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Analysis of mining's socioeconomic impacts with propensity score matching for insights on responsible mining in the Agusan Provinces of Caraga Region, Philippines

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Abstract

This study deals with the analysis of mining impacts on the socioeconomic condition of people in the mining areas of Agusan Provinces in Caraga Region, Philippines. Propensity score matching (PSM) with nearest neighbor and kernel as matching procedures has been used to get rid of selection bias and endogeneity in the estimation of impacts for the socioeconomic underpinnings of responsible mining in the said areas. The results show that mining can induce income effects and improvement in education of children and access to health facilities for the locals. These outcomes are deemed important to the development of human capital in the concerned areas for the proper management of opportunities brought about by mining. 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 judiciously these mining benefits with the foresight of sustainable development in Agusan Provinces and in Caraga Region, Philippines.

Keywords: propensity score matching; impact analysis; endogeneity; selection bias

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1. Introduction

Agusan Provinces are comprised of Agusan del Norte and Agusan del Sur in Caraga Region, Philippines, which constitute a combined area of 1,169,574 hectares or 62% of Caraga Region's land area. These provinces are known for gold mining with seven (7) mineral production sharing agreements (MPSAs)filed and secured in September 2012 for large-scale corporate mining operation, comprising an aggregate area of 14,911.24 hectares (MGB-DENR-Caraga, 2013). The said coverage of gold-associated MPSAs is yet exclusive of the area occupied by small-scale artisanal gold mining, which is rampant in Agusan Del Sur where gold panning activity along rivers is said to be a common sight. Agusan Del Sur is the province contiguous to the province of Compostela Valley, Davao that has been noted as prone to natural hazards such as quakes and typhoons due to highly-active gold mining operations in the area. Compostela Valley often catches the attention of national media in the aftermath of strong typhoons and quakes, since reported damages usually incur villages and people caught in landslides.

In the context of responsible mining pursuing for "mining with a conscience" in Caraga Region particularly in Agusan, the socioeconomic struggle is yet in the fight against poverty, since from 2006 to 2012 Agusan's poverty incidence is still quite high (NSCB, 2012).According to Downing (2002), the likelihood of a mining area to undergo high poverty can be explained by mining-induced displacement and resettlement (MIDR). MIDR is a concept put forth by Downing (2002) to mean the,

> *"risks to societal sustainability as rich mineral deposits are found with relatively low land acquisition costs (in the global market) that are being exploited with open-cast mining and are located in regions of high population density–especially on fertile and urban lands–with poor definitions of land tenure and politically weak and powerless populations, especially the indigenous peoples. The accompanying effect of which is defined with the loss of physical and non-physical assets, including homes, communities, productive land, income-earning assets and sources, subsistence, resources, cultural sites, social structures, networks and ties, cultural identity, and mutual help mechanisms"* (Downing, 2002).

However, under Philippine mining laws, poverty associated with such condition is tried to be avoided. The passage of Philippine Mining Act in 1995 and Executive Order 79 is aimed to ensure that mining would help look after the welfare of people in the mining areas in a holistic way. Both legislations are ideally intended to address the felt disruptions and impending harm arising from mining activities in the affected areas socially, economically, culturally, bio-physically and environmentally. Thus, in the implementation of these laws and with the current observations on the socioeconomic condition of people in the mining areas of Agusan, an analysis is wanted to evaluate the impacts of mining activities under the aegis of the said legislations, specifically in relation to subduing poverty incidence and enhancing welfare in the process. This is in consonance to the effort of knowing the mechanisms that can truly catalyze mining with a conscience. Relative to this, a propensity-score matching (PSM) approach is applied to deal with the analysis using cross-sectional data in Agusan 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).

