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Does Microfinancing improve Farm Productivity? Empirical Evidence on Rice farming in San Francisco, Agusan del Sur, Philippines

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ABSTRACT

Poverty remains to be the highest in agricultural areas in the Philippines. To alleviate this problem, capital empowerment through microfinancing was among the government's program in the rural areas including the municipality of San Francisco, Agusan del Sur. A total of 95 rice farmers with a 10% margin of error were interviewed to draw conclusions on the impact of microfinancing to farm productivity. Econometric modeling was employed. The production data were fitted using five standard production functions namely; (1) neoclassical, (2) neoclassical with interaction, (3) Cobb-Douglas like, (4) Transcendental and the (5) modified transcendental models. Transcendental function best fits the data with Microfinancing significantly improving farm productivity by 39%. Despite this positive impact, only 34% of these farmers were availing from formal institutions and only 18% took advantage during the last cropping. Nonetheless, it is highly recommended to strengthen the microfinance program in the Philippines by offering extension works on the benefit of Microfinancing, offering less stringent application procedure, and ensuring agricultural credits are used on its purpose, thus, improving the plight of the rural farmers.

KEYWORDS: Transcendental function, Ordinary Least Squares Method, Farm Productivity

INTRODUCTION

Poverty remains to be one of the most pressing problems in the Philippines with a population of 88.5 million in 2007. The National Statistical Coordination Board (NSCB) in the year 2006 estimated poverty incidence at 32.9%. In absolute figures, about 27.6 million Filipinos are considered poor. CARAGA is one of the regions in the country which poverty is prevalent. The region remained to be one of the most impoverished regions in the country on national and Mindanao-wide perspective (Caraga, 2010). In the years 1997, 2000 and 2006, the region has the fourth highest poverty incidence level among all regions in the country totaling to 78,804 Filipinos in 2006.

Among the areas greatly affected by poverty incidence in the region is the province of Agusan del Sur. According to NSCB, the population of poor reached more than half of the entire population in 2006. This happened despite the fact that Agusan del Sur is one of Mindanao's major rice producing provinces with 98,832 metric tons as of the second semester of 2009 (BAS 2010). San Francisco, a municipality of Agusan del Sur, is one of the places in Mindanao where industrialization and agriculture are present in an urban-rural community. In fact, it is contributing as much as 12,847.79 metric tons during the second semester of 2009 as reported by the Department of Agriculture-Municipal Office.

To alleviate poverty, one of the solutions made by the government is the creation of microfinance programs in the country. It is a provision of a broad range of financial services such as deposits, loans, payment services, money transfers and insurance to poor and low-income household and microenterprises (ADB, 2009). In particular, agriculture microfinance is a subset of rural finance dedicated to agricultural related activities such as input supply, production, distribution, wholesale, processing and marketing (MCPI, 2010). But do these programs really help alleviate the farmers from poverty? Specifically, do the existing programs of microfinance improve the productivity of rice farmers?

The main objective of the study is to compare the production of agriculture microfinance client and non-client rice farmers in San Francisco, Agusan del Sur. The study contributes to the ongoing research on the effects of microfinance using quantitative methods, specifically the effect of agriculture microfinance using statistical and econometric modeling. It provides useful information on the status of rice farmers with or without the presence of agriculture microfinance. It also contributes to the ongoing study on assessment of formal credit in the Philippines. Moreover, it highlights on the possible link between credit use and increase in income, and eventually reduce incidence of poverty.

The study has only involved data during the 2nd season of harvest of the year 2010. For the purpose of the study, it is only limited on using the major variables namely farm area, labor, seed, fertilizer, crop protection, and irrigation system in assessing the productivity of agriculture microfinance client and non-client rice farmers. Other variables (e.g. years in farming, age, education, etc.) were analyzed using standard statistical techniques.

REVIEW OF LITERATURE

The rise in use of fertilizer, biocides, improved seeds and mechanization, and hike in their prices necessitate access to credit markets for farming sector. This has increased rapidly over the past few decades. Credit also provides the poor with access to financial services to help increase their incomes and productivity (Khandker, 1998). Financial Markets in developing countries are characterized by fragmentations and imperfect market conditions. Mohamed (2003) categorized the market into two forms: formal and informal financial markets. These two forms of financial markets co-exist and operate side by side with one another. The reality of operations of the two forms of market, however, is more complex and the dividing line is not so clearcut. Formal institutions are more adopted to provide its services to the public sector, upper-income households, large-scale enterprises and non-agricultural activities, while the informal financial institutions tend to match their products and services to the characteristics and demand of the predominantly private, low-income, small-scale and rural population of most developing countries.

The Philippine Financial System is composed of the formal and the informal sector. Under the formal sector are the financial institutions governed by the Bangko

Sentral, Insurance Committee, Cooperative Development and the Securities and Exchange Commission. Moreover, under the informal sector are the money lenders, loan sharks, traders, relatives, friends and landlords. The dominant, however, is the banking system.

