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Propensity Score Matching to Analyze the Impact of Implementing Good Agricultural Practices on White Pepper Farming in Bangka Belitung Islands Province

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Abstract – White pepper produced by farmers in the Bangka Belitung Islands Province is internationally recognized as a product that is unique in both taste and quality. Thus, in international trade, the geographical indication label of Muntok White Pepper is applied. Efforts to maintain quality and productivity are carried out by applying good agricultural practices. This study aimed to examine the impact of implementing GAP on productivity, selling prices, and income of white pepper farmers in the Bangka Belitung Islands Province. This study used primary cross-section data collected from farmers in the production center of white pepper in the West Bangka Regency, South Bangka Regency, and Central Bangka Regency. The survey was conducted in April-June 2019. A sampling of respondents consisted of 164 farmer respondents who implemented GAP and 82 non-GAP farmers. This study estimated the impact of implementing GAP using the Propensity Score Matching (PSM) technique. The results show that the application of GAP significantly increased productivity, selling prices, and income of white pepper farmers. GAP socialization activity is an essential factor in its application; thus, future GAP socialization activities should be improved and more evenly distributed to all areas of white pepper farming.

Keyword – productivity, income, farming, geographical indication, Muntok White Pepper

I. INTRODUCTION

Pepper is one of the most important types of spices among other spices (King of Spices), both in terms of its role in providing foreign exchange and its distinctive use that cannot be replaced with other herbs. Indonesia is known as one of the main pepper producing countries and has an important role in the world pepper trade. The supply of Indonesian white pepper in world trade is fulfilled from the Bangka Belitung Islands Province, called Muntok White Pepper (Directorate General of Plantations 2013).

The International Pepper Community (IPC) noted that during 2006-2015, Indonesian pepper production ranked second below Vietnam in the world pepper trade. Total white pepper production in the world was 725 000 tons and Indonesia ranked second in the world after Vietnam with a production share of 12 percent or 87 000 tons (IPC 2016). We can see the share of pepper production in the world pepper trade in Figure 1.

Since Vietnam developed pepper intensively, Indonesia's position as highest production of pepper in the world market fell in 2001. This decrease was also caused by weak competitiveness due to the low productivity and quality of national pepper. The tendency of decreasing production and planted area is caused by problems faced by farmers, namely:

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(1) productivity, crop quality and pepper price levels are relatively low, while prices of production facilities are relatively high, (2) high yield losses due to pest attacks and diseases and low efforts to increase product diversification, (3) low farmers' resources and capital, and (4) competition with community tin mining and other commodity business opportunities such as palm oil (Kemala 2007; Yuhono 2007). The Provincial Government of Bangka Belitung and the Ministry of Agriculture have responded to the condition of this pepper. This form of attention was poured through the launching of the Muntok White Pepper revitalization program in Bangka Belitung Province in 2009-2012.

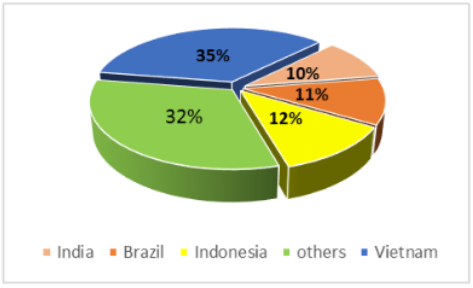

Figure 1. Share of pepper production in the world pepper trade, in 2006-2015

Source : IPC, 2016

In line with this, efforts to meet the demands of the global market for the quantity and quality of white pepper products have been carried out communally by IPC with the assistance of The United Nations Food and Agriculture Organization (FAO) in a project entitled "Smallholder Livelihood Enhancement and Income Generation via Improvement of Pepper Production, Processing, Value adding and Marketing Systems and Enterprise Diversification "in Indonesia, Sri Lanka and Vietnam. The implementation of good agriculture practice for pepper (GAP for pepper) is one of the recommendations of the project which must be promoted to the farmer level (IPC 2011).

