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Socioeconomic Impacts of Mining's Social Development and Management Program (SDMP) in Barobo, Surigao Del Sur, Philippines Using a Propensity Score Matching Analysis

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Abstract

This study deals with the analysis of mining impacts on people's socioeconomic conditions in the mining areas of Barobo, Surigao del Sur, Philippines. Propensity score matching (PSM) with nearest neighbor and caliper as matching procedures has been used to eliminate selection bias and endogeneity in the estimation of impacts of mining social development and management program (SDMP) in the said areas. The results show that mining can induce households' economic indicators like accretion of asset acquisition, an increase in food budget, reduced health expenditures, and improved access to health facilities, potable water, and gasoline stations for the locals. These outcomes are deemed relevant to the development of human capital in the concerned areas for the proper management of opportunities brought about by mining SDMP. Based on these findings, future legislations are recommended to account and institutionalize the ways of catalyzing the income effects and the revealed improvement in welfare to manage these mining benefits judiciously with the foresight of sustainable development in Barobo, Surigao del Sur, Philippines.

Keywords— Propensity score matching, Impact analysis; SDMP; Responsible mining

I. INTRODUCTION

Barobo is a coastal municipality situated in the central part of the province of Surigao del Sur. This municipality has a land area of 242.50 square kilometers, which constitutes 4.92% of Surigao del Sur's total area. Its population, as determined by the 2015 Census was 49,730. This number represented 8.04% of the people of Surigao del Sur province or 1.92% of the people of the Caraga region. Based on these statistics, the population density is calculated at 205 inhabitants per square kilometer. Tambis River in Barangay Tambis, Barobo, Surigao del Sur is a catchment basin that receives all the terrestrial runoff from the rush of small-scale gold mining. The Sorex River or Tambis River System in Barobo is an area with numerous small scale mining activities for gold. The Tambis river system is the primary river system in the municipality of Barobo, running through Barangay Tambis, Bahi, Mamis, Javier, and San Jose. It passes the municipality of Tagbina and to Municipality of Hinatuan from where it flows into the Philippines Sea (Fajardo, Magdugo, & Deiparine, 2015).

With regards to responsible mining subsequent for "mining with a conscience" in Caraga Region especially in Surigao del Sur, the socioeconomic struggle is yet in the fight against poverty, since from 2006 to 2012 the poverty incidence is still quite high in Surigao, del Sur (NSCB, 2012). As explained by Downing (2002), the probability of a mining zone to experience high poverty can be elucidated by mining-induced displacement and resettlement (MIDR), which poses significant risks to loss of tangible and intangible assets,

including properties, communities, productive land, income-producing assets, and sources, livelihood, resources, networks and ties, social structures, cultural sites, cultural identity, and general help mechanisms. Downing (2002) asserts that, “significant issue on societal sustainability upsurges as abundant natural deposits omnipresent in areas with relatively low land acquisition costs (in the global market) that are being oppressed with open-cast mining and are suited in regions of high population density with fertile and urban lands, inadequate definitions of land tenure and politically underprivileged and powerless populations – the indigenous peoples.

However, under Philippine mining laws, poverty associated with such conditions is tried to be avoided. The passage of the Philippine Mining Act in 1995 and Executive Order 79 is aimed to ensure that mining would help look after people's welfare in the mining areas. These legislations indicate to address the felt interferences and imminent harm ascending from mining activities in the regions affected economically, environmentally, bio-physically, socially, and even culturally. Along with these statutes, a Social Development and Management Program (SDMP) is required for every mining company to intensify the effort in upholding people's advantages at all costs. Under Section 2 of DENR Administrative Order No. 2000-99 named as Revised Implementing Rules and Regulations of Republic Act No. 7942, otherwise known as the "Philippine Mining Act of 1995," SDMP refers to the comprehensive five-year plan of the Contractor/ Permit Holder/ Lessee authorize to conduct actual mining and milling operations towards the sustained improvement in the expectations for everyday comforts of the host and neighboring communities by making responsible, self-reliant and asset-based communities fit for developing, executing and overseeing community advancement programs, projects, and activities in a way predictable with the standard of individuals empowerment.

Therefore, in the execution of these laws and with the existing observations on the socioeconomic condition of individuals in the mining areas, an analysis is desired to evaluate the impacts of mining activities and the implementation of SDMP under the aegis of the said legislation, specifically on reducing poverty incidence and improving welfare in the progression. This fact is in consonance to the effort of knowing the mechanisms that can genuinely effectuate mining with a sense of accountability. Relative to this, a propensity-score matching (PSM) approach is applied to deal with the analysis using cross-sectional data in Barobo, Surigao del Sur, to come up with reliable estimates on outcomes. PSM is an impact evaluation procedure that rids off endogeneity and selection bias to generate reliable results for sound inference building (Blanchard, 2013).

