# Correlation of the Influence of Management Factor and Farmer's Behavior in Technical Efficiency and Production Risk: A Case Study on Organic Rice Farming with Environmental Perspectives in Indonesia

*International Journal of Economics, Business and Management Studies*
Vol. 7, No. 1, 27-44, 2020
*e-ISSN: 2226-4809/p-ISSN: 2304-6945*

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ABSTRACT

This research is a study of organic rice farming with environmental perspectives. This study aims to analyze the correlation between the influence of management factor and farmer's behavior in technical efficiency and production risk on organic rice farming carried out in Dlingo Village, Mojosongo District, Boyolali Regency, Central Java Province, Indonesia. This research was conducted on 216 organic rice farmers as a sample during two planting seasons with a purposive sampling method. This study uses a stochastic frontier approach on production function with cross section data and the Just and Pope's function model and statistical package approach to the social sciences method on production risk. The results of this study are farming system management factor as the most dominant factor in technical efficiency with a coefficient value of -0.4527; the behavior of farmers who dare to face production risks (53.70%); tractor's rental fee as the most influential correlation factor in production (0.1486) and production risk (0.310); and the need for production management and production risk in organic rice farming in Boyolali Regency, Indonesia.

**Keywords:** *Indonesia, Agricultural management, Farmer's behavior, Organic rice farming, Environment, Technical efficiency.*
**JEL Classification:** *C10; D24; M11; O44; Q10.*
**DOI:** 10.20448/802.71.27.44
Citation | Ignatius Suprih Sudrajat (2020). Correlation of the Influence of Management Factor and Farmer's Behavior in Technical Efficiency and Production Risk: A Case Study on Organic Rice Farming with Environmental Perspectives in Indonesia. International Journal of Economics, Business and Management Studies, 7(1): 27-44.

**Funding:** This study received no specific financial support.
**Competing Interests:** The author declares that there are no conflicts of interests regarding the publication of this paper.
**History:** Received: 17 October 2019/ Revised: 22 November 2019/ Accepted: 30 December 2019/ Published: 10 February 2020
**Publisher:** Online Science Publishing

**Highlights of this paper**

- This research is a study of organic rice farming with environmental perspectives.
- This study aims to analyze the correlation between the influence of management factor and farmer's behavior in technical efficiency and production risk on organic rice farming carried out in Dlingo Village, Mojosongo District, Boyolali Regency, Central Java Province, Indonesia.

## 1. INTRODUCTION

Soil as one of the elements of the environment is important in natural life because soil is the basis of living things, namely humans, plants and animals. Soil has an important function as a medium for plant life to live and develop related to soil physical factors, soil chemical factors, and soil biological or biological factors. The best soil that can be used in agriculture is fertile soil (with a pH of around 6.5) with sufficient nutrients, so that it is useful for plant growth (Pracaya, 2005). In this case the factor of soil fertility has an important role as a basis for agricultural activities. Therefore, soil as part of the supporting components of agriculture must be considered so as not to decrease its fertility due to chemical fertilizers and pesticides used in agricultural activities.

Badan and Pengembangan (2005) stated that increased biomass production activities (from agricultural, plantation and forestry activities) that use uncontrolled soil can cause soil damage. Soil as a supporting factor in the agricultural environment is declining in quality and can even be damaged and no longer productive. Fatal soil damage can threaten the survival of humans, animals, plants and the surrounding biotic environment. The issue of damage to the surrounding land and environment has now become a global environmental issue. Environmental pollution due to the use of hazardous chemical fertilizers and pesticides needs to be addressed so that the environment can be sustainable. There are three main impacts caused by human activities that among the environmental problems existing, i.e.: (1) effects of the use of production inputs on the production of agriculture and the environment; (2) effects of the farming system on the emission of greenhouse gases; (3) effects of industrial activities and urban expansion in agricultural land. The use of the means of production inputs in modern agriculture, such as fertilizer and chemical pesticides has big impacts on the degradation of environmental quality in agriculture. Modern agriculture which was rolled out as green revolution has strong correlation with the environmental issues (Las *et al.*, 2006).

Sustainable agricultural development with an environmental perspective comes with the maintenance of the agricultural environment to meet basic human needs, namely food, clothing, shelter and healthy environment through productive management of natural resources, cultural resources, capital resources and the application of technology. Darmawan (2011) states that sustainable agricultural development is a process and condition that includes the adjustment over time between natural resources, socio-cultural inputs, and technology to maintain a dynamic balance towards adequate capacity of natural resources for future generations. Munasinghe (2004); Nurmalina (2007) added that sustainable development is not a static harmony situation. The harmony is a process of change in which natural resource exploitation, technological development orientation, and institutional development are consistent with meeting the needs of current and future generations. Three dimensional unity, namely economic, social, and ecological dimensions is expected to become a unified whole with dynamic changes towards better policies, which prioritize the interests of humans and their natural environment towards mutual prosperity.

Sustainable agricultural development can also be said as economic development in the agricultural sector, because agriculture is one of the sectors in economic life. Agricultural development policies are expected to contribute to driving economic development. In addition, the notion of agriculture itself also contains economic elements, because agriculture is a human endeavor through the life of plants, animals and the natural environment, so that humans are able to meet their needs. Although agricultural development can be seen as economic development in the agricultural sector, agricultural development can not only be viewed from the economic aspect, but also from the social, cultural, technological, environmental, and other aspects (Widodo, 2011).

