**Abstract**

Sugar Regulatory Administration (SRA) began to implement Sugarcane Block Farming (SBF) in 2012 to increase farm productivity and sugarcane yield because it is a major crop in the Philippines. SBF is the operational consolidation using multi-purpose cooperatives. To the best of my knowledge, there have been few empirical studies on SBF, and this study is the first econometric analysis of SBF. Our primary purposes are as follows: First, to describe the differences in characteristics between enrollees and dis-enrollees: Second, to estimate average treatment effects on the treated by SBF participation: Third, to determine the relationship of input variables and sugarcane production for enrollees and dis-enrollees. We collected primary data from the household survey of 165 farmers in Province of Batangas, Philippines, in September 2019. The results indicated that differences in gender among farm managers influenced SBF participation. Also, statistically positive, and significant factors affecting sugarcane production are inputs of fertilizer and planted land size for both enrollees and dis-enrollees, and enrollees have some higher input elasticities of sugarcane production than dis-enrollees. We recommend that the government should encourage participation of small-scale farmers to SBF to use optimal inputs for sugarcane production.

Key word: Sugarcane Block Farming (SBF), Smallholder farming, Agrarian policy, Philippines

JEL classification codes: Q12

1. **Introduction**

Sugarcane is one of the major crops for the Philippine agriculture sector since the value of sugarcane production is at 5th in the crops (PSA, 2018). The agriculture sector has a share of 24.3% in the country’s total employment (PSA, 2019). It is an essential sector in the Philippines. The sugarcane sector in the Philippines comprises around 78,276 farmers, and as many as 81.46% of sugarcane farmers have less than 5 ha of farmland, which means most sugarcane farmers are smallholder farmers (Sugar Regulatory Administration (SRA), 2015). In addition to the current situation, gross value added (GVA) of sugarcane declined continuously from 2011 to 2015, except in 2014, when it exhibited a rise of nearly 2 % (Pantoja et al., 2019), and liberalization of sugar trade which SRA launched in 2018 potentially affect local producers negatively (Tobias, 2020). Considering the importance of the sugarcane industry, Sugarcane Industry Roadmap was launched by SRA in 2010, and it aims: to massively increase the use of technologies to increase farm productivity and sugarcane yield; promote bioethanol from sugarcane and molasses (SRA, 2010). As part of this, SRA began to implement Sugarcane Block Farming (SBF) in 2012 (SRA, 2013). The main goal of SBF is to improve the productivity of small-scale sugarcane farmers. Following Sugarcane Industry Roadmap, Sugarcane Roadmap 2020 was released by SRA with the support and guidance of the Department of Agriculture (DA) and Department of Trade and Industry (DTI) in 2015. The objectives of the roadmap are to develop a sustainable and multi-product sugarcane industry which continues to contribute to the national economy (SRA, 2015). At the same time, SBF may also enhance the development of the national economy as well as the performance of the agriculture sector in the Philippines.

SBF is an operational consolidation of small sugarcane farmers with low farm productivities for easier access to support facilities (SRA, 2015). In February 2012, this program was launched in Province of Batangas (SRA, 2010), and around one-third of farmers in the Philippines had enrolled in SBF by 2019. In this program, multi-purpose cooperatives (MPC) have played an essential role. Pantoja et al. (2019) studied that the implementation of SBF improved sugarcane farmers’ productivity in the Philippines, but their approaches are just descriptive rather than econometric methods. Therefore, there is a lack of statistical analysis about associations between SBF participation and sugarcane production for smallholder farmers. In Ghana, block farming was implemented to maize farmers, though it was not for sugarcane farmers. It is a project that provided credit to farmers in term of inputs supply in a form of improved varieties of seeds, fertilizers and technical assistance in order for farmers to earn an appreciable returns and pay for the inputs after the crop season (Julius, 2019). Julius (2019) found that the program has had a moderately positive and significant impact on livelihood of farmers. However, this study is also lack of econometric analysis. Therefore, econometric analysis of block farming in our study would imply to stakeholders significantly.

