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DETERMINANTS OF COST EFFICIENCY OF SMALLHOLDERS PEPPER IN SARAWAK, MALAYSIA

Anita Rosli[1], Khalid Abdul Rahim[2], Alias Radam[3], Amin Mahir Abdullah[4]

[1, 2] Institute of Agricultural and Food Policy Studies,
[3] Faculty of Economics and Management, [4] Faculty of Agricultural,
Universiti Putra Malaysia, Selangor, MALAYSIA.

[1] anitarosli89@gmail.com, [2] khalid@econ.upm.edu.my, [3] alias@econ.upm.edu.my,
[4] amahir@putra.upm.edu.my

ABSTRACT

Pepper crop (Piper Nigrum L) is one of an important source of income for 67,000 rural families in the interior areas of Sarawak. This study is carried out to estimate technical, allocate, and cost efficiency among smallholders pepper in Sarawak. Then, the determinants of cost efficiency among smallholders pepper also investigated. It will identify the sources where improvements can be made to help the pepper farmers to minimize production cost. This study used 678 of smallholders pepper and the data is obtained from the field survey that was conducted in the month of August to December 2009. This study used a constant return to scale (CRS) input-oriented model to estimate technical efficiency and a Cost-DEA model is used to estimate cost efficiency. Mean of technical, allocative, and cost efficiency are 0.567, 0.585, and 0.438, respectively. Farmers are not efficient in input utilization and are not producing pepper yield at minimum input and minimize cost. The inefficiencies are due to misallocation of resources used. The contacts with extension agents per year, joining farmer's organization, full-time pepper farming, and participating in farming courses and study visit and education level is positively and statistically significant with cost efficiency among smallholders pepper.

Keywords: Piper Nigrum L, Data Envelopment Analysis, Cost Efficiency

INTRODUCTION

Pepper (*Piper Nigrum L)* is one of the *Piperaceae's* families, the king of spices and the oldest and widely used spice in the world. Pepper originally comes from the Malabar Coast, India and has been cultivated in Malaysia for more than a century. It was planted in Johor and Singapore during early 19th century and was widely planted in Sarawak in the mid-19th century (Liew, Mahendran, and Huzaimi, 2000). During the Brooke administration, they introduced the Land Incentive and Import of Foreign Labour policies to assist in the development of pepper industry in Sarawak, (Grusin, 2009). Moreover, after World War II with the rapid recovery of the world economy there was an increase in pepper demand and prices resulting in an expansion of acreage of pepper farms. This situation supports and stimulates the indigenous population to transform from subsistence production based on shifting cultivation into more commercialized farming partly relying on income from cash crops. Pepper was first cultivated by Chinese farmers in the early years and now most pepper farmers are the Iban and Bidayuh tribes and pepper farms are concentrated in certain areas such as Kuching, Samarahan, Sri Aman, Betong, Sibu, and Sarikei.

In 2011, Malaysia was the fifth largest pepper producer in the world with 25,672 metric tonnes pepper production while Vietnam was the largest pepper producer (100,000 metric tonnes) followed by India (48,000 metric tonnes), Indonesia (37,000 metric tonnes), Brazil

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(35,000 metric tonnes) and other countries (Figure 1). The pepper industry in Malaysia is export-oriented since about 90% of pepper production is for export where most of Malaysian pepper (90%) is produced in Sarawak and the remainder comes from Johor, Malacca, and Sabah. Thus, as a result the commercial name for Malaysian-grown pepper is Sarawak Pepper in the world marketplace. Pepper is popularly used in food industry and also used in medical products and cosmetic industry.

Malaysian Pepper Board (MPB) is an extension agent that is responsible for processing and pepper grading, market information, promotion, extension services, quality improvement, trading, market regulation through licensing of pepper dealers and exporters and product development of pepper. Every main district in Sarawak has an MPB office such as in Kuching (main office), Bintangor, Sarikei, Sibu, Betong, Sri Aman, Miri, and Bintulu while in Peninsular Malaysia there is only one MPB office in Senai, Johor Bahru.