II. EVALUATION METHOD

Primary data from the 572 households selected through a multi-stage systematic random sampling technique in Barobo, Surigao del Sur, have been used to analyze mining impacts on people's socioeconomic conditions. Seventy-four percent (74%) of the households are selected from the mining areas, which correspond to the study group's treated group. The rest or 26% of the total number of families are chosen from the non-mining areas, representing the untreated group. According to Holland (1986 as cited by Ticci, 2011), the control group would help solve the selection bias and purge the problem of causal inference in PSM estimations since the information from the control or untreated group serves as replacements to the missing counterfactual data for the treatment.

In this study, the treated group is located at five (5) barangays of Barobo, Surigao del Sur; namely, Cambagang, Tambis, Bahi, Javier, and San Jose. These barangays are identified as the mining areas in the municipality. Meanwhile, the non-mining areas are the barangay of Sudlon, Dughan, and Kinayan that represent the untreated group of the study.

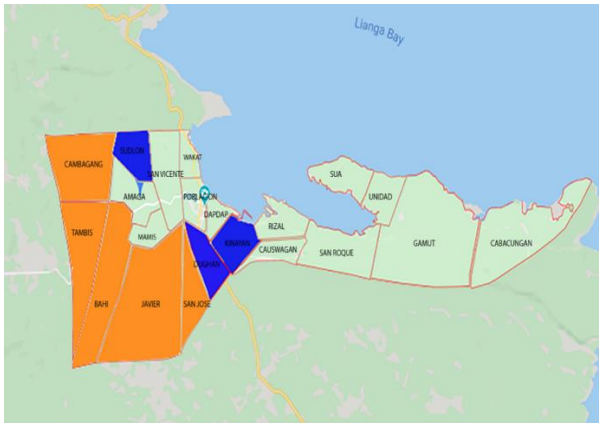

Figure 1. Topographical Map of Barobo, Surigao del Sur

Propensity Score Matching (PSM) works based on the correspondence of propensity scores between the participant and the non-participant or treated and the non-treated to determine the impacts, which is being implicit in the balancing procedure. The program effect will then be observed only from the difference in outcomes between them upon comparison, which in this study relates to mining impacts. Thus, according to Khandker, Koolwal, and Samad (2010), "if no basis for comparison could exist, the households for which no match is found would be dropped." Further clarification of the theoretical background of PSM is provided for scientific inquiry in the book of Khandker *et al*. (2010), published by the World Bank. However, two assumptions must also be remembered in the use of PSM for impact estimation. These assumptions are conditional independence and common support (Khandker *et al*., 2010).

Conditional independence or unconfoundedness requires that the common variables that affect treatment assignment and treatment-specific outcomes be observable. The dependence between treatment assignment and treatment-specific outcomes can be removed by conditioning on these observable variables, which is represented below as Equation 1 (Ticci, 2011):

$$E\left(\frac{Y_i^0}{Z_i, D_i=1}\right) = E\left(\frac{Y_i^0}{Z_i, D_i=0}\right) \qquad [1]$$

The above condition is,

"a strong assumption with no direct testable criterion, which particularly depends on specific features of the program itself. PSM will not become an appropriate estimation method if conditional independence is violated" (Khandker *et al*., 2010).

If this case happens, instrumental variables and double-difference methods can provide options for estimation. The other assumption is the Overlap Condition, also known as Positivity or Common support, in which all units have a non-zero probability of assigned to each treatment condition (Ticci, 2011) or "that treatment observations have comparison observations 'nearby' in the propensity score distribution,' according to Heckman, Lalonde, and Smith (1999 as cited by Khandker *et al*., 2010).

The process of propensity score matching undertakes a progression of the proposed six stages. At each stage, choices must be settled on concerning the decision of covariates, models for generating propensity scores, matching distances and algorithms, the valuation of treatment effects, and analyzing the quality of matches (e.g., Ho, King, & Stuart, 2007; Stuart & Rubin, 2008; Caliendo & Kopeinig, 2008; Steiner, Shadish, Cook & Clark, 2010; and Stuart, 2010). Figure 2 elucidates the typical strides in the propensity score matching procedure. Recommendations in the literature are various and originated from a varied assembly of disciplines, such as economics (Dehejia and Wahba, 2002; Abadie and Imbens, 2006), law (Rubin, 2001), medicine (Christakis and Iwashyna, 2003; Rubin, 2004), political science (Imai, 2005; Bowers and Hansen, 2005; Herron and Wand, 2007), sociology (Diprete and Engelhardt, 2004; Morgan and Harding, 2006), and also in statistics (Rosenbaum, 2002; Rubin, 2006). Further, the analysis of this study was carried out using R software (Sekhon, 2008).