Agricultural cooperatives contributed to greater technical efficiency (Ma et al., 2018), members’ acquisition of advanced technology (Tianchen et al., 2019), and increasing farm income and productivity (Ortega et al., 2019). Moreover, some researches Some past researches already revealed that inputs of fertilizer and hired labor had influenced the agricultural production (Zulu et al., 2019; Qichen et al., 2020).

Since SBF was launched seven years ago, there have been few empirical studies on the economic performance of SBF. Therefore, it is necessary to determine differences in characteristics of both SBF enrollees and dis-enrollees and evaluate SBF policy for all stakeholders and this is a first econometric analysis of SBF in the Phlippines. This study aims to determine the differences in the characteristics affecting sugarcane production of both enrollees and dis-enrollees in Province of Batangas as well as assess the impact of SBF participation on sugarcane production in the Philippines. To achieve these goals, purpose of our study are as follows:

1. To describe the differences in characteristics between enrollees and dis-enrollees.
2. To estimate average treatment effects on the treated by SBF participation.
3. To determine the relationships between input variables and sugarcane production for enrollees and dis-enrollees.
4. **SBF in the Philippines**

SBF is an operational consolidation of small sugarcane farmers with low farm productivities for easier access to support facilities (SRA, 2015). SRA targets to introduce better and cost-efficient sugarcane farming practices and improve farm productivities of farm enrollees by implementing SBF. Expected results are set as a reduction of cost production (from 1,100 PhP[[1]](#footnote-1) to 900 PhP per kg) and improvement in productivity (from 60 to 75 metric tons per ha) with coaching and guiding farm management (SRA, 2013). Furthermore, requirements for enrollees are that farmers should be legitimate sugarcane farmers, have less than 5 hectares (SRA, 2015) and willingness to be a part of SBF, according to a district officer for SRA Balayan mill district.[[2]](#footnote-2)

In February 2012, SRA launched this program in the Province of Batangas (SRA, 2010), and around 20,000 out of 78,276 sugarcane farmers joined SBF by 2019. Figure 1 shows the flow of SBF in the Philippines comparing to the case in Ghana. Multi-Purpose Cooperatives (MPC) operate SBF as a vital role while in Ghana there is no such organization as MPCs. MPCs manage for enrollees holistically from the purchase of seedlings, fertilizer, and so on to selling to mill after harvesting.

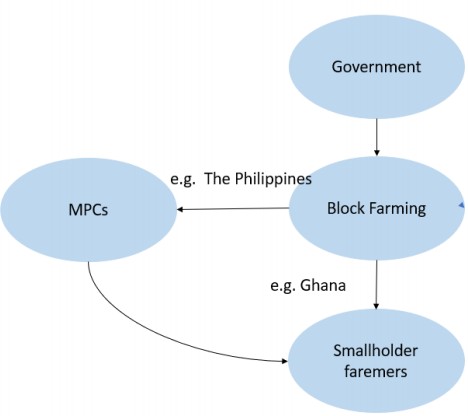


Figure 1 Flow of Sugarcane Block Farming

They collect at least 2,000 PhP share capital and registration fee when sugarcane farmers become enrollees. SRA let MPCs spend their share capital as long as the means are fair to enrollees.[[3]](#footnote-3) They pay the initial costs for enrollees temporarily. Those costs include seedlings, fertilizer, hired labor. After harvesting season, enrollees pay those initial costs back with lower interests than dis-enrollees.[[4]](#footnote-4) To stable income from sugarcane production, there are contracts to keep wholesalers for enrollees (Pantoja et al. 2019).

Table 1 presents the advantages of SBF participation: enrollees can be granted high yield varieties of sugarcane: they have priority in service delivery of sugar mills and government financing institutions: DA assists in providing infrastructure and starter inputs for the diversification of the agricultural production facilities: SRA provides technical assistance and farmers’ training on farm: farm machinery, implements, and equipment will be given to the priority 50 block farms in the form of grant.