The government, recognizing the importance of microfinance in poverty reduction and the need to support capacity building of microfinance institutions (MFIs), ranked microfinance as its top priority in the Medium-Term Philippine Development Plan (MTPDP) 2001-2004. Former President Gloria Macapagal-Arroyo has committed a great deal of money and resources to the promotion of microfinance since taking office in 2001. Along those public projects, the Rural Microenterprise Finance Project (RMFP) was implemented from 1997 until the end of 2002, with a total cost of USD $65 million. Microfinance is believed as a tool to bridge this finance gap.

There are already a number of laws passed to support Microfinancing in the Philippines. Among those are the (1) Republic Act (RA) No. 6977, (2) RA No. 8289, (3) Social Reform and Poverty Alleviation Act (RA No. 8425), (4) Agriculture and Fisheries Modernization Act (RA No. 8435), (5) General Banking Act (RA No. 8791), and (6) Barangay Micro Business Enterprises Act (RA No. 9178). Furthermore, EO 558 was issued on August 8, 2006 in line with EO 138 which revived state-administered loan subsidy programs in the Philippines.

With respect to rice production, Villano and Fleming (2004) analyzed the technical efficiency in a rain-fed lowland rice environment in Central Luzon Philippines using Stochastic Frontier Production Function with a Heteroskedastic Error. Jamora, Moya and Dawe (2009) made use of a panel data using a generalized quadratic functional form for a second-order approximation with several yield functions and analyzed thru ordinary least squares (OLS) regression, panel fixed regression and separate OLS regressions for crop years 1996-97, 2001-02 and 2006-07. Pate and Cruz (2007) studied the technical efficiency of Philippine rice-producing regions using the Cobb-Douglas production function. Bordey (2010), made use of pooled ordinary least squares (POLS) and between-farm (BE) estimates with Cobb-Douglas functional form.

METHODOLOGY

San Francisco is centrally located on the eastern part of Agusan del Sur. It is bounded on the North by the capital town of Prosperidad; on the South by the Municipality of Rosario; on the East by Surigao del Sur and on the West by the Municipality of Talacogon. It has a total land area of 39,253 hectares. Based on the review of literature on Microfinancing, shown in Figure 1 is the conceptual framework used as a guide for the study which was adopted from the microfinancing framework of the various lending program of the Philippine government.

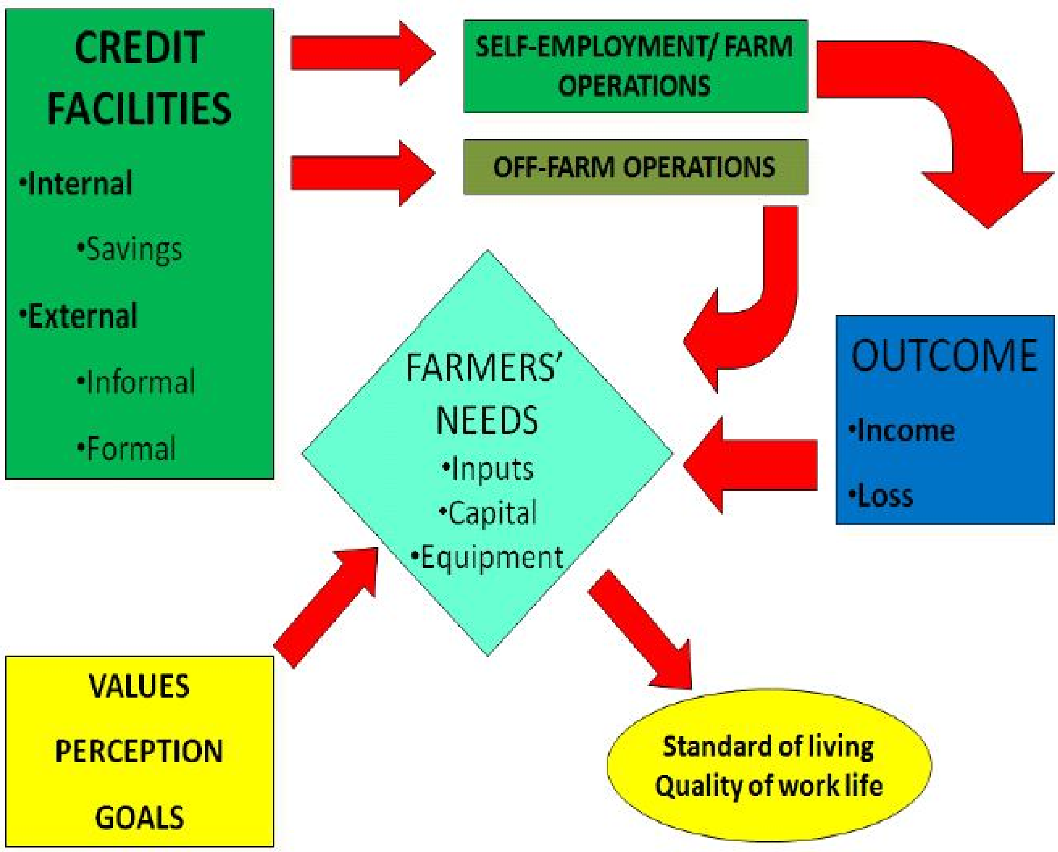

Figure 1. Conceptual Framework.