2. Literature review

Efforts to measure and comprehend the socioeconomic impacts of mining have long been dealt with in a variety of studies. An example is found in the research of Fatah (2007) regarding the impacts of coal mining in the economy and environment of South Kalimantan Province in Indonesia. The said study has used a Social Accounting Matrix (SAM) in the analysis of impacts, in which the coal industry is reported to have produced little value added per unit of output compared to other economic activities, in spite of the growth of the said industry. Further analysis in Fatah's study has favored the regulation of small-scale mining in policy recommendation. Moreover, an inquiry of Gillespie and Kragt (2012) on the non-market impacts of underground coal mining in New South Wales, Australia has exhibited that community wellbeing is adversely affected with the widening areas of mine subsidence. Through choice experiment and benefit-cost analysis, the continuation of mining is shown to be economically-efficient despite of the negative environmental externalities brought about by mining; however only with the imposition of environmental restrictions that are found to be costly in implementation (Gillespie and Kragt, 2012).

Due to concerns on endogeneity and selection bias in impact estimation involving non-experimental studies, this research has considered propensity-score matching (PSM) to determine the impacts of mining on certain socioeconomic outcome variables for the households of Agusan Provinces in Caraga Region, Philippines. According to Khandker, Koolwal and Samad (2010), "PSM constructs a statistical comparison group by modeling the probability of participating in the program on the basis of observed characteristics unaffected by the program." It is said to show "the difference in outcome as attributable to the difference in treatment especially under nonrandomized conditions" (Kaltenbach, 2008) or "estimate the effect of an event on those who do and do not experience it in the observational data (Blanchard, 2013). The following provides the explanation of applying PSM in this study on the basis of endogeneity and selection bias as given by Caliendo and Kopienig (2005), which is as follows:

> *"A problem arises when there is need to know the difference between the participants' outcome with and without treatment. Clearly, both outcomes for the same individual cannot be observed at the same time. Taking the mean outcome of non-participants as an approximation is not advisable, since participants and non-participants usually differ even in the absence of treatment. This problem is known as selection bias and a good example is the case where motivated individuals have a higher probability of entering a training programme and have also a higher probability of finding a job. The matching approach is a possible solution to the selection problem. It originated from the statistical literature and shows a close link to the experimental context. Its basic idea is to find in a large group of non-participants those individuals who are similar to the participants in all relevant pre-treatment characteristics X. That being done,*

> *differences in outcomes of this well selected and thus adequate control group and of participants can be attributed to the programme."*

In PSM, the program treatment effect is calculated through propensity score P(X) based on

> *"All observed covariates X that jointly affect participation and the outcome of interest. The aim of matching that follows in the procedure of PSM is to find the closest comparison group from a sample of nonparticipants to the sample of program participants. The closest comparison group contains the observable characteristics not affected by program participation",* (Khandker, Koolwal and Samad, 2010).

Specific application of PSM in scientific studies is exhibited in the research works of Mensah et al. (2009) about the impact of Ghana's National Health Insurance Scheme; Muehler et al. (2007) about the returns of continuous training in Germany, and Palangkaraya (2013) about the propensities to innovate among Australia's economic sectors and the effects of innovation on Australian exports. In mining, PSM has been tried in the studies of Ticci (2011), Ticci and Escobal (2012) and Palangkaraya (2013). Ticci (2011) has studied in particular the impacts of the extractive industries in the Peruvian Highlands, taking into account the local impacts of mining boom on migration, access to basic services, labor market and occupational distribution across sectors. Paired difference-in-difference (DD) is used with PSM in the estimation procedure with the treated and untreated groups associated with mining and non-mining districts, respectively. Suitable counterfactuals are emphasized in Ticci's (2011) paper to evaluate and attribute properly the estimated impacts from mining and extractive industries.

Ticci and Escobal's (2012) paper has delved into an almost similar concern, as it has investigated the link between the extractive industries and the local development in the Peruvian Highlands. The PSM-DD method has looked into the impacts of the mining industries on access to basic services and housing quality, migration and demographic trends, labor market and occupational distribution, poverty and welfare status, agricultural performance indicators (agricultural price index and agricultural production index), and education and child labor. In that paper, major impacts have been found on demographic trends and occupational distribution, particularly immigration inflows, change in labor sectoral composition and local employment. But no significant impacts have been yielded on the expected outcome indicators, specifically improvement in access to basic services, housing conditions, poverty rate and per capita real expenditure, which the study has considered a "pending chore for the mining industry and the government units of Peru for the welfare implications of mining." Given the similarity with Ticci's studies, this research has banked on the use of PSM to investigate the impacts of mining on the welfare of people in Agusan Provinces in general, so that the socioeconomic underpinnings of responsible mining would be also defined and reinforced. PSM for this study would provide the facility in which impacts of mining would be derived through "balancing observable characteristics and creating groups as similar as possible in terms of confounding variables" (Ticci, 2011).