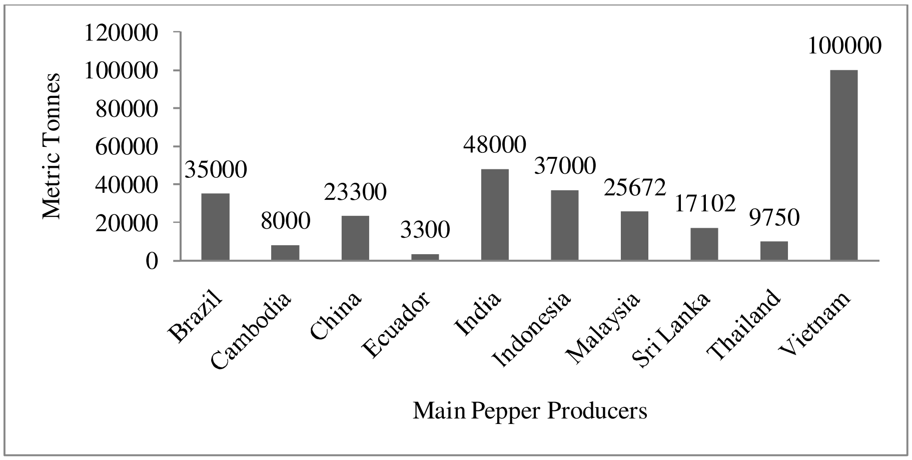

Figure 1. World Pepper Production 2011

(Source: International Pepper Community (IPC), 2012)

Pepper crop is cultivated in small farms averaging 0.2 ha and also one of an important source of income for 67,000 rural families in the interior areas of Sarawak. Market factor such as pepper price and price of inputs are affecting pepper farming in Sarawak. Pepper prices and price of inputs are not stable due to current economic conditions (demand, supply) thus farmers are price taker. Moreover, pepper is a labour and capital intensive cash crop. It requires a proper management of resources to ascertain high yield at minimum cost, and as well as increase farm profit. Meanwhile, personal preference over inputs contributes to the variation in farm performance where the combinations of inputs use make a different in output yield and cost structure. This study is carried out to estimate technical, allocative, and cost efficiency among smallholders pepper in Sarawak. Then, the determinants of cost efficiency among smallholders pepper also investigated. It will identify the sources where improvements can be made to help the pepper farmers to minimize production cost.

EFFICIENCY CONCEPTS

Micheal Farrell was a pioneer of efficiency studies in 1957 and his works were based on Debreu (1951) and Koopmans (1951) works. Farrell analyzed productive efficiency under physical efficiency on input-output transformation and price efficiency indicates optimal use of resources (Kopp, 1981). Efficiency in production refers to how farmers utilize the available resource at optimum level in order to maximize output and to minimize production cost. The input-oriented measures focus on reducing input quantities in production but maintaining the output amount. In this concept, technical and allocative efficiency are discussed by the relationship among inputs space. According to Figure 2, assume two inputs namely x_1 and x_2 to produce a single output y and assume the productivity is CRS. The unit of inputs observed at isoquant is assumed technologically fully efficient at SS' allowing for TE measurement. If firm uses the quantity inputs at P, thus the technical inefficiency is indicated by the distance QP and the amount of inputs used should be reduced by QP/0P ratio without reducing the output level.