Table 1 Advantages of SBF participation

|  |
| --- |
| 1. Granting High Yield Varieties |
| 1. Priority in service delivery of sugar mills and government financing institutions |
| 1. DA assists in providing infrastructure support such as farm-to-mill roads, irrigation and other logistical support in coordination with DAR and SRA |
| 1. DA provides starter inputs for the diversification of the agricultural production facilities |
| 1. SRA provides technical assistance |
| 1. SRA provides farmers’ training on a farm |
| 1. Farm machinery, implements, and equipment will be given to the priority 50 block farms in the form of a grant which they will manage as a business undertaking |
| Source: [Sugarcane Regulatory Authority](#_bookmark27) ([2013](#_bookmark27))), [Sugarcane Regulatory Authority](#_bookmark26) ([2010](#_bookmark26)), [Sugarcane Regulatory Authority](#_bookmark28) ([2015a](#_bookmark28)), and [Pantoja et al.](#_bookmark21) ([2019](#_bookmark21)) |

Due to the limitation of our interviews to respondents, we do not have exact data prior to the program to confirm that the enrollees could have improved their income and yield, but they felt their income increased after participating in SBF. According to SRA, SBF have boosted 29.18% total cane per hectare of block farms in average (SRA, 2015). If we had had access to panel data of the enrollees and dis-enrollees, we could clearly say whether SBF affected the enrollees.

As a qualitative interview, we asked 69 dis-enrollees the reason why they refute to participate in SBF. Twenty-two dis-enrollees said that they liked more to manage their farming on their own than to participate in SBF. 15 dis-enrollees had not known SBF when SBF was implemented. 14 dis-enrollees were not interested in SBF

1. **Data and Econometric Methods**

*Data*

The data used in this study are from a cross-sectional household survey conducted in September 2019 in Province of Batangas, CALABARZON Region, the Philippines. Reasons for selecting this study site are as follows; At first, CALABARZON region was selected in 17 regions in the Philippine because it has the most massive sugarcane production amount in Luzon island that is the largest island and is located nearby Metro Manila which is the most prosperous economic zone in the Philippines. Since CALABARZON has positioned itself as the industrial belt for the country, hosting the highest concentration of manufacturing activity with automotive assemblers predominantly located in Laguna, semiconductors, high-tech industries and electronics in Cavite and Batangas (Oxford Business Group, 2016), SRA might have selected province of Batangas as a pilot place of SBF. Province of Batangas in CARABARZON is also at fourth largest sugarcane production region in the country, shown in Figure 2, as one of the provinces that DAR implemented SBF for trial before regular implementation in 2012. In Province of Batangas, there are several block farms. We conducted a household survey at four-block farms located in three municipalities, Nasugbu, Balayan, and Lian, in Province of Batangas, the Philippines. To determine the differences in characteristics of SBF enrollees and dis-enrollees, we conducted this household survey to sugarcane farmers who do not participate in this program as well as participants in SBF. We interviewed every respondent with four enumerators who worked as translators as well from University of the Philippines Los Baños for four days from 9th September 2019 to 12th September 2019. we used a snowball sampling procedure, which means that we did not collect respondents randomly.