3. Methodology

Primary data from the 996 households who have been selected through multi-stage systematic random sampling technique in Agusan Provinces have been used in the analysis of mining impacts on the socioeconomic condition of people in the area. Sixty-three percent (63%) of the households are selected from the mining areas, which correspond to the treated group of the study. The rest or 37% of the total number of households are chosen from the non-mining areas, which represent the untreated group. According to Holland (1986 as cited Ticci, 2011), the information from the control or untreated group would help purge the "problem of causal inference" in PSM estimation by serving as replacements to the missing counterfactual data for the treatment. The control group would also help solve selection bias (Holland, 1986 as mentioned by Ticci, 2011).

In determining the impacts, PSM works on the basis of the similarity of propensity scores between the treated and the non-treated or the participant and the non-participant, which is being implied in the balancing procedure. Only the difference in outcomes between them upon comparison would constitute the program effect, which in this study corresponds to mining impacts. Thus, according to Khandker, Koolwal and Samad (2010), "households for which no match is found are dropped because no basis for comparison could exist." Further explanation on the theoretical background of PSM is provided for the purpose of scientific inquiry in the book of Khandker, Koolwal and Samad (2010), which is published by World Bank. However, two assumptions must be also remembered in the use of PSM for impact estimation. These assumptions are the conditional independence and the common support (Khandker et al., 2010).

Conditional independence or unconfoundedness (Rosenbaum and Rubin, 1983 as cited by Ticci, 2011) refers to the independence of potential outcomes to treatment assignments given a set of observable covariates, which is represented below as Equation 1 (Ticci, 2011):

$$E(Y_i^0/Z_i,D_i=1) = E(Y_i^0/Z_i,D_i=0) \qquad (1)$$

The above condition is,

> *"a strong assumption and is not a directly testable criterion – thus, it depends on specific features of the program itself. If unobserved characteristics determine program participation, conditional independence will be violated, and PSM will not become an appropriate estimation method",* (Khandker et al., 2010).

If this case happens, instrumental variables and double difference methods can provide the alternatives for estimation. The other assumption on the use of PSM is overlap or common support condition, which ensures the availability of treated and untreated groups for each covariate to be compared (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).

Prior to the estimation of average treatment impacts, this study has to go through the three steps of PSMuntil the matching part:

- Estimating a model of program participation through probit,
- Defining the region of common support and balancing tests, and
- Matching participants to non-participants through kernel and nearest neighbor.

The explanations for the said steps in PSM are also found in the same book of Khandker et al. (2010) on impact evaluation. Nearest neighbor is one of the most commonly used techniques in matching, “where each unit of treatment is matched to the comparison unit with the closest propensity score. Kernel matching has a non-parametric matching estimator, which utilizes a weighted average of all participants to construct the counterfactual match for each participant” (Khandker et al., 2010).

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

$$ATT = E(Y_i^1 - Y_i^0 / D=1)=E(Y_i^1 / D=1) - E(Y_i^0 / D=1) \quad (2)$$

where, ATT represents the change caused by mining on an outcome, Y_i^1 the estimate of an outcome value of district i if i is treated (mining district), Y_i^0 the estimate of an outcome value of district i if i is not treated, D=1 the participation status in case of treatment and D=0 the participation status of the untreated. Nearest neighbor matching for this part sticks to its default setting of having a comparison with the closest neighbor or n=1 in the ATT estimation; while kernel matching is set at an ideal epanovich bandwidth of 0.06. Both matching procedures are performed to check the consistency of findings. Robustness of the results is also looked after by means of the imposition of common support restriction (Becker and Ichino, 2002 as cited by Rejesus et al., 2011) and bootstrapping of errors up to 100 draws.

