Mining and Poverty in Papua New Guinea: Case Studies at Ok Tedi and Porgera

Londari Yamarak and Kevin A Parton
School of Management and Marketing and Institute for Land Water and Society, Charles Sturt University

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Abstract

Mining has been a controversial industry in Papua New Guinea (PNG). Its newsworthiness has stemmed from the dramatic environmental and social consequences that have dogged mining development in PNG over the last several decades. Without downplaying the importance of these issues in any way, the focus in the present paper is on the relationship between mining and poverty in two of the country’s largest mining regions – Ok Tedi and Porgera. We use the techniques of logistic regression and propensity score matching to investigate the differences between mining and non-mining villages in these two regions. The results overall suggest that mining does reduce poverty, but when you correct for non-randomness in the data the effects are much smaller than it first appears.

Keywords

mining, poverty, non-random effects, livelihood framework, PNG

Introduction

Mining plays a vital role in the economic development of many countries. Mining provides countries with commodities such as copper, bauxite, iron ore and other precious metals. Mining
also provides economic opportunities and have positive impacts on the economy for many countries around the world. Historically, this has been the case for many parts of the developed world, and if done responsibly, it can be a catalyst for social growth in most developing countries. However, mining remains controversial, as true sustainable development is not only a matter of financial flows. Mining has also been associated with several economic and social problems. As a result, there are questions about the sustainability of the economic outcome of mining. The contribution of mining to sustainable development needs to be considered in terms of economic and technical viability, ecological sustainability and social equity.

The conceptual framework for the study is Scoone’s (1998) Sustainable Livelihood Framework (SLF). It is considered an appropriate method because it is a general framework and it can be used, for example, to distinguish between the extremely different effects of mining proposed by the World Bank and the observations of Ross (2001). According to Pegg (2006), the World Bank considers that extraction of resources is a means to sustainable development and poverty reduction because:

“1) historical analogy where most developed countries today were resource rich; 2) mining can reduce poverty most directly through the creation of jobs which can generate income for workers and their families; 3) mining can generate a substantial amount of revenue for government to use for targeted poverty reduction programs; 4) mining can contribute to economic growth; 5) mining can indirectly lead to poverty reduction through technology transfers; 6) mining investment in infrastructure contributes to economic development; and 7) mining companies can lead to businesses downstream processing” (pp.378-382).

However, empirical evidence has shown that, in fact, mining can accelerate poverty and thus impact negatively upon the livelihoods of the people. An empirical study by Ross (2001) found that “mineral-dependent states have significantly higher levels of inequality than other states with similar incomes: the more that states rely on mineral exports, the smaller the share of income that accrues to the poorest twenty percent of the population’’(p. 12). The capital-intensive nature of many mining projects also means that they fail to provide “jobs that are accessible to the poor, who are generally unskilled or semi-skilled’’ (Ross, 2001, p. 9). Hence there are arguments in favour of and against the World Bank’s view of extraction of resources as a means of sustainable development. It becomes an empirical question to assess whether mining has led to poverty reduction in the case of PNG. In this context, it was the objective of
the study to investigate two mining locations in Papua New Guinea (PNG), Ok Tedi and Porgera, and assess the impact on mining on poverty.

Theory and the Mining Context in PNG

The literature has attempted to define poverty in many ways (Alkire et al., 2015). In this paper we focus on the Sustainability Livelihood Framework (SLF) developed by Scoones (1998). This is central to explaining the relationship between the people and their livelihoods, and is therefore pivotal in understanding the conceptual and methodological issues in sustaining rural livelihoods and avoiding poverty. “The concept of sustainable rural livelihoods is increasingly central to the debate about rural development, poverty, education and environmental management” (Scoones, 1998, p. 1). The key question to ask in any analysis of sustainable livelihoods is: “Given a particular context, what combination of livelihood resources result in the ability to follow what combination of livelihood strategies? Of particular interest in this framework are the institutional processes which mediate the ability to carry out such strategies and achieve (or not) such outcomes” (p.3).