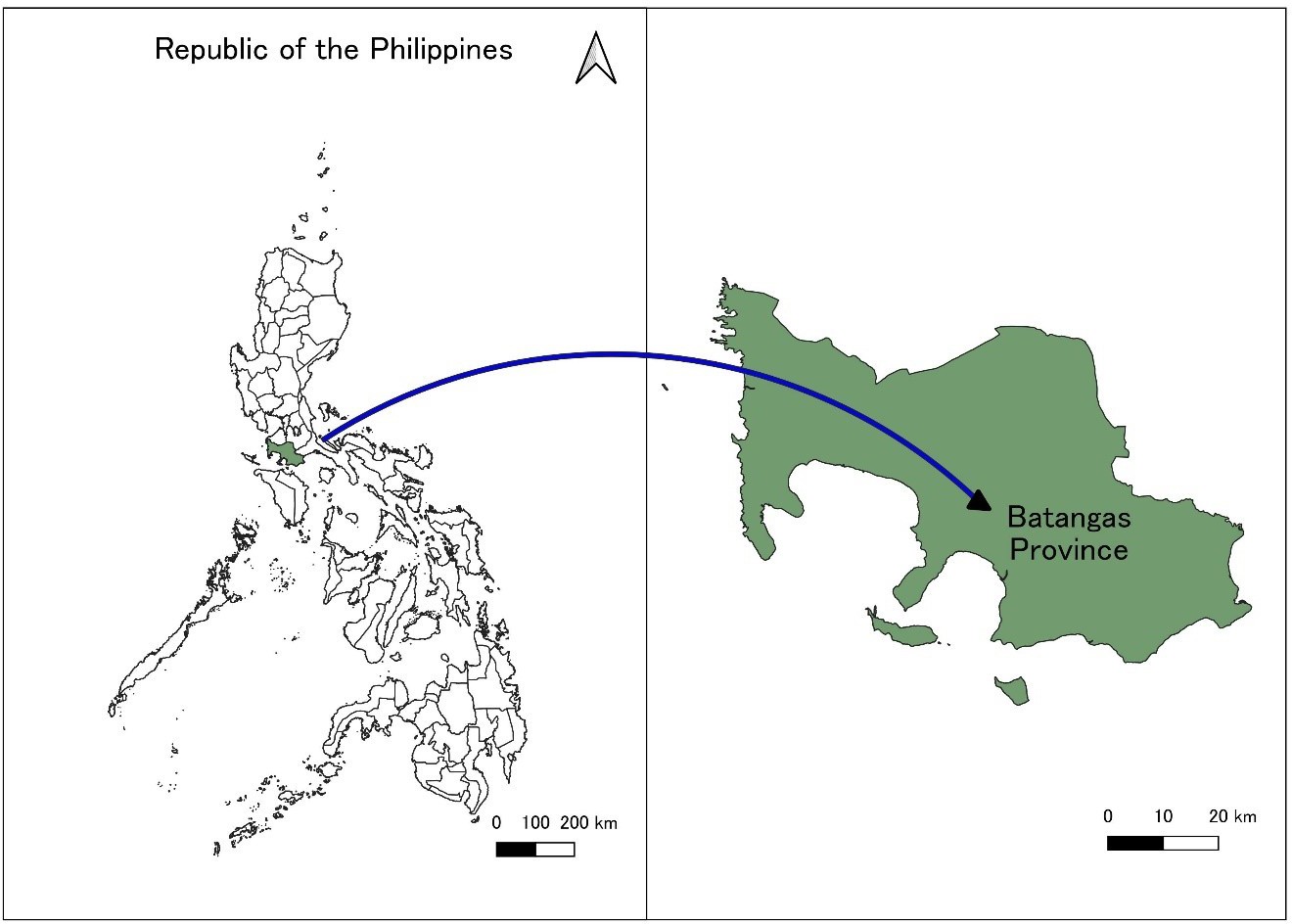


Figure 2 Map of Province of Batangas  
Modified by the Author

Table 2 presents a summary and descriptive statistics of demographic and socio-economic data in this study and the results of t-tests between enrollees and dis-enrollees. Our sample farmers comprised 165 farmers, but one farmer has planted land size of 10 ha, which means that it is not a smallholder farmer. Therefore, we eliminated the farmer from our analysis, resulting in 164 farmers. The survey respondents were primary farm manager (FMs), spouses, and other adults. The dataset presents that enrollees and dis-enrollees are significantly different in terms of some observed variables. FMs of enrollees are significantly better educated, have a higher female ratio, have less farming experience, and more access to the internet. Besides, even though most of the farmers do not introduce irrigation and internet, enrollees have smaller household size but more opportunities to access to irrigation and extension services such as technical assistance than the dis-enrollees. Furthermore, dis-enrollees showed a larger non-farm income ratio. However, the differences in those variables did not present statistical significance. In Table 3, agronomic variables in this study and the mean difference between enrollees and dis-enrollees are presented. Even though there is only one significant difference of agronomic variables between enrollees and dis-enrollees, the unit value of sugarcane of enrollees is higher than dis-enrollees because the cooperatives have contracts with mills endorsed by the government to stabilize the sugarcane price and guarantee enrollees’ income as we mentioned above. The enrollees use more family and hired labor than the dis-enrollees do. However, in terms of the cost of hired labor, the enrollees pay less for hired labor than dis-enrollees do because the cooperatives may call for hired labor such as planters and harvesters with reasonable wages, and they distribute the hired labors to the enrollees.

Table 2 Demographic and Socioeconomic variables and results of t-test

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (1) |  | (2) |  | (3) |  |
| Enr |  | Dis |  | diff |
| mean | sd | mean | sd |  | t-statistics |
| Age of FM | 60.01 | 14.83 | 63.59 | 10.78 | 3.58\* | (1.80) |