4. Results and discussion

The socioeconomic impacts of mining are evaluated on the account of the outcome variables shown in Table 1. These outcome variables are grouped into social/demographic indicators, access to social infrastructures, and economic indicators. The social/demographic indicators are intended to imply about the characteristics of the population in the area, particularly on the influx of people into the mining areas or the resource-rich areas of the Agusan Provinces. 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. However, with the balancing requirement of PSM, many of these factors are dropped from the matching process, because of failure to meet the said requirement. This means that comparison could not be made for these variables, because of failure to identify their suitable counterfactuals. The discarded variables from matching are indicated with an asterisk in Table 1.

Table 1. Definition of Variables for the Socio-economic Impact Evaluation

Variable Name	Definition
m_nm	Location of the household (1 if within mining area; 0 if outside mining area or non-mining)
Social/Demographic Indicators	
Household Size	Number of household members
Age	Age of the household head in terms of number of years
Gender*	Gender of the household head (1 if male; 0 if female)
Years in school	Number of years spent by the household head in formal education
Years in the community*	Number of years of the household in the community
Number of working household members*	Number of household members on active employment
Accessibility of Social Infrastructures	
Access to health facilities	Distance of the household to the nearest health facility (e.g. rural health units, clinics, etc.) measured in meters
Access to potable water*	Distance of the household to the nearest source of potable water measured in meters
Access to paved roads*	Distance of the household to the nearest paved road measured in meters
Access to wet market*	Distance of the household to the nearest wet market measured in meters
Access to banks*	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
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 on medicines and other health-related expenses in Philippine peso
Household income	Average household income in Philippine peso
*indicate the variables that are dropped from the model specification for the estimation of propensity scores based on the balancing property test results	

4.1. Socioeconomic determinants of mining: Probit estimation

Table 2 shows the results of analyzing the determinants of mining with the use of probit, on which mining impacts would be determined through the matching procedures of nearest neighbor and kernel with common support restriction. From the results, population number in mining areas is implied to decrease slightly, since the coefficient of the household size that is a good proxy for population in the analysis is negatively-signed. Young household heads are associated with mining based on the negatively-signed coefficient for age. Easier access to health facilities is associated with mining as well because the negatively-signed coefficient for access to health facilities in Table 2 indicates nearness of these facilities to the locals in the mining areas. Meanwhile, good economic contributions of mining are manifested in the estimation results (coefficients) for food expenditures, education expenses and income. All of them have shown positive association with mining, since their coefficients mean incremental changes or enhancements for these outcome variables as the probability that the area is with mining increases. This means that mining can induce increase in investments for human capital development through improved income streams or capacity to earn better incomes. However, the household heads in the mining areas may not have high educational attainments because of less number of years spent in formal education.

Table 2. Probit Estimates on the Socio-economic Correlates of Mining

Variable	Coefficient	p-Value
Intercept	0.8207015	0.001
Household size	-0.0702406	0.001
Age	-0.0186734	0.000
Access to health facilities	-0.0000213	0.000
Food expenditures	0.0000813	0.012
Education expenses	0.0000136	0.791
Years in formal education	-0.0117357	0.516
Income	0.0000655	0.000
Log likelihood	-549.90082	
Number of observations	996	
LR chi2(7)	213.35	
Prob>chi2	0.0000	
Pseudo R2	0.1625	