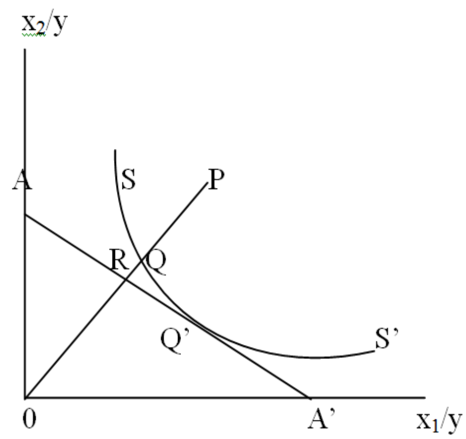

Figure 2. Technical and Allocative Efficiencies using Inputs Space

(Source: Coelli, Rao, and Battese, 1998)

Technical efficiency (TE) of farm, 0Q/0P that is equal to one (fully technical efficiency) minus QP/0P where value of QP/0P is between zero and one and this indicates the degree of technical inefficiency of farm. The unit of inputs observed that lie on isoquant is technical efficiency. The price of inputs represented by isocost line, AA', is used to measure the allocative efficiency (AE). If firm is operating at P, the AE = 0R/0Q and RQ (technically line) which is the ratio of inputs used should be reduced to save the production cost. Thus, if production of firm is allocatively efficient at point Q', the allocative inefficiency is at point Q. The total economic efficiency (EE) or also known as cost efficiency (CE) of farm is EE = 0R/0P where the distance of RP is for reduction of production cost. However, these three measures generate the production function and bounds with value of zero and one and the EE measure combines the TE and AE as:

$$TE_i \text{ x } AE_i = 0Q/0P \text{ x } 0R/0Q \quad (1)$$

$$EE_i = 0R/0P \quad (2)$$

$$\text{The cost reduction} = [1\text{-EE}] = RP/0P \quad (3)$$

MATERIALS AND METHODS

Study Area and Data Collection

The field survey was conducted in the month of August to December 2009. The survey covered nine main the areas of Sarawak such as Kuching, Serian, Sri Aman, Betong, Sarikei, Bintangor, Sibu, Miri, and Bintulu. Random sampling was used to select respondents to represent each district. Data were collected through face-to-face interviews based on questionnaires because face-to-face interview is the best method in where enumerators can clarify the question if potential respondents do not understand about the questionnaire

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structure. Through the survey 800 questionnaires were distributed however, only 678 questionnaires or respondents were valid for analysis after data cleaning process.

Empirical Model

Data Envelopment Analysis (DEA) is mathematical linear programming method that provides a way to construct the production frontiers to calculate the efficiency scores relative to the constructed frontiers. This study used a constant return to scale (CRS) input-oriented model that proposed by Charnes, Cooper, and Rhodes (1978) to estimate technical efficiency. The input-oriented measures focus on reducing input quantities in production but maintaining the output amount. The CRS model is as follows:

$$\text{Min}_{\theta,\lambda}: \theta$$

$$\text{Subject to} \quad -\theta y_i + Y\lambda \geq 0,$$

$$\theta x_i - X\lambda \geq 0,$$

$$\lambda \geq 0, \qquad (4)$$

where θ is ith farm's score of TE, y_i is pepper yield of ith farm, and x_i is quantity input use by ith farm. Assume N is number of farm where Y represents output for N farms, X represents input for N farm, λ is a vector of constants Nx1, and θ is a scalar. $Y\lambda$ and $X\lambda$ are efficiency estimation on the frontier. The value θ represents efficiency score of farm which is bounded by value of 0 and 1. If the value of θ is equal to $1(\theta = 1)$, farm is full technical efficiency while if value of θ less than 1 ($\theta \leq 1$), farm is in technical inefficiency condition.

Cost efficiency (CE) is minimum observed total cost (C*) to actual total cost (C). CE can be achieve when farmer able to produce pepper yield at minimum cost. To achieve the study objective, a Cost-DEA model is used to estimate cost efficiency. Thus, the cost minimization can be specified as:

$$\text{Min}\ \lambda, X_i^* \quad : W_i' X_i^*,$$

$$\text{Subject to} \quad -Y_i + Y\lambda \geq 0,$$

$$X_i^* - X\lambda \geq 0,$$

$$N1'\lambda = 1$$

$$\lambda \geq 0, \qquad (5)$$

W_i is a vector price of input X_i and X_i^* is the cost-minimizing vector of input quantities for i-th farm given input price W_i and output level Y_i. The cost efficiency (CE) of farm is calculated as:

$$CE = W_i' X_i^* / W_i' X_i \qquad (6)$$

Where CE is the ratio of minimum cost to observe cost and allocative efficiency (AE) can be calculated as:

$$AE = CE / TE \qquad (7)$$

The determinants of cost efficiency of smallholders pepper will estimated by using Tobit model. The inefficiency factors (socioeconomic and farm-specific factors) were separately regressed with DEA scores to find out the sources of inefficiency. The Tobit model is developed by James Tobin (1958). In the Tobit model response variable Y bounded between value 0 and 1. The Tobit model only observed the value of Y that greater than zero thus this model also known as censored normal regression model. However, if value of Y is zero or less than zero, Y is not observed or censored. The specification of Tobit model in this study is:

$$E_i = \delta_0 + \delta_1 age + \delta_2\, edu + \delta_3 ext + \delta_4 as + \delta_5 ft + \delta_6 cv + \delta_7\, exp + u_i \qquad (8)$$

E_i is efficiency score for ith farm, age refers to farmer's age, edu is education level, ext is contacts with extension agents per year, as is joining farmer's organization, ft is full-time pepper farmer, cv is attend courses and visit, and exp is farming experience. β is coefficient to be estimated, and u_i's are independently normally distributed N (0, σ^2).

DATA DESCRIPTION

Table 1 represents the summary statistics of the variable used in this study. In pepper farming, not all of pepper vines in a farm will produce pepper berries even though that vines are mature. Some of the pepper vines may damage because attacked by pest and disease, infertile vines, and weather factors (heavy rain or drought). Thus, this study considers only fruiting pepper vines as one of the independent variables. The average fruiting vines are 534 vines with a minimum 100 vines and a maximum 3500 vines. The average pepper yield is 617.58 kg for 534 pepper vines, which means that one pepper vine can produce 1.16kg black pepper. The mean for fertilizer used is 531.82kg, meaning that 1kg of fertilizer for one pepper vine and the mean fertilizer price is RM0.20 per kg. The total herbicide used is 6.79L and the mean herbicide price is RM13.93 per litre. The common pesticides and fungicides used by the farmers are in the forms of liquid and powder. Thus, pesticide and fungicide are measured by cost (RM) in technical efficiency estimation. Meanwhile, price of pesticide and fungicide are obtained from cost per unit, respectively. On average, pesticide and fungicide are RM98.88 and RM305.34 while price for pesticide and fungicide are RM37.71 and RM66.57. Fungicide is the most costly input due to its expensive price compared to other inputs. Pepper farmers in Sarawak prefer family labour compared with hired labour due to the cost constraint. Labour is measured by mandays per year. Assuming pepper farmer or family labour works four hours per day for pepper farm and they work in farm 20 days per month, it means one labour work 80 hours per month. The standard of working hour per day is eight hours, and 80 hours are divided by 8 thus one labour is equal to 10 mandays. This study considers labour who works during a year as a permanent labour thus one labour is equal to 120 mandays per year. On average, farms use 314.513 mandays in the farm. Minimum mandays used among farms is 240 mandays (two persons) and maximum is 840 mandays (seven persons).

There are seven explanatory variables used i.e. education level, contacts with extension agents per year, farmer's organization, full-time pepper farming, joining farming course and study visits, farming experience, and farmers' age. The education level is segregated into five categories albeit, did not obtain any formal education (1), attended adult school (2), attended only Primary School (3), finished Lower Secondary School (4), and manage to attend Upper Secondary School (5) where 91 respondents did not obtain any formal education, 122 respondents attended adult school, 317 respondents attended only Primary School, 118 respondents finished Lower Secondary School, and 30 of the respondents manage to attend Upper Secondary School. The mean education level is 2.81 implying that a majority of farmers attend adult education and primary school. The minimum frequency of contacts with extension agents per year is two times per year while the maximum frequency of nine times per year with a value of four times per year. Majority of farmers represented by 504 farmers join the association. Besides, 562 of 678 farmers focus on pepper cultivation compared to other commercial crops. Only 269 farmers join farming courses and visits. A minimum farming experience is 5 years and a maximum is 50 years with a mean value of 18 years

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farming experience. A minimum age of farmers in the sample is 22 years old while maximum age of farmers is 76 years old, with a mean value of 48 years old.