One concrete step that has been successfully carried out by the regional government to support the movement of white pepper development and efforts to protect white pepper commodities which are regional assets that have certain characteristics is the Geographical Indication Certificate (GIC) of Muntok White Pepper issued by the Ministry Justice and Human Rights through the Director-General of Intellectual Property Rights on May 27, 2010. The legal basis for Indonesia's Geographical Indications is Law No.15 of 2001 concerning Trademarks as well as Government Regulations No.51 of 2007 article 1 which explains that a geographical indication is a sign that indicates the area of origin of an item, which due to geographical environmental factors including natural factors, human factors, or the combination of these two factors, gives certain characteristics and qualities to the goods produced. The purpose of Geographical Indications (GI) is the protection of products, quality of products, value-added products, and rural development efforts. GI is a component of Intellectual Property Rights (IPR) protecting white pepper as trade commodities that are closely related to the Pacific Islands as a place of origin of goods. To produce good quality Pepper in GI implementation, the pre-production, production, processing, and marketing stages need to meet the standards of ISO 9000, 14000 (food quality and safety system), as well as production and processing applications based on GAP/GFP (Good Agriculture / Farming Practices) with the use of superior seeds, the implementation of environmentally friendly pepper technology, towards organic pepper using uplift, compost fertilizer, and biopesticides.

The implementation of white pepper GAP in the Bangka Belitung Islands Province to date can be said to be still low. Based on data from PMDA in the Province of Bangka Belitung Province, as of the end of 2017, the number of white pepper farmers was 49 427 farmers, of which 30 percent (14 828 farmers) were already incorporated in farmer groups and implementing GAP.

Therefore, this study aimed to examine the impact of implementing GAP on production, farming costs and income of white pepper farming in Bangka Belitung Islands Province.

II. Literature Review

There is a common perspective among stakeholders that GAP is important for realizing the quality standards of internationally traded agricultural products (Wongprawmas et al. 2015; Amekawa 2010). In limited agricultural production inputs, the adoption of GAP has the potential to become a major alternative by encouraging broader inclusion of small scale producers towards the achievement of various social, economic, and environmental benefits (Amekawa 2009).

Many important theoretical reasons underlying that agricultural technology can improve the welfare of farmers, but how can we be sure that adoptive farmers whose welfare is better than non-adopters due to the adoption of these

technologies, need to be explained by certain methods. This study used the Propensity Score Matching (PSM) method, which is an alternative method for estimating the impact of a treatment on a particular subject. PSM has the advantage of being able to correct selection bias and at the same time can also calculate the impact of farmer participation in a treatment (Wainaina et al. 2014; Maertens dan Velde 2017; Ng'ombe et al. 2014)

III. RESEARCH METHOD

This study used primary cross-section data collected based on a list of questions covering the demographic characteristics of farm households, agricultural production, income, and marketing. Data collection was carried out in April-June 2019. The study sites were in three districts, namely the South Bangka Regency, Central Bangka Regency, and West Bangka Regency as centers of white pepper production in the Province of Bangka Belitung Islands. The site was selected intentionally considering the farmers who implement GAP in the area with guidance from the Pepper Marketing Development Agency (PMDA).

To obtain data that represented the application of activity, the approach used in this study was with and without projects (farmers who applied and did not implement GAP) in production centers in the Province of Bangka Belitung Islands. The sampling method was done using a cluster sampling method for GAP farmers, while the sampling for non-GAP farmers was done by the snowball sampling method. The sample of farmer households was 224 respondents, consisting of 142 farmers implementing GAP and 82 non-GAP farmers.

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The analysis procedure using PSM techniques referred to (Baker 2000) and (Caliendo and Kopeinig 2008) with the following stages.

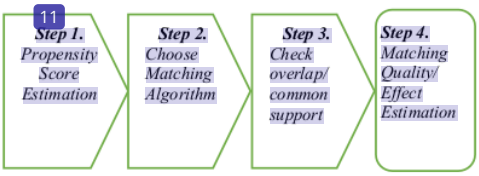

Figure 2. The stages of PSM

First, the model and variables to be used for estimation were determined. In this case, the logit model was used, where farmers' participation in implementing GAP was represented in a binary form with values of 0 and 1. Farmers who implement GAP were given a value of 1 and non-GAP farmers were given a value of 0. The general form of the logit model is written as follows (Hosmer and Lemeshow 2004).