| Gender of FM (=1, if Male) | 0.50 | 0.56 | 0.64 | 0.48 | 0.14\* | (1.68) |
| Education level | 3.34 | 2.07 | 2.64 | 1.38 | -0.71\*\*\* | (-2.62) |
| Experience of farming (year) | 36.49 | 18.07 | 40.86 | 17.17 | 4.37 | (1.58) |
| Family size | 4.28 | 2.14 | 4.84 | 1.98 | 0.56\* | (1.71) |
| Irrigation (=1, if yes) | 0.03 | 0.17 | 0.01 | 0.12 | -0.02 | (-0.73) |
| Extension service (=1, if yes) | 0.50 | 0.50 | 0.39 | 0.49 | -0.11 | (-1.39) |
| Using internet (=1, if yes) | 0.17 | 0.37 | 0.07 | 0.26 | -0.09\* | (-1.90) |
| Non-farm income (peso) | 179671.58 | 335979.15 | 149650.09 | 177586.48 | -30021.50 | (-0.74) |
| Farm income ratio | 0.16 | 0.37 | 0.12 | 0.32 | -0.04 | (-0.77) |
| Observations | 96 |  | 69 |  | 165 |  |

Table 3 Agronomic variables and results of t-test

*Methods*

We study differences in characteristics of SBF enrollees and dis-enrollees. However, the SBF participation as the treatment is endogenous, since the farmers self-select into the participation in SBF, which is called sample selection bias (Heckman, 1979). To account for the bias due to all observed variables, we use PSM, which is the technique to match households with similar observable characteristics. A propensity score is a conditional probability of assignment to a particular treatment given a vector of observed variables (Rosenbaum & Rubin, 1983). Propensity scores are presented as follows;

where presents SBF participation, which is a binary variable: is covariate: is a parameter. Thus, the propensity score is estimated using a nonlinear logistic regression from a set of observable variables that are expected to affect the probability and participation. However, as noted in the literature, (Ortega et al. 2019; Liverpool-Tasie 2014; Becker and Ichino 2002), the independent variables used for the propensity score should not be affected by SBF participation. In this study, the propensity scores are based on either respondent’s variables that do not change much over time or characteristics that are not affected by the participation in the SBF due to lack of the household data before the SBF implementation, following Liverpool-Tasie (2014). As a matching method, the nearest neighbor matching method is used in this study and matched enrollees and dis-enrollees, whose difference of the propensity scores are within 0.07.