One part of sustainable agriculture is organic farming. Organic farming is a form of ecological agriculture that emphasizes sustainability for present and future generations. Organic farming system is one of the solutions to solve the classic problems in agriculture, for example about production and production risks faced by farmers. Sudrajat (2018) stated organic farming began to be developed by farmers in Indonesia after the era of green revolution technology. The green revolution which initially brought a dramatic increase in agricultural output is now beginning to be felt to have a negative impact. Rice production began to decline due to the use of chemical fertilizers and pesticides during the green revolution since 1963 until now, so that efforts are needed to increase land productivity and soil conservation through organic agriculture. The philosophy that underlies organic agriculture is to develop the principles of feeding the soil which then provides the soil with food for plants (feeding the soil that feeds the plants) and not providing food directly to the plants. Based on this concept it can be understood that the philosophy of organic farming is to build soil fertility with the hope that the food produced will provide health for humans and the environment, so that it will also have an impact on the economic health of the community (Von Uexkull, 1984).

One of the things that need to be considered in organic rice farming is about farm efficiency. Regarding efficiency, there have been many studies on the efficiency of rice farming, both technical, allocative, and economic efficiency using the stochastic frontier approach. However, efficiency studies using the stochastic frontier approach on organic rice farming are still very limited. Some researchers who examined the technical efficiency or production efficiency with the stochastic frontier approach on organic or semi-organic rice farming were conducted by Gultom *et al.* (2014); Khairizal and Amin (2014); Murniati *et al.* (2014); Riyardi *et al.* (2017); Narendar *et al.* (2018); Hidayati *et al.* (2019); Sudrajat (2019a). Some researchers who examined cost efficiency with the stochastic frontier approach on organic rice and conventional rice farming were conducted by Ghosh and Raychaudhuri (2015); Ouedraogo (2015); Ajoma *et al.* (2016); Rathnayake and Amaratunge (2016); Arifin *et al.* (2018); Sudrajat *et al.* (2018). There are also some researchers who examine economic efficiency or profit efficiency with the stochastic frontier approach on organic and conventional rice farming, among others conducted by Adamu and Bakari (2015); Kaka *et al.* (2016); Khoy *et al.* (2016); Chang *et al.* (2017); Dang (2017); Sudrajat *et al.* (2017); Froehlich *et al.* (2018).

In addition to technical, allocative and economic efficiency, there are also some researchers who examine the farmer's behavior on facing production risk, both on organic or conventional rice, as done by Zakirin *et al.* (2013); Suharyanto *et al.* (2015); Asbullah *et al.* (2017); Hasanah *et al.* (2018); Bola and Prihtanti (2019); Erny *et al.* (2019); Sudrajat (2019b). In addition, there are also researchers who examine the study of technical efficiency and production risk on organic or conventional rice farming, as conducted byKumbhakar (2002); Villano and Fleming (2006); Rahayu (2011); Tiedemann and Latacz-Lohmann (2012); Nainggolan *et al.* (2019). It turns out that if observed it is still rare for researchers to examine the effect of management factors and farmer's behavior on technical efficiency and production risk on organic rice farming. This research is a study that aims to analyze the correlation between the influence of management factors and farmer's behavior in technical efficiency and production risk on organic rice farming in Dlingo Village, Mojosongo District, Boyolali Regency, Central Java Province, Indonesia.

## 2. THEORETICAL APPROACHES

### *2.1. Stochastic Frontier Production Function*

The production function can be seen as a physical relationship between the variables described in the form of output (Y) and the variables that explain in the form of inputs (X). The discussion of the production function is a very interesting discussion in the economic theory of production, because with the production function the researchers can find out the relationship between factors of production (input) and production (output) directly, so that the relationship between input and output becomes easier to understand. In addition, researchers can also find out the relationship between the variables explained or the dependent variable (Y) with the variables that explain or the independent variable (X) as well as knowing the relationship between explanatory variables (Soekartawi, 1990). In a simple mathematical form the production function is generally written in Equation 1:

$$Y = f(X_1, X_2, \ldots, X_i \ldots\ldots, X_n) \quad (1)$$

where:

$Y$ = physical production results.

$X_1, \ldots, X_n$ = production factors.

The stochastic frontier production function is widely applied in empirical studies in agriculture. Soekartawi (1990) states that the frontier production function is used to measure how the actual function is towards its frontier position. The frontier production function is the maximum production function that can be obtained from a number of combinations of factors of production at a particular technological level. The frontier production function describes the relationship between factors of production and output whose position is located on the "isoquant". Farrell (1957) states the stochastic frontier production function is "the best practice frontier" because one of its advantages in analyzing the efficiency and inefficiency of a production process. This can happen because a standard error is included in the model that displays technical efficiency in a model that has default errors.

The stochastic frontier production function approach is carried out to estimate the frontier and not the average production function, because the average production function approach has the problem of simultaneous equations that are biased and easily multi collinear (Lau and Yotopoulos, 1971). The stochastic frontier production function approach uses the econometrics method. Coelli *et al.* (1998) detailed the concept of the stochastic frontier production function. An important idea behind the stochastic frontier model is that errors are combined into two parts. The symmetric component allows for random variations from frontiers between companies or farms, capturing the effects of measurement errors, other statistical disturbances, and random interruptions outside the control of the company or farm. The one-sided component captures the effect of relative inefficiencies on stochastic frontiers.

Coelli (1996) asserts that the frontier production function is a production function that describes the maximum output that can be achieved from each level of input use. If a farm is at a point in the frontier production function, it means that the farm is technically efficient. Aigner *et al.* (1977); Meeusen and van Den Broeck (1977); Jondrow *et al.* (1982) suggested that the stochastic frontier function is an extension of the original deterministic model to measure unexpected effects (stochastic frontier) within the limits of production. In this production function a random error ($v_i$) is added to the non-negative random variable ($u_i$), as stated in Equation 2:

$$Y = \alpha_0 + \alpha_i X_i + \ldots + \alpha_k X_k + (v_i - u_i) \quad (2)$$

where:

$Y$ = farm production in natural logarithm (ln).