Ashley and Carney (1999) define sustainable livelihood as a way of thinking about development’s objectives, scope and priorities in order to enhance poverty elimination. Its main objective is for the marginalised and the poor to realise a sustainable improvement against the indicators of poverty. While different organisations applying the SLF adopt their own tailored definitions, it is common practice to draw on the work of Chambers and Conway (1992). They define a livelihood as comprising the capabilities, assets (including both material and social resources) and activities required for a means for living. A livelihood is sustainable when it can cope with and recover from the stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base. The framework can be applied to a range of different scales and in different situations from a community, society, individual households or a region, or even within a country, with sustainable outcomes assessed at different levels and with different livelihood approaches. The SLF “serves as an instrument for the investigation of poor people’s livelihoods, whilst visualising the main factors of influence” (Kollmair & Gamper, 2002, p. 4). The focus is on poverty reduction interventions for empowering the poor to build on their opportunities.

Hence, a livelihood approach is primarily a conceptual framework at micro-, intermediate and macro-levels, analysing the relationship between poverty and people’s access to resources and
their diverse livelihood activities (Hussein, 2002). Over time, the concept of livelihood was defined as having adequate stocks, food and cash to meet basic needs, or more simply to have access to the means of gaining a living. In this way, the methodological and conceptual bases for the livelihood approach come from studies of rural poverty, based on the definition of Chambers (1989). This is summarised by Adjei (2007) as low-income groups or households aiming at sustainable livelihoods through countering vulnerability in the face of risk and insecurity, using both tangible and intangible assets.

The SLF as shown in Figure 1 is useful for analysis in research and applied development organisations because it has a number of the basic elements mentioned above. These elements are important because they incorporate all major aspects of a sustainable livelihood. They are made up of combinations of livelihood resources (the capitals) and livelihood strategies with their predicted outcomes. These predicted outcomes are achieved through applying a number of strategies and thus the framework mediates this application. The important element of the framework is that it recognises all the players it represents. It values the people as actors, with or without assets and/or capabilities, whether poor or not, in pursuit of their livelihood goals (Adato & Meinzen-Dick, 2002). For example, in the context of mining, some farming lands maybe lost as a mine is developed. Without additional resources the displaced farmers could be impoverished. However, a sustainable outcome could be achieved for these farmers. It could involve giving them financial compensation and training programs so that some can be employed in the mining industry, while others can farm more intensively producing fruit and vegetables to be sold in the expanded local markets.
Clearly mining directly affects the sustainable livelihood resources, the asset base upon which people build their livelihoods. It affects livelihood choices and livelihood outcomes; and its institutional processes and its structures are affected directly. Applying the SLF, this study explores the extent to which the development of mining in two regions of PNG has impacted on local people’s livelihoods in the context of the four linkages between mining and poverty reduction promulgated in theory and shown in Figure 2.
In the analysis of poverty, it is essential to understand the relationships between economic transformation, institutional change, and livelihoods in given rural spaces. The target is to connect economic growth with institutional arrangements and ensure that the rural poor are able to participate in the growth process. However, this relationship has received less attention in the mining communities. The limited engagement of communities with mining investors and the government can result in thus unsustainable livelihood outcomes (Johnson, 2012). In particular, this framework suggests that poverty can be understood as a result of particular forms of economic development being present. Alternatively, security and the integrity of the livelihoods and the ability of the population in a given territory to control what it views as its own resources can be considered as aspects of sustainability. In this context, the extent to which the communities in the mining areas can mobilise their resources depends greatly on the relative power and property rights of economic actors (especially the mining companies). That relative power is determined by the state agencies and to a great extent, relative strength or weakness of the communities themselves. This relative power relationship can determine the end result.

Baxter (2001) considered that for the mining benefits in PNG to have a positive impact on the communities, the government must provide a greater willingness to support its people. Johnson (2012) further stated that the communities are supposed to be the ultimate beneficiaries of

**Figure 2: Mining-Poverty Reduction Linkages**

(Source: Adapted from Weber-Fahr et al. (2002, p. 447))
PNG’s mining and mineral wealth. However, the legal and payments system is complex, opaque, and one-sided. He further stated that “the national government lacks a credible, concise, and explicit program to detail its payments from and to stakeholders and track how stakeholders under its control operate” (Johnson, 2012, p. 11). Under such mining conditions, there can be catastrophic impacts of mining, thus adding to poverty. Moreover, the severity of the impact depends on whether the individual is directly or indirectly affected by the mining and how community households react. The combined effect of the mining investment and the adapting strategies of individual households could lead to severe detrimental outcomes for the overall community. By exploring the relationships between the Mining Poverty Reduction Linkages Framework (see Figure 2) and the SLF, the objective was to identify the type of linkages that would reduce poverty and provide a sustainable livelihood for the affected communities.