To diagnose a balance of distributions of independent variables after PSM, standardized mean difference (SMD) is the most commonly used statistic to examine the balance (Zhang et al. 2019). SMD is as follows:

where and are the sample mean for enrollees’ and dis-enrollees’ groups, respectively;

and are sample variance for enrollees’ and dis-enrollees’ groups. If SMD is larger than 0.1, it presents the imbalance.

The causal effect for that individual is the difference in the potential outcome if the treatment is received and the potential outcome if it is not (Stock & Watson, 2015). ATE is used to evaluate the impact of SBF participation on productivity since the expected value of the difference in outcomes between the treatment and control groups is the ATE in the population. (Stock & Watson, 2015). ATE is as follows:

whererepresents the outcome when a smallholder farmer participates in SBF and be the outcome when he/she does not participate in SBF. denotes a treatment indicator, meaning one if a farmer is treated. Average treatment effect on the treated (ATT) is formulated as follows:

ATT is an average over the subpopulation of treated people of treatment effects (Newey, 2007).Random assignment means that whether a person is treated does not depend on their outcomes. The specific statistical assumption that we make is shown in equation (5),

i.e. the mean of the nontreated variable does not depend on treatment status (Newey, 2007)

If we assume a random assignment

Then we find that *ATE =ATT,* since

Before estimating ATT, we execute propensity scores matching to assume random assignment. Therefore, we can simultaneously estimate ATE and ATT of the unit value of sugarcane, sugarcane yield, production value per ha, and production cost per ha among enrollees and dis-enrollees because SBF aims to improve productivity, profitability, and production cost.

To determine differences in factors affecting sugarcane production between enrollees and dis-enrollees, we use the Cobb-Douglas production function. Studying the impact of various factors of agricultural production is to calculate their contribution to agricultural production (Qichen et al., 2020). Therefore, comparing input elasticities of sugarcane production calculated from production functions between the treatment group and the control group reveals the difference in the contribution of inputs on sugarcane production between enrollees and dis-enrollees. The Cobb-Douglas production function can be specified as follows:

The model obtained by logarithm transformation is written as follows:

we add a term to equation (9) for enrollees. Therefore, the estimation models for enrollees and dis-enrollees are presented as follows respectively.

Where we calculated labor as a sum of family labor and hired labor. Then we calculate the equation (10) and (11) for matched enrollees and dis-enrollees, respectively, so that we obtain coefficients of the models of sugarcane production.

1. **Results**

Table 4 presents the estimation results of propensity score in equation (1). The gender of farm managers was correlated with SBF participation. The other variables were not correlated with SBF participation. In Figure 3, the left figure presents the dis-enrollees’ propensity scores, and the right figure presents the enrollees’ propensity scores from the matched pool. Figure 4 presents the histogram of the SBF participation probability among unmatched enrollees and dis-enrollees. Table 5 presents the result of the balance diagnosis. SMDs after matching are smaller than 0.1, respectively excluding planted land size; thus, four out of five variables present balanced matching.

Figure 3 Histogram of propensity scores before matching

Calculated by the author

Figure 4 Histogram of propensity scores after matching

Calculated by the author

Table 5 Balance diagnosis

Table 6 presents the estimated ATT from respondents. After nearest neighbor matching, our analysis found: a gap unit value of sugarcane is 280 PhP per metric ton: yield gap between enrollees and dis-enrollees is negative 5.65 tons per ha: production value gap between enrollees and dis-enrollees is 1,760 PhP per ha: enrollees pay 41,170 PhP per ha as production cost while dis-enrollees pay 41,120 PhP per ha. All differences in unit value, yield, production values, and production costs are not statistically significant because our sample size is small so that that standard errors might have been substantial.