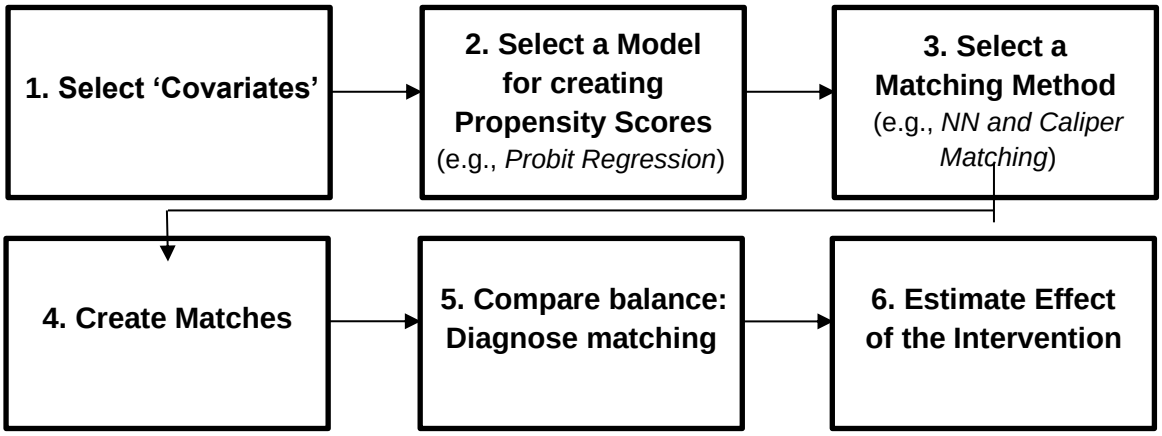

Figure 2. Relevant Procedures in using PSM

In this study, the methods used in matching participants to non-participants are the Nearest Neighbor and Caliper. Nearest neighbor matching is a solution to a matching problem that involves pairing a given point with another, 'closest' point (Khandker *et al*., 2010). Meanwhile, caliper matching is the distance that is acceptable when matching treated and non-treated groups. Applying caliper matching means that those individuals from the comparison group are chosen as a matching partner for a treated individual that lies within the caliper ('propensity range') and is closest in terms of the propensity score. However, when observations fall outside, the caliper would be dropped; thus, more enormous differences will not result in matches (Caliendo & Kopeinig, 2008).

The impacts are estimated through the average treatment effect on the treated (ATT) in this study, which is specified in Equation 2 as:

[2]

$$ATT = E\left(Y_i^1 - Y_i^0 \,/D = 1\right) = E\left(Y_i^1/D = 1\right) - E\left(Y_i^0/\, D = 1\right)$$

where, ATT represents the change caused by mining on an outcome, Y_i^1 the estimation of an outcome value of area i if i is treated (mining district), Y_i^0 the estimation of an outcome value of area i if i is not treated, $D = 1$ the involvement status in case of treatment and $D = 0$ the involvement status of the untreated. Nearest matching for this part sticks to its default setting of having a comparison with the closest neighbor or n=1 in the ATT estimation. In contrast, caliper matching is set at its maximum tolerated difference between matched subjects in a "non-perfect" matching intention at the default setting at a minimum of 0.2 standard deviations. Both matching procedures are performed to check the consistency of findings. Robustness of the results is also looked after through the imposition of common support restriction (Becker and Ichino, 2002, as mentioned by Rejesus *et al*., 2011) and bootstrapping of errors up to 100 draws.

III.RESULTS AND ANALYSIS

The social/demographic profiles shown in Table 1 are intended to imply the characteristics of the population in the area, particularly on the influx of people into the mining areas or the resource-rich areas of Barobo, Surigao del Sur.