Table 1. Summary of Statistics of the Variables for Smallholder Pepper in Sarawak

Variables	*Number of farmers*	*Minimum*	*Maximum*	*Mean*	*Standard Deviation*
Output					
Pepper Yield (Kg)	678	150	6925	617.58	623.41
Inputs					
Labour (Mandays)	678	240	840	314.513	113.119
Fruiting vines	678	100	3500	534.03	430.63
Fertilizer (Kg)	678	50	4000	531.82	489.54
Herbicide (Litre)	678	3	32	6.79	4.32
Pesticide cost (RM)	678	10	691.07	98.88	80.48
Fungicide cost (RM)	678	14	2760	305.34	339.51
Input Prices					
Fertilizer (RM)	678	0.20	5.60	2.52	0.55
Herbicide (RM)	678	3.33	50.00	13.93	7.04
Pesticide per unit (RM)	678	10.00	98.40	37.71	15.47
Fungicide per unit (RM)	678	3.50	260.00	66.57	50.01
Explanatory variables					
Education level	678	1	5	2.81	1.02
Contacts with extension	678	2	9	4.12	1.32
Farmer's organization	504	0	1	0.74	0.44
Full-time pepper farming	562	0	1	0.83	0.38
Course and visit	269	0	1	0.4	0.49
Farming experience	678	5	50	17.74	7.77
Farmers' age	678	22	76	47.88	10.95

RESULTS

The scores for technical, allocative, and cost efficiency of smallholders pepper is presented in Table 2.

Table 2. Efficiency Index of Smallholders Pepper

Efficiency index	*TE*	*AE*	*CE*
0.100 - 0.199	0	0	4
0.200 - 0.299	13	6	71
0.300 - 0.399	88	48	189
0.400 - 0.499	167	197	252
0.500 - 0.599	171	181	96
0.600 - 0.699	105	75	35
0.700 - 0.799	56	75	17
0.800 - 0.899	40	60	9
0.900 - 0.999	16	31	4
1.000	22	5	1
Minimum	0.214	0.214	0.193
Maximum	1.000	1.000	1.000
Mean	0.567	0.585	0.438
Standard Deviation	0.170	0.163	0.125

Mean of technical, allocative, and cost efficiency are 0.567, 0.585, and 0.438, respectively. On average, the farmers should reduce are about 34% input utilization at the same production level. Technical efficiency scores range from 0.214 to 1.000. Under technical efficiency, 22 farms are technically efficient. Allocative efficiency scores of farms range from 0.214 to 1.00 with a mean value of 0.585 and only 5 farms are allocative efficient. Thus, allocative efficiency among farms could be improved by 41% through optimal utilization of capital given inputs price at available technology. Cost efficiency among farms range from 0.193 to 1.000, with a mean value of 0.438 and only one farm achieved cost efficiency. The farmers in average cost efficiency scores can achieve most efficient counterpart by realizing a 56% [i.e., 1- (0.438/1.000) x 100] input cost. However, if the most cost inefficient farmers want to achieve standard of most cost efficient farmers, they should reveals 99% [i.e., 1- (0.193/1.000) x 100] of input cost.