$X_{i\text{-}k}$ = number of inputs used by the farm in natural logarithm (ln).

$\alpha_0$ = constant.

$\alpha_{i\text{-}k}$ = estimated parameter.

$v_i$ = error factors caused by factors beyond the farmers' control.

$u_i$ = error factors caused by factors under the farmers' control.

### *2.2. The Concept of Production Efficiency*

The ability of the agricultural sector to produce depends on the level of farm income and the resulting surplus. The level of farm income is an important factor to support economic growth in general and is a major determinant of farmer's household welfare specifically (Adiyoga, 1999). The level of farm income is determined by the efficiency of farmers to allocate their resources to various alternative production activities. If farmers do not use these resources efficiently, there will be an untapped potential to increase farm income and create a surplus. Therefore, the identification of efficient use of resources is an important issue that determines the existence of various opportunities in the agricultural sector in relation to their contribution to economic growth and improving the welfare of farmers' households (Weersink *et al.*, 1990). Doll and Orazeem (1984); Debertin (1986); Lipsey *et al.* (1987) defines efficiency as the maximum amount of output achieved by the use of a certain number of inputs or to produce a certain number of outputs using the smallest possible input. Kumbhakar and Lovell (2000) measures efficiency as the level of success of a manager in allocating available inputs and outputs in achieving goals and achieving the highest level of efficiency in costs, revenues and profits.

Farrell (1957); Coelli *et al.* (1998) states that efficiency is classified into three, namely technical efficiency (TE), allocative efficiency (AE), and economic efficiency (EE). Technical efficiency (TE) shows the ability of a farm to obtain maximum output from a certain number of inputs or in other words, technical efficiency is used to measure the amount of production that can be achieved at a certain level of input. This technical efficiency is related to the ability of farmers to use inputs to produce certain outputs at certain technological levels to produce on the frontier isoquant curve. Soekartawi (1987) explained that the availability of facilities or factors of production (input) does not mean that the productivity obtained by farmers will be high, but how farmers do their business efficiently is a very important effort. Technical efficiency will be achieved if farmers are able to allocate factors of production in such a way that high production is achieved. If the farmer gets a big profit in his farming it is said that allocation of production factors is allocatively efficient. This method can be achieved by buying factors of production at low prices and selling results at relatively high prices. If the farmer is able to increase his production with the price of production facilities can be reduced but the selling price is high, then the farmer performs technical efficiency and price efficiency or economic efficiency.

### *2.3. Farmer's Behavior in Facing Risks*

Hardaker *et al.* (1997) explained that the situation of farmers' decision making in production risk is faced with two things, namely risk and uncertainty. The terms "risk" and "uncertainty" can be defined in various contexts, Risk is uncertain consequences, particularly exposure to unfavorable consequences; and uncertainty as imperfect knowledge. Soekartawi (1993) defines risk as the possibility of loss or the possibility of loss, so the chance of occurrence is known first, whereas uncertainty is something that cannot be predicted beforehand, and because the chance of loss is not known beforehand. Risks in agricultural production are caused by the dependence of agricultural activities on nature, where the adverse effects of nature have greatly influenced the total agricultural yields. Uncertainty situation is intended as a risk of production in farming faced by each farmer and it appears from the variations in production gains and revenues.

Robison and Barry (1987) states risk is the chance of an event that can be measured and based on experience. Uncertainty is the opportunity for an event that cannot be predicted. Risk analysis is related to decision making theory. In this case farmers are assumed to act rationally in decision making. Some sources of risk faced by farmers include: (i) production risk; (ii) market or price risk; (iii) institutional risk; (iv) policy risk; and (v) financial risk. From these sources, it turns out that the most important risks faced by farmers are production risk and product prices. Both of these risks, namely production risk and product price must be considered by farmers to face the problem of risk and uncertainty that will later affect the income received by farmers (Harwood *et al.*, 1999; Moschini and Hennessy, 1999). Ellis (1988) states that the attitudes of farmers in facing production risks are grouped into three, namely: risk aversion, risk neutral, and risk taker. The three attitudes of farmers in facing production risks related to utility and income can be seen in Figure 1.