Across the developing world, mining represents a significant livelihood and source of income for rural communities and their poverty-affected population (Adjei, 2007; Weber-Fahr et al., 2002). However, mining can also be a threat to sustainable livelihoods through its systemic impact, if best practices proposed by the World Bank (Pegg, 2006) are not considered. The impacts of mining do not merely affect certain SLF components leaving others unaffected. The impact of mining on livelihoods is not only cross-sectoral, but more importantly systemic. In realising that, studying the impacts of mining on the SLF can help in identifying ways to help the marginalised and the poor in the affected mining communities. Such analysis places the disadvantaged, the marginalised and the poor at the centre of development.

According to Weber-Fahr et al. (2002) poverty either develops or is reduced in four linked domains shown in Figure 2: (1) economic opportunities, (2) improved capabilities, (3) enhanced security of the poor, and (4) empowerment of rural people.

Considering first economic opportunities, according to the World Bank, in PNG, mining is ‘critical’, contributing between 15 and 50 percent of all exports (Weber-Fahr, 2002). There were 22 countries with this level of mining exports had an average annual GDP per capita growth rate of -1.1 percent between 1990 and 1999 (Weber-Fahr, 2002). This would mean poverty exacerbation rather than poverty reduction for countries that depend on mining like PNG. So, it is necessary to look more closely at such economies.
Economic opportunities can be presented to both the state and the rural poor. Mining can bring economic opportunities such as the fiscal income generated through taxes collected from the mining operation. The revenue collected can be invested in improving the livelihoods of the people. The funds can be used to improve schools, hospitals, infrastructure development and other development projects. These funds can be spent on welfare and poverty reduction interventions (Weber-Fahr et al., 2002). For some countries, the mining sector contributes substantial amounts of revenue. According to Callan (2013, p.3), “the largest contribution to national development by the big four mining companies in PNG was taxes and other statutory payments paid to the national government, K1,568.4 million. This represents an average of 17.2 percent of the PNG government’s total revenue and grants over the period”.

Mining can also impact significantly and positively by increasing the capabilities of the poor as a group in the mining region (Weber-Fahr et al., 2002). Employment is one of the great promises of resources development for the local region. However, this contribution has been questioned because of the capital-intensive nature of mining, so that the employment created is less than what was predicted. The data available on mining regions suggests that the revenue generated by the mining companies is substantial in comparison with the number of jobs created. For example, in Mali, Sadiola Gold Mining is estimated to have created one mining job for every US$700,000 invested, while Randgold mine directly created 127 jobs, or one job for every US$1.123 million invested (Pegg, 2006).

In terms of the second area in Figure 2, improved capabilities of the poor, in the medium and long term, training provided for miners and other skilled employees is likely to have positive spill-over effects on the surrounding workforce and the community (Weber-Fahr et al., 2002). Government spending on health and education are important to reduce poverty. As part of the mining’s corporate social responsibility (CSR), the governments can negotiate agreements with mining companies for better health and education services. A healthy and an educated population are foundation for a prosperous nation. Mining countries and regions would be expected to invest more on health and education so that they can continue to support themselves after the life of a mining venture. However, some studies have shown the opposite effects, for example with that dependency on minerals resources correlated with lower spending on education. Based on tests done by Gylfason (2001) on three different measures of education against natural resources abundance, the findings were:
“1) an increase of 18 percentage points in the share of natural capital from one country to the next is associated with a decrease in public expenditure on education by 1 percent of GNP. 2) a regression line though the 52 observations, one per country, suggests that an increase in the natural capital share by five percent points is associated with a decrease by one year of the schooling that an average girl at the age of school entry can expect to receive; 3) and a five percentage point increase in the share of natural capital is associated with a 10 percentage point decrease in secondary-school enrolment from one country to another,” (p. 852–853).