In this study, the factors that were suspected to influence the participation of farmers in the GAP consisted of the age of farmers, formal education of farmers, length of farming experience, number of family members, area of pepper harvested area, distance to market, income outside of pepper farming, and involvement in GAP socialization. Furthermore, logit regression then produced propensity values. The **propensity value** is the probability value if the subject does not receive treatment but in reality, the subject receives the treatment (counterfactual).

Second, a matching algorithm was selected, which was done by matching observations from GAP farmers and control groups (non-GAP) based on their propensity scores using the Nearest Neighbor Matching (NNM) method. NNM is a matching method based on the closest propensity value. This method gives the same weight to each unit by comparing the closest propensity value.

Third, the common support was analyzed, which was done by matching characteristics between GAP farmers and non-GAP farmers by matching propensity values. Individuals whose propensity values were outside the range were excluded from the covariate.

Fourth, the impact of treatment by comparing farm production and income between GAP farmers and non-GAP farmers was calculated with the following equation.

$$P_i = \text{Ln}\frac{P_i}{1-P_i} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots\cdots\cdots\cdots + \beta_i x_i \quad (1)$$

$$ATT = E\{E[Yi|p(Xi); D = 1] - E[Yi|p(Xi); D = 0]|D = 1\} \quad (2)$$

ATT is the average treatment on treated (the impact of GAP), D = 1 is the group of GAP farmers and D = 0 is the group of non-GAP farmers.

IV. RESULT AND DISCUSSION

4.1 Characteristics of farmers

The observations and interviews with respondents resulted in a description of the characteristics of farmers that were seen in the existing management of white pepper

farming, namely production, revenue, and farm income as shown in Table 1.

Table 1. Production, revenue, and income of white pepper farming in 2018

Description	Non-GAP	GAP	Total
Production			
Max (kg/Ha)	2500	4100	4011
Min (kg/Ha)	113	136	113
Average (kg/Ha)	819	1234	1088
Revenue			
Max (Rp (millions)/Ha)	200.0	207.7	207.7
Min (Rp (millions)/Ha)	5.7	6.9	5.7
Average (Rp(millions)/Ha)	42.5	59.9	53.3
Income			
Max (Rp (millions)/Ha)	185.7	194.6	195
Min (Rp (millions)/Ha)	1.9	1.8	1.8
Average (Rp (millions)/Ha)	32.9	47.9	42.2

Source: developed from survey data.

Table 1 shows the differences in the amount of production, revenue and farm income between groups of farmers who implement GAP and who did not. The difference was then proven by the PSM method so that it explained the difference as a result of the implementation of technology in white pepper farming.

4.2 Factors Influencing Farmers to Implement the GAP

The logit model was used to estimate the factors influencing farmers' participation in the GAP. Testing the goodness of the model using the Hosmer-Lemeslow's test obtained the probability value of the chi2 statistical test of 0.6560, which was greater than $\alpha = 0.05$, meaning that the model was fit for use in predictions. The ability of the model to predict correctly was 68.51 percent.

The parameter testing was carried out simultaneously and partially. Simultaneous testing used the likelihood ratio test. The test results obtained by the LR chi2 value of 47.66 with Prob> chi2 of 0.0000, which shows that the independent variables in the model simultaneously influenced the participation of farmers implementing GAP. The partial test was carried out using the Wald test. The results show that the participation of farmers in implementing GAP was influenced by the age of farmers, formal education of farmers, experience of farming, number of family members, area of pepper harvested area, involvement in GAP socialization, and pepper farming income.