Table 1. Definition of Social/Demographic Profiles of the Respondents

Social/ Demographic Profiles	**Definition**
Household Size	Number of household members
Household Type	Type of family structure (1 if nuclear; 2 if extended
Age	Age of the household head regarding the number of years
Sex	Sex of the household head (1 if male; 0 if female)
Years in the	Number of years of the

Community	household head living in the community
Number of working household members	Number of household members that are actively earning income
Number of household members attending school	Number of household members that are currently studying

Moreover, the socioeconomic impacts of mining are evaluated on account of the outcome variables shown in Table 2. These outcome variables are grouped into *access to social infrastructures* and *economic indicators*. The access to social infrastructures is intended to manifest the contribution of mining to improving welfare through enhancing mobility, addressing health and food safety concerns, and facilitating financial intermediation in the mining areas. Meanwhile, the economic indicators are intended to measure the household's economic position with others.

Table 2. Variable Characterization for the Socio-economic Impact Evaluation

Variable Name	Definition
Accessibility of Social Infrastructures	
Access to Health Facilities	The distance of the household to the nearest health facility (e.g., rural health units, clinics, etc.) measured in meters
Access to Paved Roads	The distance of the household to the nearest paved road measured in meters
Access to Potable Water	The distance of the household to the nearest source of potable water measured in meters
Access to Gasoline Station	The distance of the household to the nearest gasoline station measured in meters
Access to Wet Markets	The distance of the household to the nearest wet market measured in meters
Access to Grocery Stores	The distance of the household to the nearest grocery stores measured in meters
Access to Banks	The distance of the household to the nearest bank measured in meters
Economic Indicators	
Asset	Value of anything owned by the household in terms of Philippine peso
Liabilities/Loans	Value of anything owed by the household in terms of Philippine peso
Food Expenditures	Average monthly expenditures of the household on food in Philippine peso
Education Expenditures	Average monthly expenditures of the household on education in Philippine peso
Health Expenditures	Average monthly expenditures of the household on health in Philippine peso
Household Income	Average household income in Philippine peso
Savings per Month	Average household savings in Philippine peso

The estimation of the Propensity Score is presented in Table 3. Using the probit to estimate the propensity score, the only household size variable has a significant coefficient.

Table 3. Estimation of the Propensity Score

Variable	Estimate	Std. Error	z value	Pr(>|z|)
Intercept	-0.130586	0.271131	-0.482	0.6301
Household Size	0.101722	0.047933	2.122	0.0338*
Household Type	-0.011609	0.165332	-0.070	0.9440
Age	0.007137	0.005236	1.363	0.1729
Sex	-0.339488	0.185018	-1.835	0.0665
Years in the Community	0.002629	0.003836	0.685	0.4931
Number of working household members	0.065477	0.090234	0.726	0.4681
Number of household members attending school	-0.105974	0.059705	-1.775	0.0759

The present study shows the impact of Sustainable Management and Development Program (SMDP) of Mining Company on selected accessibility of social infrastructures in Barobo, Surigao del Sur, such as access to health facilities, paved roads, potable water, gasoline station, wet markets, grocery stores, and banks is presaged (Table 4).

Both the nearest neighbor matching and the caliper matching have produced the same results among the accessibility of social infrastructures in terms of health facilities, potable water, and gasoline station. Few of the services provided by mining company under the SMDP are in a position to make significant differences in the accessibility of the locals to their essential needs, including health facilities, potable water, and gasoline stations. The estimated *ATT* values show that SMDP has a significant negative impact on the accessibility of health facilities, clean water, and gasoline station. The result implies the association of services provided by the mining company to more convenient access to the aforementioned social infrastructures. The negatively-signed coefficients for access to health facilities, potable water, and gasoline station in Table 4 indicate the nearness of these facilities to the locals in the mining areas.

However, other factors of accessibility to social infrastructures such as paved roads, wet markets, grocery stores, and banks, were the insignificant impact of SMDP in mining areas of Barobo, Surigao del Sur, Philippines.

The implementation of SMDP has a statistically significant impact on few factors of accessibility to social infrastructures. This result is consistent with the findings of Ferguson (2012), who witnessed that the effect of Mining Companies on the access of locals to their essential needs is significantly evident.

Table 4. Impact of Sustainable Management and Development Program (SMDP) of Mining Company on Accessibility of Social Infrastructures in Barobo, Surigao del Sur, Philippines

Variable	Nearest Neighboring Matching		Caliper Matching	
	ATT	***t***	***ATT***	***t***
Accessibility of Social Infrastructures				
Access to Health Facilities	-1624.51	-8.13***	-1586.15	-8.22***
Access to Paved Roads	6.90	0.21	2.76	0.09
Access to Potable Water	-745.47	-9.94***	-737.52	-10.15***
Access to Gasoline Station	-1803.15	10.28***	-1889.69	10.80***
Access to Wet Markets	113.48	1.47	102.66	1.38
Access to Grocery Stores	1705.87	1.55	1942.23	1.84*
Access to Banks	1705.87	1.55	1942.23	1.84*
*** - significant at 1% level of significance *** - significant at 5% level of significance *** - significant at 10% level of significance				

Impact of Sustainable Management and Development Program (SMDP) of Mining Company in terms of economic indicators is presented in Table 4, which is composed of assets, liabilities/loans, food expenditures, education expenditures, health expenditures, household income, and savings per month.