The report of input slack for sample farms is represented in Table 3. A slack variable refers excess of an input use and a farm can reduce the expenditure of input by the amount of slack variable, without reducing the production level. Excess in inputs use tend to increase inefficiency in farm operation. However, the excess in labour use is not reported because pepper farmers in this study used family labour thus the cost for labour does not exist. About 5% (35) of farmers have excess in fertilizer use, 31% (211) of farmers excess in herbicide use, 37% (252) of farmers excess in fungicide use, and 31% (212) of farmers have excess in pesticide use. The excess inputs use of herbicide, fungicide, and pesticide are 1.80%, 12.45%, 25.35%, and 14.07% respectively. Farms should reduce these input expenditures by the same percentage.

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Table 3. Input Slacks and Number of farms using excess inputs

Input	*Number of Farmers*	*Mean Slack*	*Mean Input use*	*Excess Input use (%)*
Fertilizer (kg)	35	9.56	531.82	1.80
Herbicide (Litre)	211	0.84	6.78	12.45
Fungicide Cost (RM)	252	77.40	305.34	25.35
Pesticide Cost (RM)	212	13.92	98.88	14.07

The excessive use of herbicide, fungicide, and pesticide indicates farms should reduce the use of these inputs to reduce production cost and gain more profit. Fungicide input experienced high excess in expenditure since fungicide prices are expensive compared to other chemical cost such as pesticide and herbicide. However, fertilizer has a small excess percentage represented by 1.80% which means farms utilize fertilizer better than other inputs because fertilizer is the most important input to increase pepper yield. The results of input slack show that herbicide, fungicide, and pesticide are greatly overutilized.

Table 4: Determinants of Cost Efficiency

Explanatory Variable	*Coefficient*	*Standard Error*	*Probability Value*
Constant	0.258	0.033	0.000*
Education level	0.013	0.005	0.010**
Contacts with extension	0.009	0.003	0.007*
Farmer's organization	0.067	0.011	0.000*
Fulltime pepper farming	0.064	0.012	0.000*
Course and visit	0.048	0.009	0.000*
Farming experience	2.84E-04	0.001	0.678
Farmers' age	-3.87E-04	0.001	-0.445

*, **, *** represents significant at 1%, 5%, and 10%

This study finds that cost efficiency is influenced by socioeconomic and farm-specific factors. The contacts with extension agents per year, joining farmer's organization, full-time pepper farming, and participating in farming courses and study visit are positively and statistically significant at 1%, and education level is positively and significant at 5% with cost efficiency among smallholders pepper. The frequency of contacts with extension agents is able to improve efficiency in pepper farming because farmers improve farm practices based on advice of extension agents. The benefits of joining farmer's association include consultation services; obtain subsidies, and marketing facility. Farmers who cultivate pepper as a main cash crop in the farm are more efficient because they put more effort to the main crop compared with other crops**.** Farming courses and study visits are important to educate farmers on pepper farming especially to beginners in pepper farming. Full-time pepper farming is significant factor in influencing efficiency. Farmers who have education are more efficient than farmers who do not because it is easier for farmers who have education to grasp the farming information, knowledge and skills through reading materials provided to them by the extension agents. However, some of these explanatory variables are not significant with cost efficiency. Farmers' age has a negative relationship with cost efficiency indicated that older farmers are inefficient compared to young farmers but farmers' age does not significantly influence cost inefficiency. Farming experience has positive relationship with farmers' age because older farmers have more farming experience. However, in the case of Sarawak, pepper farming experience does not significantly influence efficiency among farms but this factor has positive relationship with efficiency. Even though the farmers have more farming experience, if they still practice traditional pepper farming skills they are not efficient in farm management especially in input usage.

CONCLUSION

The findings in this study show that pepper farms are inefficient where the mean of technical, allocative, and cost efficiency of pepper farms are low. Farmers are not efficient in input utilization and are not producing pepper yield at minimum input and minimize cost. The inefficiencies are due to misallocation of resources used. However, efficiency in farm management is positively and significantly influenced by education level, the frequency of contacts with extension agents per year, being member of farmer's organization, being full-time pepper farmers, and attending farming courses and study visits. It is imperative that farmers should improve their farm management skills through agronomic education given by extension agents.

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