Mining companies may also provide training for small enterprises that supply them with goods and services, bringing them up to international standards in terms of quality and reliability. They can take the form of investment in education and health, often provided initially for the mine’s employees, but then extended to the general public, investment in local government capacity, investment in community related services or activities with universal access, best accomplished in conjunction with the local authority. A mining operation has the potential to positively increase the capacities of the poor as a group, but mining operations can also negatively affect the poor’s capabilities. They also entail risks to people’s health and the environment.

*Security* is the third area of the framework of Figure 2. Mineral development can create new communities and bring benefits to those already in existence. The mining companies can contribute, through higher incomes, to improved nutrition, education, and health care in a community (Weber-Fahr et al., 2002). This reduces risk and vulnerability. For example, most of the children of the principal landowners of Porgera Gold Mining in PNG have a better educational training overseas and employment opportunities. Mining improves the standard of living for these people though better paid jobs. Mining companies also have provided better medical insurance for the mine landowners. This has greatly improved their communities.

However, it is not always the case in the developing countries, where many people continue to suffer. The “benefits may be unevenly shared, and for some there may be poor recompense for the loss of existing livelihoods and the damage to the environment and culture” (Starke, 2016). The poor and the vulnerable continue to be disadvantaged while those in power and influence tends to benefit more. According to the World Bank, “most mining companies in developing countries demonstrate clearly that there are substantial social and economic benefits to local communities, but they do not come automatically, and their sustainability is a key issue. There
is a clear need to redistribute more tax revenues to local governments and to build capacity at the community level” (Walser, 2000, p. 87).

However, a mining operation can also expose the local population, particularly the poor, to serious health risks and pose a threat to the natural environment as well as to local communities’ stability of employment, income, and purchasing power. As Ross (2003) explains, countries with a high level of resources dependency are also at greater risk from economic shocks. Economics shocks can be as a result of lack of economic diversification and their cyclical nature of commodity prices. There are also risk of health and safety. This can be related to work injuries, exposure to infectious diseases and environmental hazards. For example, the people of Ok Tedi Mining in PNG are exposed to contagious diseases that directly results from contamination from the nearby Ok Tedi River. Ok Tedi Mining’s “tailings have been discharged directly to the river system for the last 15 years” (Banks, 2002, p. 44). The livelihoods of the people that depend on the river system are badly affected. Similar problems have arisen in Porgera (Human Rights Watch, 2010).

In the mining areas, the cost of living rises and that affects the consumption levels of the local people. This impacts upon the cost of basic consumables for the poor who may not be able to cope. Most mining jobs pay substantial wages and salaries that are much higher than other industries. The prices of basic consumables such as food, fuel and transport increases (Weber-Fahr et al., 2002). “Mining can also use significant land and water, which can affect the poor who depend on these resources for their livelihoods and food” (Weber-Fahr et al., 2002, p. 452). New mining opportunities should bring jobs, business activities, roads, schools, and health clinics to remote and previously impoverished areas. However, the outcome can be far from this with mining investment resulting in social tension and sometimes violent conflict. This can give rise to cultural instability as well as political instability.

The fourth area of Figure 2 is empowerment of local communities. Mining companies can empower the local communities by involving local people to participate in the decision making for the communities’ welfare (Weber-Fahr et al., 2002).

When there is break down in the communication process, key stakeholders in the mining project are not well informed. “This, in turn, can decrease the poor’s access to transparent and effective public decision making processes” (Weber-Fahr et al., 2002, p. 453). To achieve empowerment of the local people, there must be concerted efforts from other all stakeholders through public
consultation and disclosure of vital information. Such efforts can have a positive effect on the people and their relationship with mining companies can be made stronger. Those affected are able to understand the consequences of decisions and the impacts on them. The government, companies and the people must continue to have dialogue, so people are informed about upcoming and ongoing investments and how other parties are able to participate. Such participation and knowledge transfer are vital to local capacity building that can benefit the people so that they can improve on their livelihoods for a sustainable living (Weber-Fahr et al., 2002). However, if this is not done as discussed above, there is risk of corruption that follows the creation of economic resources and power, which can disempower local people. Such an environment created can breed more poverty and unsustainable livelihood strategies that are disastrous for the poor.