In this study, the credit facilities are described as channels for financial credit services. This can be availed through internal and external sources. It is internal when an individual uses his own personal equity (i.e. savings). On the other hand, external credit facilities are channels for credit which come from other sources other than the person's own equity (i.e. formal institutions like commercial banks, rural banks, and informal institutions like private moneylenders, neighbor, friend, traders, etc.), which normally charges high interest rates.

The proceeds from the credit channels available will be used for their business purposes. The effect of availing credit systems from the facilities stated above will be reflected on the farm procedures in terms of productivity, efficiency and effectiveness. The farm can also engage not in farm operations. This is characterized by the purchasing power of the farmer to be able to buy things not needed in the farm such as personal needs, family needs, etc.

Farm operations and employment of one will then give outcomes. These outcomes will be measured if these operations and actions incurred losses or gains which was pre-determined depending on how the credit was used in the operations. In defining the farmers' needs, it is necessary to identify the inputs needed in farm operations. It is in this concept where the farmer's requirements will be dependent on the outcome of the borrowed funds from credit facilities. Whether the farmer's operations result to loss or gain in outcome, the inputs, capital and equipment will be affected too.

Furthermore, the framework has not failed to realize that the farmer's needs are influenced by the person's personal values, perception and set goals. This is an important node that will affect the choices of the farmer/borrower. The quality of work life can be described depending on the extent the credit facilities has affected the farm operations of a farm household. The quality of farmers' work life and the standard of living will depend much on the outcome of the farm operations.

The study made use of primary data which was gathered from client and non-client agricultural microfinance rice farmers in San Francisco, Agusan del Sur. It was collected through interviews of the farmers using prepared and pre-tested questionnaire. The list of agriculture microfinance rice farmer client was contrived from the microfinance institutions available in the area while the list of the non-client agriculture microfinance rice farmer was taken from the municipal office of the Department of Agriculture in the study area.

First, the study profiled the client and non-client agriculture microfinance rice farmers using descriptive statistics such as frequency counts, percentage and mean. Using the t-test, the study was able to identify whether results are significant. Furthermore, the study also used an econometric approach.

The study made use of the standard production functions namely the neoclassical, neoclassical with interaction, Cobb-Douglas like, transcendental and modified transcendental production functions. The researcher has carried out tests to determine which model best fits for the data. The chosen model was validated through the F-test and standard tests for multiple regression analysis. Furthermore, the model includes the variables irrigation and seeds as cited from Jamora, Mataia and Dawe (2009), farm area, labor fertilizer, crop protection, and the application of agriculture microfinance in rice farm production. Thus, the model adopted for the study is explained as:

$$Y_i = f(Area, Labor, Seed, Fert, Pes, Herb, Irri, Micro) \quad (1)$$

where:

Y_i = Volume of Production in kg during last cropping

Land = Farm size in hectare

Labor = No. of human labor employed in man-days

Seed = Seed/seedling used in kg

Fert = Fertilizer used in kg

Pes = Pesticide used in kg

Herb = Herbicide used in kga

Irri = 1 if farm is irrigated; 0 if farm is rain fed

Micro = 1 if engaged in agriculture microfinance loan during cropping; 0 otherwise

All other major factors affecting production function of rice farmers contribute positively where the output increases when the inputs increase. It is mainly because all factors suggest are assumed to improve the productivity of producing rice. The OLS estimation was perform through the use of GNU Regression Econometrics and Time-series Library (GRETL) software.

The different production elasticities at means of significant inputs were computed from the generated production function. Furthermore, this measures the responsiveness of output to changes in inputs.

The municipality of San Francisco, Agusan del Sur has a total of 22 barangays. Sampling method was used in the study for gathering data for both client and non-client rice farmers. In order to determine the number of the sample size, the study has adopted the Slovin Formula which is shown in the equation:

$$n = \frac{N}{1 + Ne^2} \qquad (2)$$

where:
n = sample size
N = population
e = margin of error

Using the equation, the derived sample size is 95 respondents from the population of 2,546 rice farmers in San Francisco, Agusan del Sur with 10% margin of error. According to the only microfinance institution in the study area, there are 459 rice farmers who availed agriculture microfinance in their institution. The number of rice farmer clients consists 11% relative to the population of rice farmers in the area. The study interviewed 17 of 95 rice farmers engaging in agriculture microfinance from the barangays of Lapinigan, Pasta, Caimpugan, Barangay 3, Tagapua and Borbon. The sample which are non-agriculture microfinance client came from other barangays namely Alegria, Hubang, Caimpugan, Barangay 1, Barangay 3, Barangay 4, Barangay 5, Bitanagan, Sta. Ana, Ebro, Bayugan 2, New Vizayas, Karaos, Rizal, Tagapua, Borbon, San Isidro, Buenasuerte, Ladgadan and Pasta.

RESULTS AND DISCUSSION

Two main groups or farmers were identified in this study; (1) client farmers which are those who have history of availing Microfinancing specific for agriculture purposes during the previous cropping season, otherwise they are considered (2) the non-client farmers.