4.2. The socioeconomic impacts of mining

The socioeconomic impacts of mining are indicated by the coefficients of the average treatment effects on the treated (ATT) from PSM with the use of nearest neighbor and kernel as matching procedures. Nearest neighbor matching in this analysis is set at its default of n=1, referring only to the closest neighbor. Kernel matching is set at its ideal epanovich bandwidth of 0.06. This is quite a strict procedure for the estimation of mining impacts, which is retained in the study to secure robust results. Table 2 shows the outcome variables where mining has made significant differences on the socioeconomic condition of people in the mining areas of Agusan Provinces. Consistency of findings is observed directly in the outcome variables of education expenses and years in formal education of the household head. The negative coefficients of educational expenses under both matching procedures imply the reduced expenses incurred by the households in the education of children in the mining areas of Agusan Provinces. This can attributed to the form of compliance of the mining companies in the said areas under the Philippine Mining Act of 1995 and EO 79 where they could sponsor the education of children through scholarships or payment of matriculation fees and provision of school supplies. Under the part of SDMP or Social Development and Management Program of the Philippine Mining Act, the mining companies would have to provide adequate leverage to their host communities in support to the promotion of social welfare in the mining areas. For this matter, some of the mining companies especially in the contiguous areas of Agusan Provinces have already made substantial contribution to the promotion of education through provision of school buildings and educational facilities (MGB-DENR-Caraga, 2013).

With respect to the other consistent result on the years in formal education, the coefficients under the two matching procedures imply that the household heads in the mining areas are actually able to earn a bit higher educational attainment, which counters the earlier association with mining in probit estimation as shown in Table 2. With the matching results, a contribution of mining is made clearer that it is able to ramp up the educational attainment of the household heads in the concerned areas. However, due to the differences in matching consideration between the two procedures, the results are noted to be different as well for the outcomes on age, access to health facilities and income. Under the stricter nearest neighbor approach, the outcome of mining on age of the household head has yielded an indication that household heads in mining areas are younger. This finding would have been consistent with kernel, had the coefficient on age under kernel matching been significant. This different result of kernel may have been due to the use of a weighted average of all untreated members as the counterfactual (Khandker, et al). matching results have also showed, among others, a significant but negatively-signed ATT coefficient corresponding to access to health facilities. This indicates that mining has contributed to easier access to such facilities by making them nearer to the households in the mining areas of Agusan Provinces. However, the income effect of mining is indicated in this study with the significance of the positively-signed ATT coefficient on income under kernel matching. It means that in general mining can increase income of households by Php 951 per month or US$21 per month.

Table 3. The Socioeconomic Impacts (ATT) of Mining in Agusan Provinces, Caraga Region, Philippines

VARIABLE	NEAREST NEIGHBOR MATCHING		KERNEL MATCHING	
	ATT	t	ATT	t
Household size	-0.057	-0.160	0.114	0.329
Age	-2.531	-1.731**	-0.662	-0.538
Access to health facilities	-240.762	-0.404	-771.393	-1.888**
Food expenditures	-131.891	-0.752	1.281	0.008
Education expenses	-216.139	-2.044***	-196.932	-1.700**
Years in formal education	0.343	2.913***	0.296	2.261***
Income	308.285	0.466	950.892	1.336*
** *significant at 1% level of confidence **significant at 5% level of confidence *significant at 10% level of confidence				

5. Conclusion and recommendations

Mining has been put in a controversial position for a number of years already in Philippine discourses on social or public welfare, because of the destruction it has caused in the environment that has affected the people residing in areas near to mining tenements. The Philippine legislations had to be reinforced further to address the variety of concerns arising from mining being in the hotbed. In this study, the impacts of mining are being analyzed with utmost consideration on robustness of results to suggest the reinforcements for responsible mining – thus, the use of PSM with nearest and kernel matching procedures in the analysis. The findings of the study show that mining can catalyze socioeconomic development in Agusan Provinces through its associated income effects. These income effects can be used in improving human capital in the said provinces through education, nutrition and/or investment in wellbeing.

Mining can particularly make a difference in the condition of people through the mining industry's support to the promotion of education of children and to the improvement of public access to social infrastructures and services. It means that mining can bring in opportunities for the improvement of human capital to enable civil societies and communities to manage wisely the income effects of mining for sustainable development. However, it must be remembered with these findings that the fate of a mining area is everybody's concern even in the context of responsible mining. Thus, it is important 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 in reflecting these determinants in future national and local legislations for the identification of strategies and options in the management of mining benefits in the resource-rich areas of Agusan Provinces in Caraga Region, Philippines.

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