In summary, the framework in Figure 2 can be used as a basis to compare actual practice by the mining companies against each of the linkages in the model. Each linkage shows a two-way relationship. If the various linkages are working well, then investments by multi-national mining companies create economic opportunities that can positively impact on both the microeconomic and macroeconomic situation. At an aggregate level, mining generates substantial revenue through government taxes, royalties, and net foreign exchange which the government can use to intervene in poverty alleviation projects (Pegg, 2006; Weber-Fahr et al., 2002). Hence revenue generation can lead to poverty reduction (Pegg, 2006). At the micro-level, mining investment can create employment opportunities for the local people. This will increase income earning opportunities that in turn can be invested in other income earning opportunities which can sustain and support their local communities (Weber-Fahr et al., 2002). However, as noted above there have been problems observed in each of the four key areas considered both generally with mining in developing countries and in the two regions of our study in PNG.

**Methods**

There were three main steps of the Propensity Score Matching (PSM) method used in this study. First, to “create the propensity score, a common first step is to use a logit or probit regression with treatment as the outcome variable and the potential confounders as explanatory variables” (Garrido et al., 2014, p. 1705). In our case logistic regression was employed.
Many social phenomena are discrete in nature, i.e., a person makes one choice, but not the other, or an individual or group passes from one stage to another. In the PNG case, a given point in time a mining person cannot become a non-mining individual. Binary discrete phenomena of this kind take the form of a dichotomous indicator or dummy variable. Although it is possible to represent mining and non-mining with any numbers, employing variables with values 1 and 0 has advantages. “The mean of a dummy variable equals the proportion of cases with a value of 1, and can be interpreted as a probability” (Pampel, 2011, p. 2). In this study, a logistic model was set up to test the association between the four types of factors shown in Figure 2 that were considered likely to determine the level of poverty. For instance, a mining household can have access to education and education grants for their children, while a non-mining household has access to neither.

The conditional probability of receiving the treatment when there are two treatment conditions (i.e., mining versus non-mining) is estimated using binary logistic regression. Denoting the binary treatment condition as $W_i (W_i = 1$, if it is a mining household, and $W_i = 0)$, if it is a non-mining household) for the $i$th case $(i = 1, \ldots, N)$, the vector of conditioning variables as $X_i$, and the vector of regression parameters as $\beta_i$, a binary logistic regression depicts the conditional probability of being a mining household is as follows:

$$P(W_i | X_i = x_i) = E(W_i) = \frac{e^{x_i \beta_i}}{1 + e^{x_i \beta_i}} = \frac{1}{1 + e^{-x_i \beta_i}}. \quad (1)$$

This is a nonlinear model, meaning that the dependent variable $W_i$ is not a linear function of the vector of conditioning variables $x_i$. However, by using an appropriate link function such as a logit function, we can express the model as a generalised linear model (McCullagh & Nelder, 1989). Although $W_i$ is not a linear function of $x_i$, its transformed variable through the logit function (i.e., the natural logarithm of odds or $log_e \{ \frac{P(W_i)}{1-P(W_i)} \}$) becomes a linear function of $x_i$:

$$log_e \left( \frac{P}{1-P} \right) = X_i \beta_i, \quad (2)$$

where $P$ denotes $P(W_i)$.

The second step in the PSM method is to check whether there is a region of common support or overlap condition between the mining households and non-mining households. The region of common support is determined by comparing the minimum and maximum values of
propensity score in both the mining and non-mining groups. It rules out the phenomenon of perfect predictability of \( D \) given \( X \):

\[
(Overlap) \quad 0 < P(D = 1 \mid X) < 1
\]

(3)

It ensures that households with the same \( X \) values have a positive probability of being both participants (mining) and non-participants (non-mining) (Heckman et al., 1999).