Both agriculture microfinance client and non-client rice farmers have almost the same profile. Both client and non-client are males, married, 48 years old, a household size of 5 members, with 23 years in farming, having elementary to secondary education, rice farming as major occupation, who owns his land of about 2.07 hectares devoting 1.85 ha for rice production planting RC 82 variety, facing a daily wage rate of 156 pesos per day hiring 14 man-days per hectare for labor not including family labor, using 58 kg of seed per ha, applying fertilizer at a rate of 135 kg per ha, pesticide at 1.95 kg per ha, herbicide at 1 kg per ha, and insignificant amount of manure at 0.04 kg per ha. Their other source of income includes carpentry, livestock farming, and operating a small retail store in the neighborhood. See Table 1.

Table 1. Comparison of Microfinance Client and Non-client Farmers Inputs and Output.

	Land Area for rice production (ha)	Family Labor (person)	Hired Labor (man-days per ha)	Volume of Seed (kg per ha)	Volume of Fertilizer (kg per ha)	Volume of Pesticide (kg per ha)	Volume of Herbicide (kg per ha)	Volume of Output (kg per ha)
Non-Client	1.85	2	14	59	127	1.98	0.93	1792
Client	1.84	1	14	54	174	1.80	1.32	2849
All	1.85	2	14	58	135	1.95	1.00	1981
t-test	0.98	0.00***	0.65	0.61	0.20	0.73	0.17	0.00***

Table 2. Comparison of Microfinance Client and Non-client Farmers Cost of Inputs, Revenue and Net Profit.

	Cost of Power Thriller (PhP per ha)	Cost of Irrigation (PhP per ha)	Cost of Hired Labor (PhP per ha)	Cost of Seed (PhP per ha)	Cost of Fertilizer (PhP per ha)	Cost of Pesticide (PhP per ha)	Cost of Herbicide (PhP per ha)	Revenue (PhP per ha)	Net Profit (PhP per ha)
Non-Client	2779	262	2121	509	1934	1532	770	25085	15167
Client	1294	576	2245	490	1807	716	693	39880	32039
All	2514	318	2143	506	1912	1386	757	27733	18186
t-test	0.21	0.30	0.65	0.86	0.81	0.01***	0.72	0.04**	0.00***

Similarly direct costs incurred using farm inputs were considered and profitability of rice farming in the area was measured and compared. The net profit was an overestimation, in some sense, since family labor, land rental were not properly accounted by the farmers. They treat these inputs as free of use since it is owned by them. Moreover, interests from Microfinancing was not included in the analysis due to varying, amount, interest rates and period of payment.

Based on Table 1 and 2, there are three possible trigger for high production of client farmers reflecting higher profit; (1) fertilizer use was higher for client farmers at 20% level of significance, (2) herbicide use was higher for client farmers at 17% level of significance, (3) client farmers were spending less on pesticide use at 1% level of significance, and (4) client farmers were investing more on irrigation at 30% level of significance and less on power thriller at 21% level of significance.

The fourth point could be supported with the fact that client farmers owned tractor (52%) and turtle (18%) while for non-client rice farmers, a smaller number of them owned tractor (45%) and turtle (1%). The decision also of the client farmers to invest more on irrigation was due to the pressing problem faced by the rice farmers in the area which is the unavailability of water supply. In fact, most of farmers are using rainfed mechanism for rice production. Other problems identified include drainage facility, pests, farm financing, technological problems, government support and farmroad problems.

The main difference of the two groups with 5% level of significance is their use of family labor where on the average client farmers employed one member of the family as full time rice farmer while the non-client farmers utilized two members of the family, and pesticide cost where client farmers were observed to spend less than non-client farmers. More importantly, the volume of production of the two groups is statistically different; client farmers producing 2849 kg per ha while non-client producing 1792 kg per ha. This is equivalent to increase of 59% in output for client farmers. Thus, reflecting higher income for client farmers valued at Php 32,039 compared to PhP 15167 of non-client farmers significant at 1% level of confidence. This suggests that client farmers are more productive than non-client farmers as shown in Figure 2. Furthermore, client farmers are considered more profitable than non client as shown in Figure 3.