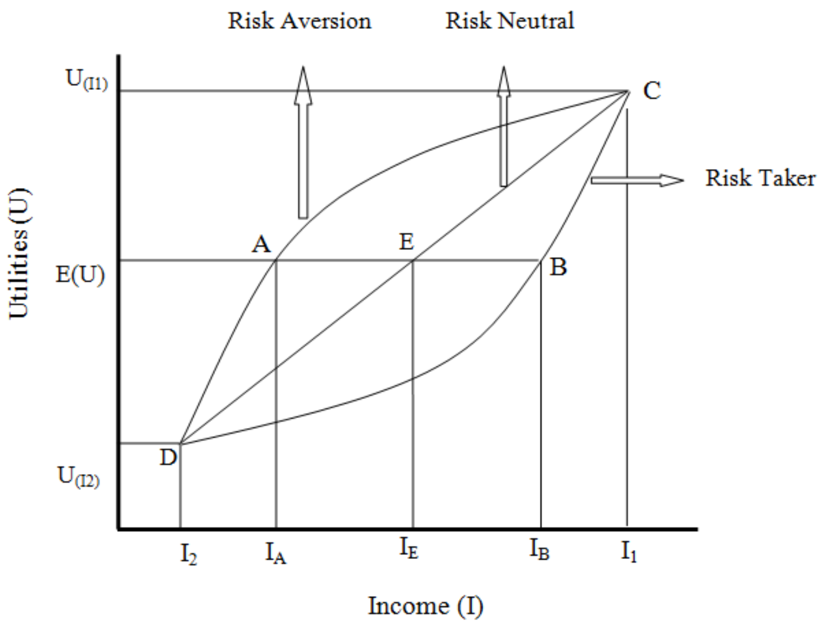


**Figure-1.** Theory of farmer's behavior on facing production risk.
**Source:** Ellis (1988).

Robison and Barry (1987) states the attitude of farmers as decision makers in dealing with production risks can be classified into three categories, namely: (1) Decision makers who avoid production risk (risk aversion). This attitude shows that if there is an increase in variance of the profit, the decision maker will compensate by increasing the expected profit which is a measure of the level of satisfaction (utility); (2) Decision makers who dare to face production risk (risk takers). If there is an increase in the range of profits, the decision maker will compensate by increasing the expected profit; (3) Decision makers that are neutral about production risk (risk neutral). If there is an increase in the range of profits, the decision maker will not compensate by increasing or decreasing the expected profit.

### *2.4. Production Management and Risk Management*

Osburn and Schneeberger (1978) explain agricultural management is how to plan a farm to be carried out, organize the workforce needed, give direction to the workforce about what needs to be done, coordinate what things are challenges in carrying out these agricultural activities and oversee labor and production so as to achieve the goal, in this case is to get profits or profits for these producers. Production in agribusiness activities can be interpreted as a set of procedures and activities that occur in the creation of agribusiness products (agricultural business products, fisheries, livestock, forestry, and processed products). Agribusiness management is a set of decisions to support the implementation of agribusiness production, from planning, organizing, implementing, controlling, controlling, to evaluating the production process. In this case production management has a comprehensive impact and is related to various functions such as financial, personnel, financial, research and development, procurement and storage functions, and others. Production management involves several things including: location, size or volume decisions, facility layout, purchasing, inventory, scheduling, and production quality (Firdaus, 2008).

Risk management is the systematic application of management policies, procedures and activities for hazard identification, analysis, assessment, handling and monitoring and evaluation of risks. Risk management can also be interpreted as a structured approach in managing uncertainty related to threats. This includes a series of human activities, such as; risk assessment, development of strategies to manage and mitigate risk using empowerment resources owned (Jolly, 1983). Harwood *et al.* (1999) describes how farmers can manage risk. Risk management carried out by farmers is useful to minimize the level of loss during the production process. Some risk management that can be applied in agricultural activities are business diversification, vertical integration, production contracts, sales contracts, hedging, financial and expenditure management, liquidity, leasing, insurance and other risk management, such as adding inputs and outputs, using technology, and optimizing the use of machines. The strategies that can be taken in risk management include transferring the risk to other parties, avoiding the risk, reducing the negative effects of the risk, and accommodating some or all of the consequences of a particular risk. Risk management of traditional agricultural production is related to risks that arise in the implementation of production, such as floods, landslides, crop failure due to pests and plant diseases, etc. Related to financial risk management, for example risks that can be managed by using financial instruments, so as to reduce production costs and increase revenue.

## 3. DATA AND METHODOLOGY

### *3.1. Research Place and Data Collection*

This research was conducted in Boyolali Regency, Central Java Province, Indonesia, which included five districts (Andong, Nagasari, Sambi, Simo and Mojosongo) and seven villages (Catur, Jatisari, Dlingo, Metuk, Andong, Wates and Glonggong). From five districts, four are rain-fed agriculture (Districts: Andong, Nogosari, Sambi and Simo) and one other district is irrigated agriculture, Mojosongo District. In this study, one district was selected, namely Mojosongo District which is an irrigated organic agriculture with water sources from the spring above, so that all farmers really do organic rice farming. The organic rice farming land which is cultivated occupies a specific location separate from the conventional rice cultivation location (one stretch of organic rice) located in Dlingo Village, Mojosongo District.

Boyolali Regency is known as a rice-producing area including organic rice. Data on the area of organic rice commodity certified by the Indonesian Organic Alliance/ *Aliansi Organik Indonesia* (AOI) stated that Boyolali Regency has an area of organic rice of 10.2 hectares of all organic material commodities (vegetables, horticulture, etc.) covering 318.45 hectares (Aliansi, 2017). It indicates that Boyolali Regency is a place for producing organic food, especially organic rice, which should be taken into account in Indonesia. Rice farmers in Boyolali Regency are classified into conventional rice farmers, ICS (Internal Control System) certified organic rice farmers and national certified organic rice farmers. Based on data from the Boyolali Organic Rice Farmers Association (Appoli) in 2014, organic rice farmers were divided into rice farmers who transitioned to organic rice, known as ICS and nationally certified farmers. The number of certified farmers is 521 farmers who are also the study population, spread in five districts, namely Sambi District (Catur Village: 72 farmers and Jatisari Village: 60 farmers), Mojosongo District (Dlingo Village: 151 farmers and Metuk Village: 56 farmers), Andong District (Andong Village: 79 farmers), Simo

District (Wates Village: 13 farmers), and Nogosari District (Glonggong Village as many as 30 farmers). From 521 farmer population, 216 organic rice farmers were taken as samples with purposive sampling method.

