area of cultivated land (in hectares), and agricultural fixed assets (in 10 thousand Japanese yen). The agricultural fixed assets are deflated to 2015 prices.

Appendix 3: Estimates of Parameters of the Translog Stochastic Frontier Production Functions

	Coefficient
ln Labour	2.969
	(19.114)
ln Capital	−4.604
	(18.261)
ln Land	−3.886**
	(1.701)
ln Labour * ln Labour	−3.891***
	(0.641)
ln Capital * ln Capital	−0.585***
	(0.144)
ln Land * ln Land	−2.673***
	(0.677)
ln Labour * ln Capital	0.406**
	(0.206)
ln Labour * ln Land	2.888***
	(0.650)
ln Capital * ln Land	0.186
	(0.236)
Year	−0.035
	(0.026)
Year * Year	0.000
	(0.000)
Year * ln Labour	0.001
	(0.009)
Year * ln Capital	0.003
	(0.009)
Year * ln Land	0.000
	(0.000)
sigma u	0.265
sigma v	0.038
lambda	6.933

Note. Model uses random-effects time-varying inefficiency effects model estimators. Standard errors are reported in parentheses. Significant levels are * 0.10, ** 0.05, and *** 0.01.
Source: Own calculations