Logit regression analysis results show that farmer participation in implementing GAP was higher among farmers who were older, had higher education, had more family members, had larger planting areas and were more active in participating in GAP socialization activities. Whereas the longer experience had the impact of reducing the possibility of implementing GAP. These factors were similar to a study conducted in Zambia, which revealed at least 18 socioeconomic factors that were influential in implementing agriculture-based cultivation conservation (Ng'ombe *et al*. 2014).

Table 2. Factors influencing farmers to implement the GAP

Variable	Coef	S.E	P > | z |		Marginal effect
Farmers' age	0.1792	0.0837	0.032	**	0.0386
Farmers' experience	-0.1942	0.0847	0.022	**	-0.0419
Farmers' formal education	0.0964	0.0579	0.096	*	0.0208
Number of family members	0.3551	0.1681	0.035	**	0.0766
Pepper planting area	0.7438	0.3085	0.016	**	0.1604
Distance to the marker	0.0097	0.0259	0.708		0.0021
Income outside of farming	-0.0063	0.0106	0.552		-0.0013
Involvement in the GAP socialization	7.5409	1.9163	0.000	***	1.6258
Constant	-0.4150	2.1403	0.846		
Pseudo R	0.1620				
Hosmer-Lemeslow's (prob>chi2)	0.6560			LR chi2	47.66
% of correct prediction	68.51%			Prob > chi2	0.0000

*Signifikan at p = 0.10, **Signifikan at p = 0.05, ***Signifikan at p = 0.001

4.3 Impact of GAP Implementation on Production and Income of White Pepper Farmers

In the initial stage, from the results of the logit regression, it was confirmed that the characteristics of GAP and non-GAP farmers were matching by obtaining a propensity score of 224 farmer households consisting of 142 GAP farmers and 82 non-GAP farmers. Propensity scores for GAP farmers ranged from 0.1949 to 0.9807 with an average of 0.6936 while for non-GAP farmers, the propensity score ranged from 0.1312 to 0.9661 with an average of 0.5304. The distribution of propensity scores is shown in Figure 2.

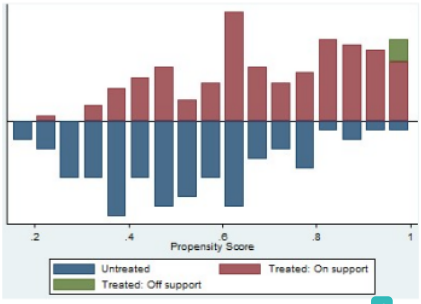

Figure 2. Distribution of GAP ang Non-GAP farmers Propensity Scores

Figure 2 shows that upper half of the graph is the propensity score for GAP farmers, while the lower half is the propensity score for non-GAP farmers.

Then, covariate balancing was done to test the hypothesis that the covariates in both groups have the same distribution after matching. The test results show that there were significant differences before matching on the age variables of farmers, farming experience, farmer education, number of farmers' family members, and involvement in the socialization but after matching there were no more significantly different variables (Table 3).

The results of covariate balancing testing show that the covariates used in matching had the same distribution between GAP and non-GAP farmers. Thus, the calculation of the impact of implementing GAP was not constrained by selection bias. The study then continued to calculate the impact on white pepper farming.

Table 3. Covariate balancing before and after matching

Variable	Sample	Mean		% bias	% reduct bias	t-test	
		GAP	Non GAP			t	p>|t|
Farmers' age	Unmatched	45.317	47.854	-24.9	88.9	-1.87	0.063
	Matched	45.449	45.732	-2.8		-0.23	0.821
Farmers' experience	Unmatched	24.915	28.244	-32.4	66.5	-2.41	0.017
	Matched	25.08	26.196	-10.9		-0.89	0.375
Farmers' education	Unmatched	9.4041	8.3902	34.9	91.4	2.55	0.012
	Matched	9.3478	9.4348	-3.0		-0.23	0.817
Number of family members	Unmatched	3.2465	2.9146	33.9	65.1	2.43	0.016
	Matched	3.2446	3.3406	-11.9		-1.04	0.297
Pepper planting area	Unmatched	0.9630	0.8701	15.8	35.7	1.12	0.263
	Matched	0.9656	1.0254	-10.2		-0.76	0.447
Involvement in GAP socialization	Unmatched	0.19131	0.1087	70.9	75.1	4.83	0.000
	Matched	0.17995	0.2005	-17.6		-1.17	0.243