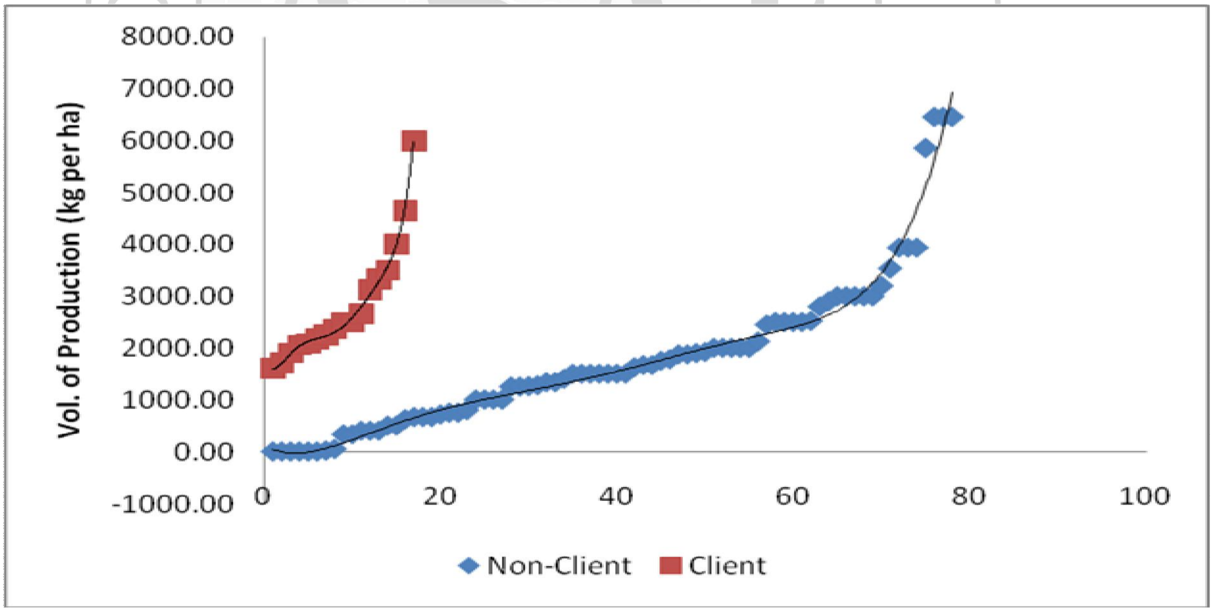

Figure 2. Client farmers are more productive than non-client farmers.

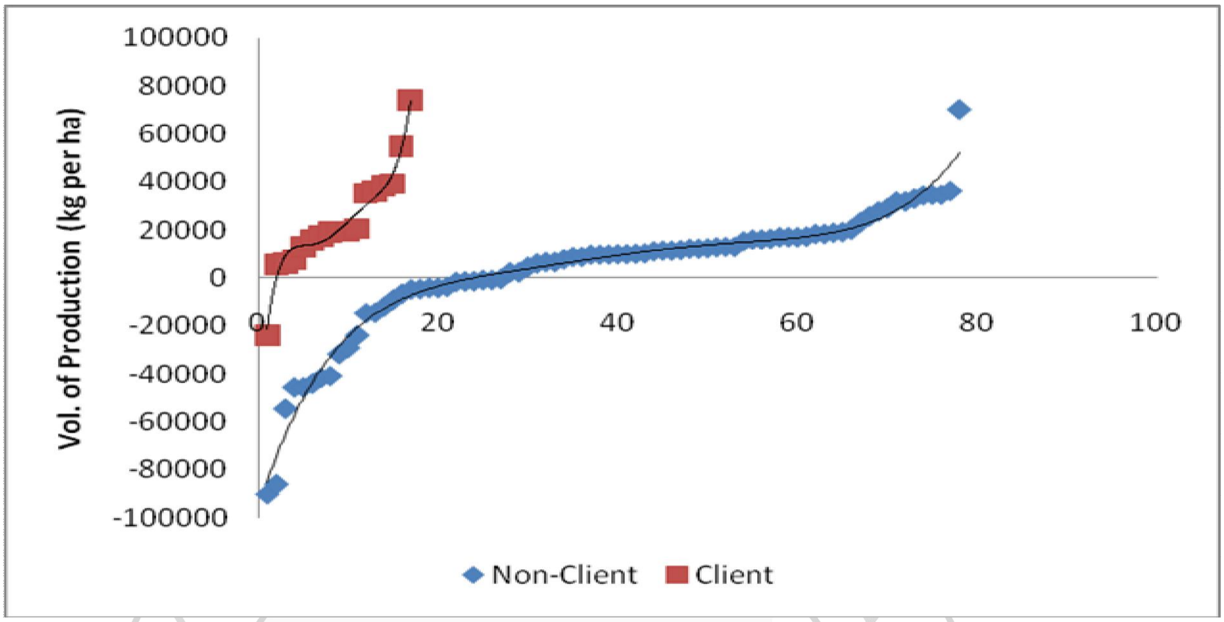

Figure 3. Client farmers are more profitable than non-client farmers.

In order to reach the desired production volume, physical inputs are essential. In the study, the inputs which were considered in econometric modeling are land area, labor, seed, fertilizer and crop protection chemicals which include pesticide and herbicide use. Due to insignificant amount of manure it was no longer considered in the model. The production data were fitted into the five standard production functions such as (1) neoclassical, (2) neoclassical with interaction, (3) Cobb-Douglas like, (4) Transcendental and the (5) modified transcendental functions.

The different production functions used have their own strengths and weaknesses. Some of those shortcomings like the heteroscedasticity of the variance was corrected. Collinearity were no longer tested since the different inputs were assumed to be positively contributing to the production. Similarly, serial correlation is not applicable since cross-section data were used and the ordering of the data is arbitrary. See Table 3 for comparison of production functions while details are reflected in Appendices 1-5.

Table 3. Comparison of Five Standard Production Function Models.