The result from estimates of Nearest Neighboring Matching and Caliper Matching indicates the implementation of SMDP by the mining company in Barobo, Surigao del Sur have a significant impact on selected economic indicators of the locals, namely; asset, food expenditures, and health expenditures. Both *ATT* values from different matching methods show that SMDP has increased the asset and food expenditures of those locals living in mining areas. The positively-signed *ATT* coefficient on the asset under the nearest neighboring matching means that in mining areas can increase the asset of households by Php 1,139.34 per month. Moreover, the food expenditures of the families can also increase up to Php 1045.39 per month under SMDP in mining areas. However, the negatively-signed *ATT* coefficient on health expenditures under both matching procedures implies the reduced expenses incurred by the households in the mining areas of Barobo, Surigao del Sur.

The implementation of SMDP has a statistically significant impact on few factors of economic indicators among households. This result is consistent with the findings of Reyes (2014), who viewed that the effect of mining companies on the households' economic status is deemed significant.

Table 4. Impact of Sustainable Management and Development Program (SMDP) of Mining Company on Economic Indicators in Barobo, Surigao del Sur, Philippines

Variable	**Nearest Neighboring Matching**		**Caliper Matching**	
	ATT	***t***	***ATT***	***t***
Economic Indicators				
Asset	1139.34	3.90***	1093.36	3.90***
Liabilities/Loans	1149.04	0.21	1497.17	0.29
Food Expenditures	1045.39	4.79***	1036.16	4.96***
Education Expenditures	379.40	1.45	327.84	1.35
Health Expenditures	-436.67	-3.33***	-440.05	-3.45***
Household Income	1879.60	1.32	1509.31	1.13
Savings per Month	1388.55	1.19	1053.19	0.98
*** - significant at 1% level of significance *** - significant at 5% level of significance *** - significant at 10% level of significance				

IV. DISCUSSION

Mining is an activity that needs to be adequately planned and associated with significant impacts on the welfare of the community. It might be a short-term activity but with long-term effects. Thus, the mining industry should design best practices to contribute to its Social Development and Management Program (SDMP) and improve its image in terms of accessibility to social infrastructures and households' economic indicators.

On top of these, it shows that the main significant impacts of the implementation of mining companies in Barobo, Surigao del Sur, is concerning the health facilities and expenditures of the locals. These impacts can be attributed to the form of compliance of the mining company in the said areas under the Social Development and Management Program (SDMP), where they could sponsor or donate health facilities needed in the community. In fact, the mining company regularly provides general health and dental services to its employees and dependents, as well as residents

of surrounding towns and nearby municipalities. Aside from that, the company already provided a 16-bed hospital at the Co-O Mine site and established a clinic at the mill site for employees and residents free of charge.

In addition, the economic aspects of the locals in the mining area have been alleviated, which can be attributed to the programs implemented by the mining company. It provided funds for the Union (Philsaga Employees Labor Union-PTGWO) livelihood programs, in conjunction with the Department of Labor and Employment, such as tailoring and water purifying. It has also funded the construction of a 3-story building to house the sewing, the water purifying station, and commissary to sell goods, items, and food at a low-profit margin. With these works done by the company, it is highly evident that their Social Development and Management Program (SDMP) found in the study to have a significant impact on the welfare of the community.

V. RECOMMENDATION

Mining can mainly make a difference in people's condition through the mining industry's support for the promotion of the community's economic status and the improvement of public access to social infrastructures and services. It means that mining can bring in opportunities for the advancement of human capital to enable civil societies and communities to manage wisely the income effects of mining for sustainable development. However, these findings must be evoked by the fact that the fate of a mining area is everybody's concern, even in responsible mining. Thus, it is vital to nurture the integrity and quality of people who would manage the opportunities brought about by mining for the pursuit of sustainable development. The insights from this study, given the revealed determinants of mining in this context, would have to be taken with utmost consideration especially to other factors found to be insignificant in the study and to be used in reflecting these determinants in future national and local legislation for the identification of strategies to improve mining's programs for the benefits in the resource-rich areas of Barobo, Surigao del Sur, Philippines.

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