*Significant at p < 0.10, ** Significant at p < 0.05, *** Significant at p < 0.01

The next stage was removing results that are too high or too low using the analysis of the common support. Based on this analysis, there were three samples in the group of GAP farmers who had a propensity score out of range so that they need to be excluded. Of the 224 samples used, only 220 samples were used to analyze the impact of applying GAP on white pepper farming. The difference between the average GAP group and the non-GAP group reflected the impact of treatment or ATT.

Table 4. Impact of GAP implementation on the production and income of white pepper farmers

Variable	Sample	GAP	non-GAP	Diff.	%	S.E.	t-stat	Sig
Income (Rp (millions) /ha)	Unmatched	39.86	20.13	19.72		4.69	4.20	
	ATT	40.33	25.39	14.93	59	5.14	2.90	**
Production cost (Rp (millions) /ha)	Unmatched	17.77	15.36	2.41		1.05	2.28	
	ATT	17.73	15.06	2.65	17	1.61	1.65	
Productivity (kg/ha)	Unmatched	1167	747	420		100	4.19	
	ATT	1175	857	318	37	118	2.68	**
Pepper selling price (Rp/kg)	Unmatched	49 656	47 508	2 147		272	7.88	
	ATT	49 679	47 566	2 113	4	372	5.68	***

*Significant at p < 0.10, ** Significant at p < 0.05, *** Significant at p < 0.01

Source: Estimated from survey data.

The results show that the implementation of GAP had a significant impact on the income of white pepper farming and its productivity as shown in Table 4. **The income of white pepper farming** was positive and significant at p <0.010, meaning that the implementation of GAP increases farmers' income from white pepper farming. The increase in farmers' income from white pepper farming was estimated to be approximately Rp. 14.9 million/ha, an increase of 59% of the average income of farmers of white pepper. The increased farmers' income is also found in studies conducted by Tufa et al. (2019) and Tran and Goto (2019).

Productivity was positive and significant at p <0.10, meaning that the implementation of GAP increases the productivity of farmers' white pepper farming. The increase of white pepper farming productivity reached 318 kg/ha or an increase of 37% from the average productivity of white pepper farming in the study area. The increased productivity also found in a study conducted in Malawi (Tufa et al. 2019).

The **selling price** of white pepper produced by farmers who implement GAP was positive and significant at p <0.10, meaning that the application of GAP increases the selling price of white pepper. The increase in the price of white pepper was Rp.2 113 / kg or an increase of 4% from the average price of white pepper in the study area. The increase in the price of pepper as a result of the implementation of GAP was related to the quality of white pepper produced. Based on observations in the field, white pepper produced by farmers who implement GAP has better quality, such as more uniform granules size, cleaner from dirt or insects, and it has a moisture content that meets the demand of collecting traders, which is approximately 12%. Up to this point, pepper farmers in the Bangka Belitung Islands Province sell their farms in the form of dry white pepper and they are free to sell to any collecting traders. This study also found that fluctuations in pepper prices would encourage some farmers to save pepper. These farmers tend to wait for stable and profitable prices before they sold white pepper to collectors. However, most of the other farmers can only accept the current price. The difference in the quality of the crop, the limited capital of farming, and the absence of partnerships contribute to this difference. These results are the same as the results of a research conducted by Tran and Goto (2019), which shows that tea farmers in Vietnam who are certified and implement environmentally friendly cultivation have a higher selling price for their products.

V. CONCLUSION

The results show that the implementation of GAP by white pepper farmers significantly increased productivity, selling prices, and income of white pepper farmers. The higher income was driven by increased production and improved quality of white pepper. The implementation of GAP by farmers was influenced by the age of the farmer,

farmer education, farming experience, land area, and the involvement in socialization activities.

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