	Neoclassical 2nd degree	Neoclassical 2nd degree with Interaction	Cobb-Douglas like	Transcendental	Transcendental with Interaction
Sample Size	95	95	60	60	60
Significant Variables	Labor*** Fert*** Irri*** Micro*** Herb**	Micro*** Herb*** Irri** Fert** Pest*	const*** Land*** Fert** Herb**	const*** Micro**	const*** Micro**
Adjusted R^2	0.83	0.86	0.69	0.72	0.72
Significance of the model	Yes***	Yes***	Yes***	Yes***	Yes***
Normality Test	No	No	Yes**	Yes***	Yes***
Heteroskedasticity Test	Corrected	Corrected	Yes***	Yes***	Yes***
Ramsey's RESET	No	No	No	Yes**	No

***0.01, **0.05, *0.10

It can be observed in Table 3 that although there were a number of significant variables and there was a high Adjusted R^2 value using the Neo-classical (and with interaction) production function models, these however were not correctly specified as can be seen in Ramsey's RESET. Cobb-Douglas, on the other hand, suffered the same specification problem plus the fact that it had the least Adjusted R^2 value. Comparing against Transcendental with interaction model, the standard Transcendental function was superior with all the assumptions met plus a relatively high Adjusted R^2 though only constant and Microfinancing variable were significant. It can be observed also that Microfinancing was significant to all models except Cobb-Douglas like production function. Thus, it can be concluded that the best production function that best fit the data was the Transcendental function. The model is specified below:

$$\ln \text{Output} = 7.02^{***} + 0.26\ \text{Land} + 0.001\ \text{Labor} + 0.001\ \text{Fert} - 0.002\ \text{Seed} + 0.005\ \text{Pest} + 0.11\ \text{Herb} + 0.12\ \text{Irri} + 0.33\ \text{Micro}^{***}$$

$$+ 0.16 \ln(\text{Land}) - 0.01 \ln(\text{Labor}) - 0.17 \ln(\text{Fert})$$
$$+ 0.22 \ln(\text{Seed}) + 0.08 \ln(\text{Pest}) - 0.14 \ln(\text{Herb})$$

(3)

In original form using the exponential notation (3) can be written as:

$$\text{Output} = \exp(7.02^{***}+0.26\text{Land}+0.001\text{Labor}+0.001\text{Fert}+0.002\text{SSeed}+0.005\text{Pest} +0.11\text{Herb} + 0.12\text{Irri} + 0.33\text{Micro})*\text{Land}^{0.16}\text{Labor}^{-0.01}\text{Fert}^{-0.17}\text{Seed}^{0.22}\text{Pest}^{0.08}\text{Herb}^{-0.14}$$

(4)

Equation (4) implies that client-farmers were producing exp(0.33) = 1.39 times the non-client farmers. Thus, there was an additional 39% increase in output for client farmers. This value was relatively lower by 20% compared to the 59% increase calculated using the average figures in Table 1. It can be concluded that agriculture microfinance improved productivity in the case of rice farming in San Francisco, Agusan del Sur, Philippines.

Although it positively impacts productivity, the prevalence of those availing these services was relatively low. Only 34% of the respondents have availed loans in financial institutions. Only 18% (17 respondents) took advantage during the previous cropping. Majority of the reasons why farmers were not availing was that they perceived Microfinancing as not vital for farm operations (53%) while others were risk-averse (35%) and some 6% complained of high interest rates. In many cases, most of the farmers availed from informal credits (65% for clients and 72% for non-clients). These loans, however, were for emergency purposes, education, and household expenditures. Even Agricultural loans from formal institutions were also used for other purposes.

Thus, there is still a great gap of extending formal microfianance services to the rural farmers, thus, improve productivity of rice in the country. The role of the financial institutions is critical to further economic development especially in depressed areas like San Francisco, Agusan del Sur, Philippines.

SUMMARY, CONCLUSION & RECOMMENDATION

This study attempted to address the question "Does Microfinancing improve farm productivity. Using econometric modeling, the production data on rice farming in San Francisco, Agusan del Sur, Philippines, were fitted in five standard production functions namely (1) neoclassical, (2) neoclassical with interaction, (3) Cobb-Douglas like, (4) Transcendental and the (5) modified transcendental function. Transcendental emerged to be the best model among them. It was empirically shown that microfinancing significantly improves farm productivity by 39%. However, there is still a wide gap existing in the study area since only 18% of the respondents availed of the program during the previous cropping while only 34% have availed Microfinancing in general.

The following are the recommendations arrived in the course of this study:

1. Microfinance institutions and local government units should widely promote and disseminate information on the productivity of adding agriculture microfinance in the production system. Extension works should be delivered.
2. Improve formal microfinance credit services by providing less stringent application procedure. In addition, formal institutions should provide mechanism on how to ensure that agricultural loans are used for farm improvements.
3. Further empirical tests could be performed like the use of technical efficiency. It would be best if time-series analysis is performed.
4. Further studies on microfinancing should be conducted with focus on the proliferation of informal credit providers and its implications to farm profitability.