This research is a qualitative and quantitative research supported by primary and secondary data through in-depth interviews with existing farmers and stakeholders. Primary data collection is carried out to capture the characteristics of farm households, land tenure structures, farm household income structures, organic rice farming inputs and socio-economic factors that affect the efficiency of organic rice farming, while secondary data collection includes data from Central Bureau of Statistics/ *Badan Pusat Statistik* (BPS) on growth Indonesian population and rice production and growth data. Besides that, it is also equipped with description data of Boyolali Regency and its districts which are related to the development of land area, productivity, farmer groups, agricultural management, etc.

### *3.2. Data Analysis*

#### *3.2.1. Data of Technical Efficiency*

In this research, technical efficiency's data was analyzed with stochastic frontier production function (with cross section data) and then was estimated with Maximum Likelihood Estimation (MLE). MLE requires a particular assumption about the distribution of disturbance. There is a large class of disturbance distributions which may be specified which make the maximum likelihood frontier estimator regular and well behaved.The estimation of production function has been one of the more popular areas of applied econometrics (Greene, 1980). Recent work in duality theory which has linked production and cost functions has made this topic even more attractive. Stochastic frontier production function is an original deterministic model to measure the unpredictable effects (stochastic frontier) in the production limits. Stochastic frontier production function is formulated as follows:

$$Y = \alpha_0 + \alpha_i X_i + \ldots + \alpha_k X_k + (v_i - u_i),\ i = 1,\ldots,N \qquad (3)$$

where:

$Y$ = organic rice production in natural logarithm (ln).

$X_i$ = number of inputs used in production process in natural logarithm (ln).

$\alpha_0$ = constant.

$\alpha_{i-k}$ = estimated parameter.

$v_i$ = error factors caused by factors beyond the farmers' control.

$u_i$ = error factors caused by factors under the farmers' control.

Stochastic frontier production function in Equation 3 was assumed to have the form of Cobb-Douglas production function that transformed into natural logarithm (ln) by including the effects of determinant factors of the level of technical inefficiency, so that stochastic frontier production function can be written in Equation 4:

$$\ln Y = \alpha_0 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \alpha_4 \ln X_4 + \alpha_5 \ln X_5 + \alpha_6 \ln X_6 + \alpha_7 \ln X_7 + \alpha_8 \ln X_8 + \alpha_9 \ln X_9 + \alpha_{10} D_1 + \alpha_{11} D_2 + \alpha_{12} D_3 + (v_i - u_i) \qquad (4)$$

where:

$Y$ = number of grain production of organic rice (kg/ha/planting season).

$X_1$ = land area used by farmers (ha/planting season).

$X_2$ = number of organic rice seeds (kg/ha/planting season).

$X_3$ = amount of solid organic fertilizer (kg/ha/planting season).

$X_4$ = amount of liquid organic fertilizer (ltr/ha/planting season).

$X_5$ = amount of liquid organic pesticide (ltr/ha/planting season).

$X_6$ = amount of solid organic pesticide (kg/ha/planting season).

$X_7$ = wage of non-family labors (IDR/man days/planting season).

$X_8$ = wage of family labors (IDR/man days/planting season).

$X_9$ = tractor's rental fee (IDR/ha/planting season).

$D_1$ = dummy 1 ($D_1$ = 1; *mentikwangi* cultivar; $D_1$ = 0, other cultivars).

$D_2$ = dummy 2 ($D_2$ = 1; IR64 cultivar; $D_2$ = 0, other cultivars).

$D_3$ = dummy 3 ($D_3$ = 1; *pandanwangi* cultivar; $D_3$ = 0, other cultivars).

$\alpha_0$ = constant.

$\alpha_{1,...,12}$ = coefficient of regression on production factors.

$v_i$ = error factors caused by factors beyond the farmers' control.

$u_i$ = error factors caused by factors under the farmers' control.

The effect of the factors determining the level of production inefficiency on organic rice farming system in Boyolali Regency can be formulated in Equation 5 as follows:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} \quad (5)$$

where:

$U_i$ = production inefficiency.

$Z_1$ = farmer's age (years old).

$Z_2$ = formal education level of the farmer (years).

$Z_3$ = period of organic rice farming system (years).

$Z_4$ = number of family members (person).

$Z_5$ = frequency of participation in extension (times).

$Z_6$ = frequency of participation in training (times).

$Z_7$ = coaching or courses about organic rice farming (score).

$Z_8$ = role of farmers groups and field agricultural extension officer (score).

$Z_9$ = role of institutions/ associations (score).

$Z_{10}$ = farming system management (score).

$\delta_0$ = constant.

$\delta_{1,...,10}$ = coefficient of regression on determinant factors of technical inefficiency.

### 3.2.2. Data of Production Risk

To determine the farmer behavior on facing production risk on organic rice farming system in Boyolali Regency was used Just & Pope's production risk function model, i.e., production function plus the production risk function. Measurement of production risk (Just and Pope, 1979) refers to the method of Moscardi and De Janvry (1977). Measurements are made by selecting the most significant factors that influence the determination of regression results with statistical package approach to the social sciences (SPSS) method. The most significant influencing factor parameters are used to determine the level of farmer behavior on facing production risk based on econometric approach. The production risk function can be formulated in Equation 6 as follows:

$$y = f_j(x, z) + u = f_j(x, z) + h_j(x, z)\,\varepsilon \quad (6)$$

Where:

$y$ = the number of output.

$x$ = vector of the number of variables input ($x_i$,...,$x_j$).

$z$ = vector of the number of quasi fixed input ($z_i$, ...,$z_k$).

$f_j(x,z)$ = production function.

$h_j(x, z)\varepsilon$ = production risk function.

u = heteroskedastic error term with mean = nol and varians = $(h(.))^2$

ε = homoskedastic error term with mean = nol and varians = 1.