Table 6 Estimation results of ATT

Table 7 presents the results of the Cobb-Douglas production function (10) and (11). For enrollees, estimation results show that the fertilizer application elasticity of sugarcane production is significantly positive; that is, if fertilizer inputs increase by 1%, sugarcane production will increase by 0.330%. Planted land size elasticity of sugarcane production is positive at the 1% level of statistical significance; that is, if planted land size increase by 1%, the sugarcane production will increase by 0.674%. For dis-enrollees, estimation results showed that fertilizer elasticity of sugarcane production and planted land size of elasticity of sugarcane production are statistically significant at the 10% level and 1% level respectively; that is, if fertilizer inputs increase by 1%, the sugarcane production will increase by 0.272 % and if planted land size increases by 1%, the sugarcane production will increase by 0.652%. The fertilizer inputs elasticity of sugarcane production and planted land size elasticity of sugarcane production for both enrollees and dis-enrollees showed positive and significance. Enrollees have higher input elasticities of sugarcane production than enrollees in terms of fertilizer and planted land size. VIF[[5]](#footnote-5) statistics present a degree of multicollinearity. The suggested cutoff of variables is VIF of 10.0, which corresponds to multiple correlations of 0.95 with other independent variables (Hair et al. 2014). All obtained VIFs are below 10.0 so that we do not consider multicollinearity in this analysis.

Table 7 Parameter estimation for the Cobb-Douglas Production Function

1. **Conclusions and policy implications**

The purpose of the study was to describe the differences in characteristics between enrollees and dis-enrollees of Sugarcane Block Farming (SBF), to estimate average treatment effects on the treated by SBF participation, and to determine the input-output relationship for enrollees and dis-enrollees.

In terms of differences in the characteristics of enrollees and dis-enrollees, there are some significant differences in characteristics. Farm managers of enrollees are significantly better educated, have a higher female ratio, have less farming experience, and more access to the internet*.*

We did not establish if SBF participation influences the unit value of sugarcane, sugarcane yield, sugarcane production value per ha, and sugarcane production cost per ha. To do so, we would need to obtain the panel data, and larger sample size then analyzes changes of yield and production value per ha overtime.

Regarding propensity score matching, female FMs are more likely to participate in SBF. From this result, the Philippine government can more often reach out their implementation to dis-enrollees who are female. The results of the production function analysis presented that statistically positive significant factors affecting sugarcane production are inputs of fertilizer and planted land size for both enrollees and dis-enrollees, and enrollees have higher input elasticities of sugarcane production.

The results from the logistic regression indicated that the gender of farm managers have a significant relationship with SBF participation. We recommend that the government should extend SBF implementation and promotion more to dis-enrollees who are female. By doing so, more smallholder sugarcane farmers would participate in SBF. From the result of production function analysis, the fertilizer input is significant for both enrollees and dis-enrollees. Therefore, smallholder farmers use the recommended inputs of fertilizer and planted land size for best sugarcane production by learning at seminars or workshop through SBF so that they would get more sugarcane production and reduce more cost of agricultural inputs.

The data in this study just showed the information in the year 2019 after SBF implementation in 2012 and are not collected randomly. Therefore, the matching estimation might have some bias. Moreover, the sample is made up of 96 enrollees and 69 dis-enrollees. When propensity score matching is executed, approximately 40 enrollees are discarded; furthermore, we intentionally eliminated one dis-enrollee because this farmer was no longer a smallholder farmer. Not all data have been used for assessing the ATT and analyzing the production function. Therefore, if we could have a larger sample size, we could have presented different results from the analysis. We could not exclude heterogeneity including the site traits such as soil fertility, precipitation, and some geographical factors. In the interviews, we failed to collect the reason why enrollees had decided to register them to SBF. Hence, further research may require considering those limitations.

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1. 1 PhP = 0.020 USD (16/Jul/2020) [↑](#footnote-ref-1)
2. Source from the author’s interview [↑](#footnote-ref-2)
3. Source from the author’s interview [↑](#footnote-ref-3)
4. Author’s interview [↑](#footnote-ref-4)
5. , presents a coefficient of determination of the regression equation where is regressed on the other *X*’s (Theil, 1971). [↑](#footnote-ref-5)