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APPENDICES

Appendix 1: Heteroskedasticity-corrected Neo-classical second order Model
Using n=95; Dependent Variable: Output

	coefficient	std. error	t-ratio	p-value	
const	-148.914	534.148	-0.2788	0.7811	
Land	210.335	526.538	0.3995	0.6906	
Labor	66.1111	41.1728	1.606	0.1123	
Fert	-2.58117	2.33468	-1.106	0.2722	
Seed	1.41669	9.98366	0.1419	0.8875	
Pest	-284.371	203.467	-1.398	0.1661	
Herb	601.607	305.486	1.969	0.0524	*
sq_Land	308.819	109.682	2.816	0.0061	***
sq_Labor	-0.914860	0.960582	-0.9524	0.3438	
sq_Fert	0.0111194	0.00232980	4.773	8.07e-06	***
sq_Seed	-0.00228208	0.0372324	-0.06129	0.9513	
sq_Pest	45.2571	28.2811	1.600	0.1135	
sq_Herb	-92.9650	46.7067	-1.990	0.0500	**
Irri	909.776	309.697	2.938	0.0043	***
Micro	910.036	332.266	2.739	0.0076	***

Statistics based on the weighted data:

Sum squared resid	194.9303	S.E. of regression	1.560970
R-squared	0.851571	Adjusted R-squared	0.825596
F(14, 80)	32.78420	P-value(F)	2.66e-27
Log-likelihood	-168.9405	Akaike criterion	367.8810
Schwarz criterion	406.1892	Hannan-Quinn	383.3604

Statistics based on the original data:

Mean dependent var	4149.347	S.D. dependent var	5388.498
Sum squared resid	3.87e+08	S.E. of regression	2199.244

Normality Test: Jarque-Bera test = 53.0856, with p-value 2.96895e-012

RESET test for specification (cubes only)
Test statistic: F = 26.509995,
with p-value = P(F(2,78) > 26.51) = 1.64e-009

RESET test for specification (squares and cubes)

Test statistic: F = 24.330919,
with p-value = P(F(1,79) > 24.3309) = 4.41e-006

RESET test for specification (squares only)
Test statistic: F = 16.219971,
with p-value = P(F(1,79) > 16.22) = 0.000129

Appendix 2: Heteroskedasticity-corrected Neo-classical second order with interaction Model

Using n=95; Dependent Variable: Output

	coefficient	std. error	t-ratio	p-value	
const	-269.308	621.072	-0.4336	0.6657	
Land	569.754	651.483	0.8745	0.3845	
Labor	38.8523	44.1922	0.8792	0.3820	
Fert	-1.31417	2.50799	-0.5240	0.6018	
Seed	3.22805	10.7427	0.3005	0.7646	
Pest	-329.098	195.659	-1.682	0.0965	*
Herb	564.320	238.833	2.363	0.0206	**
Irri	651.599	270.945	2.405	0.0185	**
Micro	897.494	256.928	3.493	0.0008	***
Inter	2.33152e-06	3.82412e-06	0.6097	0.5438	
sq_Land	230.770	163.750	1.409	0.1627	
sq_Labor	-0.155199	1.04021	-0.1492	0.8818	
sq_Fert	0.00945346	0.00432979	2.183	0.0320	**
sq_Seed	-0.00868290	0.0386206	-0.2248	0.8227	
sq_Pest	49.5441	26.9624	1.838	0.0699	*
sq_Herb	-119.447	42.2647	-2.826	0.0060	***

Statistics based on the weighted data:

Sum squared resid	165.9699	S.E. of regression	1.449443
R-squared	0.886200	Adjusted R-squared	0.864592
F(15, 79)	41.01338	P-value(F)	5.56e-31
Log-likelihood	-161.3008	Akaike criterion	354.6016
Schwarz criterion	395.4636	Hannan-Quinn	371.1129

Statistics based on the original data:

Mean dependent var	4149.347	S.D. dependent var	5388.498
Sum squared resid	3.70e+08	S.E. of regression	2164.075

Normality Test: Jarque-Bera test = 47.8796, with p-value 4.0094e-011

RESET test for specification (cubes only)
Test statistic: F = 26.092666,
with p-value = P(F(2,77) > 26.0927) = 2.23e-009

RESET test for specification (squares and cubes)
Test statistic: F = 31.844081,
with p-value = P(F(1,78) > 31.8441) = 2.58e-007

RESET test for specification (squares only)
Test statistic: F = 20.581730,
with p-value = P(F(1,78) > 20.5817) = 2.04e-005

Appendix 3: Cobb-Douglas like Model
Using n=60; Dependent Variable: l_Output

	coefficient	std. error	t-ratio	p-value	
const	6.29867	0.906610	6.947	6.59e-09	***
Irri	0.114633	0.147982	0.7746	0.4421	
Micro	0.203903	0.156715	1.301	0.1991	
l_Land	0.677033	0.168567	4.016	0.0002	***
l_Labor	-0.0744385	0.140879	-0.5284	0.5995	
l_Fert	0.290516	0.121643	2.388	0.0207	**
l_Seed	-0.0120420	0.119503	-0.1008	0.9201	
l_Pest	0.0178259	0.123548	0.1443	0.8858	
l_Herb	0.267609	0.127907	2.092	0.0414	**

Mean dependent var	8.278055	S.D. dependent var	0.824276
Sum squared resid	10.74770	S.E. of regression	0.459063
R-squared	0.731887	Adjusted R-squared	0.689830
F(8, 51)	17.40229	P-value(F)	3.74e-12
Log-likelihood	-33.54673	Akaike criterion	85.09347
Schwarz criterion	103.9426	Hannan-Quinn	92.46639