If $h_j(x,z)$ is positive, it means the addition of input j can raise the risk, on the contrary, if $h_j(x,z)$ is negative, it means the addition of input j can reduce the risk.

Where:

$f_j(x,z)$ = production function.

Y = organic rice production (kg/ha/planting season).

$X_1$ = land area used by the farmers (ha/planting season).

$X_2$ = number of organic rice seeds (kg/ha/planting season).

$X_3$ = amount of solid organic fertilizer (kg/ha/planting season).

$X_4$ = amount of liquid organic fertilizer (liter/ha/planting season).

$X_5$ = amount of liquid organic pesticide (liter/ha/planting season).

$X_6$ = amount of solid organic pesticide (kg/ha/planting season).

$X_7$ = wage of non-family labors (IDR/man days/planting season).

$X_8$ = wage of family labors (IDR/man days/planting season).

$X_9$ = tractor's rental fee (IDR/ha/planting season).

To calculate the farmer behavior on production risk is used a function of behavior on risk in Equation 7:

$$f_j = \tilde{w}_j - h_j\theta_i \tag{7}$$

Where $\theta_i$ can be described in Equation 8:

$$\theta_i \equiv \frac{E\left[U'\left(\frac{\pi^e}{p}\right)\varepsilon\right]}{E\left[U'\left(\frac{\pi^e}{p}\right)\right]} \tag{8}$$

where:

$f_j$ = marginal product with input j.

$w_j$ = normalized input price j.

$h_j$ = first derivative of risk function to input j.

$\theta_i$ = production risk behavior.

### *3.3. Hypothesis*

#### *3.3.1. Hypothesis of Production Inefficiency*

Testing a hypothesis on the variables that influence the production inefficiency can be formulated as follows:

*$H_0$:$\delta_i$= 0 : If $t_{count}<t_{table}$, then $H_0$ was accepted ($H_1$ rejected). It means that the variables did not influence the production inefficiency of organic rice farming in Boyolali, Indonesia.*

*$H_1$:$\delta_i \neq 0$ : If $t_{count}>t_{table}$, then $H_0$ was rejected ($H_1$ accepted). It means that the variables influenced the production inefficiency of organic rice farming in Boyolali, Indonesia.*

#### *3.3.2. Hypothesis about Farmer Behavior*

Testing hypotheses about farmer behavior in dealing with risks and on choosing the level of production risk on organic rice farming in Boyolali Regency, Indonesia is carried out in the form of the following hypothesis:

If $h_j > 0$ and $\theta_i < 0$ → $f_j < w_j - h_j\theta_i$ → $f_j$ should increase, so that $f_j = w_j - h_j\theta_i$, or $x_j$ input should decrease. Therefore, if $h_j > 0$ and $\theta_i < 0$, it means the farmers are afraid to face the risk (risk averse). On the other hand, if $h_j > 0$ and $\theta_i > 0$, so the farmers are dare to face the risk (risk seeking).

If $h_j < 0$ and $\theta_i > 0$ → $f_j < w_j - h_j\theta_i$ → $f_j$ should increase, so that $f_j = w_j - h_j\theta_i$, or $x_j$ input should increase. Therefore, if $h_j < 0$ and $\theta_i > 0$, it means the farmers are afraid to face the risk (risk averse). On the other hand, if $h_j < 0$ and $\theta_i < 0$, so the farmers are dare to face the risk (risk seeking).

## 4. RESULTS AND DISCUSSION

### *4.1. Tractor's Rental Fee as a Correlation Factor of Production Efficiency and Production Risk*

From the result of the research, the production of organic rice is determined by the use of the inputs such as land area used by the farmers, number of organic rice seeds, amount of solid organic fertilizer, amount of liquid organic fertilizer, amount of solid organic pesticide, amount of liquid organic pesticide, wage of non-family labors, wage of family labors, tractor's rental fee, and cultivars used. Analysis of the production function here illustrates the relation between production and its inputs in the research of the stochastic frontier production function. The results of the analysis are then estimated using the maximum likelihood estimation (MLE) method. From nine variables suspected to affect the production of organic rice, variables that influenced the production significantly were land area used by the farmers, amount of liquid organic fertilizer, amount of solid organic pesticide, wage of family labors, tractor's rental fee, and the cultivars used. Variables including number of organic rice seeds, amount of solid organic fertilizer and amount of liquid organic pesticide were not statistically significant.

**Table-1.** Estimation result of variables in stochastic frontier production function.

| Variable | Parameter | Coefficient of regression | Standard error | T-Ratio |
|---|---|---|---|---|
| Constant | $\alpha_0$ | 152.3626 | 0.8001 | 9.276 |
| Land area used by farmers | $\alpha_1$ | 0.0011* | 0.0676 | 1.673 |
| Number of organic rice seeds | $\alpha_2$ | -0.0897$^{NS}$ | 0.0738 | -1.215 |
| Amount of solid organic fertilizer | $\alpha_3$ | -0.0511$^{NS}$ | 0.0365 | -1.400 |
| Amount of liquid organic fertilizer | $\alpha_4$ | 0.0132* | 0.0081 | 1.691 |
| Amount liquid organic pesticide | $\alpha_5$ | 0.0010$^{NS}$ | 0.0085 | 0.121 |
| Amount solid organic pesticide | $\alpha_6$ | -0.0489*** | 0.0104 | -4.685 |
| Wage of non-family labors | $\alpha_7$ | 0.0115*** | 0.0031 | 3.703 |
| Wage of family labors | $\alpha_8$ | 0.0375*** | 0.0053 | 7.043 |
| Tractor's rental fee | $\alpha_9$ | 0.1486*** | 0.0690 | 2.153 |
| Dummy 1 | $\alpha_{10}$ | 0.0424*** | 0.0069 | 6.125 |
| Dummy 2 | $\alpha_{11}$ | 0.0709$^{NS}$ | 0.0560 | 1.267 |
| Dummy 3 | $\alpha_{12}$ | -0.0508*** | 0.0688 | 1.227 |
| Sigma-square | | 0.6088 | 0.1929 | 3.156 |
| Gamma | | 0.9877 | 0.0088 | 112.678 |
| Log likelihood function | | 467.5480 | | |
| LR test of the one-sided error | | 152.3626 | | |
| Mean efficiency | | 0.5928 | | |
| Number of observations | | 216 | | |
| Note: | | | | |
| *** = significant at α=1% | | t-table 1% = 2,358 | | |
| ** = significant at α=5% | | t-table 5% = 1,980 | | |
| * = significant at α=10% | | t-table 10% = 1,658 | | |
| NS = non significant at α=10% | | | | |