Log-likelihood for Output = -530.23

White's test for heteroskedasticity -
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 45.0793
with p-value = P(Chi-Square(42) > 45.0793) = 0.344397

Normality Test: Jarque-Bera test = 5.30336, with p-value 0.0705327

RESET test for specification (cubes only)
Test statistic: F = 4.323579,
with p-value = P(F(2,49) > 4.32358) = 0.0187

RESET test for specification (squares and cubes)
Test statistic: F = 8.804715,
with p-value = P(F(1,50) > 8.80472) = 0.0046

RESET test for specification (squares only)
Test statistic: F = 8.822698,
with p-value = P(F(1,50) > 8.8227) = 0.00456

Appendix 4: Transcendental Model
Using n=60; Dependent Variable: l_Output

	coefficient	std. error	t-ratio	p-value	
const	7.02116	2.29450	3.060	0.0037	***
Land	0.261565	0.166070	1.575	0.1223	
Labor	0.00113239	0.0246742	0.04589	0.9636	
Fert	0.00103319	0.000661500	1.562	0.1253	
Seed	-0.00180491	0.00381613	-0.4730	0.6385	
Pest	0.00538103	0.0855056	0.06293	0.9501	
Herb	0.105445	0.133798	0.7881	0.4348	
Irri	0.121020	0.158150	0.7652	0.4481	
Micro	0.334545	0.162260	2.062	0.0450	**
l_Land	0.163610	0.390259	0.4192	0.6770	
l_Labor	-0.0130225	0.504176	-0.02583	0.9795	
l_Fert	-0.165184	0.256398	-0.6442	0.5227	
l_Seed	0.219442	0.471568	0.4653	0.6439	
l_Pest	0.0818882	0.290574	0.2818	0.7794	
l_Herb	-0.136899	0.337745	-0.4053	0.6872	

Mean dependent var	8.278055	S.D. dependent var	0.824276
Sum squared resid	8.608996	S.E. of regression	0.437391
R-squared	0.785239	Adjusted R-squared	0.718425
F(14, 45)	11.75254	P-value(F)	9.93e-11
Log-likelihood	-26.89021	Akaike criterion	83.78041
Schwarz criterion	115.1956	Hannan-Quinn	96.06861

Log-likelihood for Output = -523.574

White's test for heteroskedasticity -
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 31.1431
with p-value = P(Chi-Square(26) > 31.1431) = 0.222984

Normality Test: Jarque-Bera test = 2.24916, with p-value 0.324788

RESET test for specification (cubes only)
Test statistic: F = 2.450213,
with p-value = P(F(2,43) > 2.45021) = 0.0982

RESET test for specification (squares and cubes)

Test statistic: F = 1.019897,
with p-value = P(F(1,44) > 1.0199) = 0.318

RESET test for specification (squares only)
Test statistic: F = 1.343325,
with p-value = P(F(1,44) > 1.34332) = 0.253

Appendix 4: Transcendental with Interaction Model
Using n=60; Dependent Variable: l_Output

	coefficient	std. error	t-ratio	p-value	
const	7.23567	2.32755	3.109	0.0033	***
Land	0.364608	0.222159	1.641	0.1079	
Labor	-0.000853287	0.0249740	-0.03417	0.9729	
Fert	0.00146425	0.000904517	1.619	0.1126	
Seed	-0.00158780	0.00385013	-0.4124	0.6820	
Pest	-0.0143124	0.0904332	-0.1583	0.8750	
Herb	0.159937	0.155266	1.030	0.3086	
Irri	0.157272	0.167189	0.9407	0.3520	
Micro	0.340116	0.163371	2.082	0.0432	**
l_Land	-0.0121374	0.465258	-0.02609	0.9793	
l_Labor	0.0280627	0.510385	0.05498	0.9564	
l_Fert	-0.282662	0.307218	-0.9201	0.3626	
l_Seed	0.220616	0.474240	0.4652	0.6441	
l_Pest	0.178255	0.322743	0.5523	0.5835	
l_Herb	-0.232141	0.365654	-0.6349	0.5288	
Inter	-3.48980e-010	4.96157e-010	-0.7034	0.4855	

Mean dependent var	8.278055	S.D. dependent var	0.824276
Sum squared resid	8.513275	S.E. of regression	0.439868
R-squared	0.787627	Adjusted R-squared	0.715227
F(15, 44)	10.87885	P-value(F)	2.80e-10
Log-likelihood	-26.55478	Akaike criterion	85.10955
Schwarz criterion	118.6191	Hannan-Quinn	98.21697

Log-likelihood for Output = -523.238

White's test for heteroskedasticity -
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 29.3683
with p-value = P(Chi-Square(28) > 29.3683) = 0.394029

Normality Test: Jarque-Bera test = 1.56871, with p-value 0.456414
RESET test for specification (cubes only)
Test statistic: F = 3.647188,
with p-value = P(F(2,42) > 3.64719) = 0.0346

RESET test for specification (squares and cubes)
Test statistic: F = 0.144918,
with p-value = P(F(1,43) > 0.144918) = 0.705

RESET test for specification (squares only)
Test statistic: F = 0.355817,
with p-value = P(F(1,43) > 0.355817) = 0.554