**Source:** Analysis of Primary Data 2016.

Variables influencing positively, namely land area used by the farmers, amount of liquid organic fertilizer, wage of non-family labor, wage of family labors, and tractor's rental fee illustrated that if those variables are increased at a certain level, they can increase the production of organic rice, while variables influencing negatively (amount of solid organic pesticides) showed their over use by farmers so it is necessary to reduce the use. From the variable that positively influences the stochastic frontier production function, it turns out that the tractor's rental fee variable is the most dominant variable influencing production efficiency with a coefficient of 0.1486. This shows that if the tractor's performance is improved (tractor rental costs added), the efficiency of organic rice production will also increase. The estimation result of variables in stochastic frontier production function can be seen in the Table 1.

For risks caused by the production function by selecting the most significant factors that influence the determination of the regression results. The most significant influence factor parameter is used to determine the level of behavior of farmers in facing production risk based on the statistical package for social science (SPSS) method. Table 2 shows the most significant factor parameters that influence the determination of the regression results. This parameter will be used to determine the level of behavior of farmers in facing production risk based on an econometric approach.

**Table-2.** Most significant variable of production risk.

| Model | Unstandardized coefficient | | Standardized coefficient | t-count | Significant |
|---|---|---|---|---|---|
| | β | Standard error | β | | |
| (Constant) | 5.844 | 1.014 | | 5.764 | .000 |
| $X_9$ | .195 | .074 | .177 | 2.634 | .009 |
| (Constant) | 4.791 | 1.067 | | 4.489 | .000 |
| $X_9$ | .342 | .090 | .310 | 3.799 | .000 |
| $X_2$ | -.264 | .095 | -.227 | -2.785 | .006 |

**Source:** Analysis of Primary Data 2016.

Based on Table 2 the most significant factor influencing and contributing greatly to the risk of organic rice production is tractor's rental fee with coefficient value of 0.310. In order to match production function {f (x, z)} and production risk function {h (x, z}ε) it is necessary to look at the factor of production which has the greatest contribution to organic rice production, i.e. tractor's rental fee factor ($X_9$). Furthermore, it should be seen that $f_j$ (marginal product with input j), $w_j$ (normalized input price j), $h_j$ (first derivative of risk function to input j) and $\theta_i$ (production risk behavior) from calculation result using SPSS (Statistical Package for the Social Sciences) method (Pallant, 2010). As the most dominant factor, tractor's rental fee is very influential on organic rice production and production risk. If the tractor's rental fee is higher, the organic rice production will be greater; and if the tractor's rental fee is higher, then the behavior of farmers in making decisions facing production risk in terms of risk seeking will be even greater.

From the estimation results of the variables that affect the production function, it is found that the tractor's rental fee variable is the most significant variable with a coefficient value of 0.1486. Likewise, the variables that affect production risk found that the tractor's rental fee variable was the most significant variable with a coefficient of 0.310. The variable tractor's rental fee in this case is a correlation variable between production efficiency and production risk. This can be understood, if the tractor's performance in managing organic rice farming in Boyolali Regency is improved, it will be able to improve production efficiency and improve the behavior of farmers to dare to face the production risks.

Technology development in agriculture (agricultural mechanization), in this case the use of tractors in organic rice farming is very helpful for farmers in cultivating land, so it is ready for planting. The use of tractors in

Mojosongo District, Boyolali Regency, Indonesia is considered very effective in supporting organic rice production, so as to increase technical efficiency. In addition, the use of these tractors can also support farmers (farmer's behavior) to be more courageous in facing production risks because they can save farmers' labor (more efficiently). Existing workforce can be used for other purposes that are more beneficial for organic rice production, so that it can increase farmers' income and at the same time reduce the risk of future production.

### *4.2. Management Factors as Dominant Factors*

The variables of farmer's age, organic rice farming period, the number of family members, and training/ courses about organic rice farming statistically explained no significant effects on technical inefficiency of organic rice farming at α = 10%. Determinant factors of technical inefficiency of organic rice farming system (formal education level of farmers, frequency of participation in extension, frequency of participation in training, role of farmers' groups and field agricultural extension officer, role of institutions/ associations, and farming system management) had a negative coefficient. It suggests that the higher the value of these variables, then the inefficiency will decrease. From the most influence variables toward technical inefficiency of organic farming, variable of farming system management was the most dominant variable in determining the technical inefficiency of organic rice farming with coefficient value of -0.4527. It means, the higher the value of farming system management, the technical inefficiency of organic rice farming will further go down. It can be seen on Table 3:

**Table-3.** Estimation result of factors causing production efficiency on organic rice farming.

| Variable | Parameter | Coefficient of regression | Standard error | t-count |
|---|---|---|---|---|
| Constant | $Z_0$ | -5.0529 | 0.0289 | -1.760 |
| Farmer's age | $Z_1$ | 0.0099$^{NS}$ | 0.0105 | 0.939 |
| Formal education level of farmers | $Z_2$ | -0.0451$^{*}$ | 0.0281 | -1.697 |
| Organic rice farming period | $Z_3$ | -0.0726$^{NS}$ | 0.0477 | -1.623 |
| Number of farmers' family members | $Z_4$ | -0.0935$^{NS}$ | 0.0760 | -1.231 |
| Frequency of participation in extension | $Z_5$ | -0.0231$^{***}$ | 0.0044 | -5.275 |
| Frequency of participation in training | $Z_6$ | -0.1734$^{***}$ | 0.0592 | -2.930 |
| Counseling/ course about organic farming | $Z_7$ | -0.0359$^{NS}$ | 0.0425 | -0.845 |
| Role of farmer groups and field agricultural extension officer | $Z_8$ | -0.0995$^{**}$ | 0.0536 | -1.856 |
| Role of institutions/ associations | $Z_9$ | -0.1651$^{***}$ | 0.0531 | -3.107 |
| Farming system management | $Z_{10}$ | -0.4527$^{***}$ | 0.1461 | -3.098 |
| Note: | | | | |
| *** = significant at α=1% | | t-table 1% | = 2,358 | |
| ** = significant at α=5% | | t-table 5% | = 1,980 | |
| * = significant at α=10% | | t-table 10% | = 1,658 | |
| NS = non significant at α=10% | | | | |

**Source:** Analysis of Primary Data 2016.

The results of the research showed that the farmers were not capable yet to be technically efficient in carrying out organic rice farming system. The use of the production factors could not be combined well resulting in inefficiency. It was indicated by the average value of inefficiency which was reaching 0.5928 or 59.28% Table 1. Thus, the farmers technically were not able to combine the actual inputs to produce maximum output efficiently. Therefore, to get the efficient organic rice farming system, it is necessary to increase the value of the variable of formal education level of farmers, frequency of participation in extension, frequency of participation in training, role of farmer groups and field agricultural extension officer, role of institutions/ associations, and farming system management.

### 4.3. Farmer's Behavior on Facing Production Risk

Farmer's behavior towards organic rice production risk is assumed to maximize the expected utility from normalized profit with price. In this study, the farmer's behavior of organic rice farming is examined to determine how farmers' attitudes in dealing with existing production risks; whether dare to face risk (risk seeking) or avoid risk (risk averse). The attitude of organic rice farmers in Boyolali Regency, Indonesia on making decisions can be shown in Table 4:

**Table-4.** Farmer behavior on production risk of organic rice farming.

| Risk averse arrow-pratt | Number of samples | Percentage |
|---|---|---|
| Risk Averse (RA) | 100 | 46.30 |
| Risk Seeking (RS) | 116 | 53.70 |
| Total | 216 | 100.00 |

**Source:** Analysis of Primary Data 2016.

In Table 4 can be seen that from the 216 samples, there are 46.30% of the farmers (100 people) making decisions are afraid of risk (risk averse). Organic rice farmer behavior shows that if there is an increase of variance in profit then the farmers will compensate by raising the expected profit and it is a measure of satisfaction level of the farmers. While 53.70% of other farmers (116 people) are dare to take risk (risk seeking). The farmer's behavior shows that if there is an increase in profit range, the farmers will compensate by lowering the expected profit. Furthermore, to see the level of risk faced by farmers, the coefficient of variation was used. The greater value of coefficient of variation shows the greater risk of organic rice production and conversely, the smaller value of coefficient of variation shows the smaller risk of production risk of organic rice farming.

In terms of farm management, to reduce the risk it is necessary to apply good farm management, such as: use of superior varieties of seeds, use of quality and labeled seeds, carry out perfect soil management as recommended, maintain nursery properly, regulate populations or planting systems regularly and right as recommended, provide organic fertilizer according to soil needs, water supply (irrigating) rice plants carried out effectively and efficiently in accordance with soil conditions (intermittent irrigation), pest and disease control carried out in an integrated and environmentally friendly manner, weed control is carried out in an appropriately, handling the harvest and post-harvest processes is done well, and using quality seeds, clean, and healthy.

## 5. CONCLUSION

Organic farming is part of sustainable agriculture with an environmental perspective. Organic farming aims at producing healthy food for present and future generations and at the same time preserving the environment of agriculture. As an environmentally friendly agriculture, organic agriculture puts forward three dimensions, namely the ecological, economic and social dimensions that are sustainable.

From the estimation results it was found that the tractor's rental fee as a correlation factor that unites between production efficiency and production risk. Tractor's rental fee is the most dominant factor influencing production efficiency and production risk with coefficients of values of 0.1486 and 0.310, respectively. This is intended if the performance of the tractor is improved, it will be able to increase production efficiency and convince farmers to be more willing to face the risks of organic rice production in Boyolali Regency, Indonesia.

Variable of farming system management was a variable that most high influence on the technical inefficiency of organic rice farming with coefficient value of -0.4527. It means, if the value of farming system management is increased, the technical inefficiency of organic rice farming will further go down.

Farmers behavior on facing production risk are 46.30% farmers make risk averse decision (risk averse) and 53.70% other farmers dare to face the risk (risk seeking). It's mean the farmers of organic rice farming in Boyolali Regency, Indonesia make risk seeking decision or more dare to face the production risk.

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