The third step in the PSM method is to estimate the average treatment effect on the treated (ATT). The ATT is used to explicitly evaluate the effects on those for whom the program is actually intended (Becker and Ichino, 2002). Thus, we use ATT to assess the effects of participation on household impacts. ATT is computed by matching mining and non-mining community households that are closest in terms of their propensity scores, and the ATT shows the effect on poverty of being a mining household. In this study, the treated group are the mining households and the ATT is calculated as follows:

\[
ATT = E(T \mid D = 1) = E(Y(1) \mid D = 1) - E(Y(0) \mid D = 1)
\]

(5)

where \( E(Y(1) \mid D = 1) \) represents the expected impacts of mining on mining households and \( E(Y(0) \mid D = 1) \) denotes the counterfactual impacts on non-mining households (Shehu & Siddique, 2014). The key assumption, is that adjusting for pre-treatment differences solves the problem of drawing casual differences. This is formalised by using the concept of unconfoundedness.

An estimate of the propensity score is not enough to estimate the ATT of interest using equation (5). The reason is that the probability of observing two units with the same value of the propensity score is in principle zero since \( p(X) \) is a continuous variable. A number of matching techniques have been suggested in the literature to overcome this problem and four of the most widely used are nearest neighbour matching, radius matching, kernel matching and stratification matching (Becker & Ichino, 2002). We present results for these four matching methods.

**Results**

The first-stage results in Table 1 show the logistic regression based on the combined dataset from Ok Tedi and Porgera. The variables used are human capital \((p < 0.001)\), inside capital
(p < 0.001), village participation to help (p < 0.001), information volunteering (p < 0.001), food eaten in the last 30 days (p < 0.001), square meals in 12 months (p < 0.001), income satisfaction (p < 0.001), and rich and poor ladder (p < 0.001). These variables are clearly indicators of whether a village is a mining village or not. The LR test ($\chi^2$) is significant, and a pseudo R-squared is 0.67 is considered a relationship with reasonable explanatory power in this type of analysis. Similar results were obtained for Ok Tedi and Porgera regions separately. Unfortunately, space does not permit discussion about them.

Human capital is basically the education level of the households. The results, as indicated by the significant coefficient (1% level) for human capital in the model (see Table 1), suggest that, controlling for other variables, human capital directly affects the probability of being a mining household (see Figure 3). There tends to be more school places available in mining villages. Also households have more discretionary income. When there is more income, more children of mining households tend to attend schools, colleges and universities.

Inside capital consist of televisions, VCD/DVD players, refrigerators, freezers and cars. The results, as indicated by the significant coefficient (1% level) for inside capital in the model, suggest that, controlling for other variables, inside capital is directly related to the probability of being a mining household (see Table 1). The mining villagers accumulate inside capital based on their income. When there is more income, there is tendency to buy more inside capital.
### Table 1: Logistic Model Estimation Results for Ok Tedi and Porgera Combined (Mining Impacts on the Indigenous People in Papua New Guinea)

<table>
<thead>
<tr>
<th>Mining and Non-mining</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>Z</th>
<th>P&gt;z</th>
<th>[95% Confidence Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Capital</td>
<td>1.46</td>
<td>0.38</td>
<td>3.85</td>
<td>0.000***</td>
<td>0.72 2.20</td>
</tr>
<tr>
<td>Inside Capital</td>
<td>0.42</td>
<td>0.09</td>
<td>4.40</td>
<td>0.000***</td>
<td>0.23 0.60</td>
</tr>
<tr>
<td>Village participation to help</td>
<td>0.55</td>
<td>0.14</td>
<td>3.83</td>
<td>0.000***</td>
<td>0.27 0.83</td>
</tr>
<tr>
<td>Information Volunteering</td>
<td>-0.33</td>
<td>0.15</td>
<td>-2.22</td>
<td>0.027***</td>
<td>-0.72 -0.11</td>
</tr>
<tr>
<td>Food eaten in the last 30 days</td>
<td>2.10</td>
<td>0.36</td>
<td>5.89</td>
<td>0.000***</td>
<td>1.40 2.81</td>
</tr>
<tr>
<td>Food eaten in the last 12 months</td>
<td>1.75</td>
<td>0.33</td>
<td>5.25</td>
<td>0.000***</td>
<td>1.10 2.50</td>
</tr>
<tr>
<td>Income Satisfaction</td>
<td>-2.36</td>
<td>0.45</td>
<td>-5.28</td>
<td>0.000***</td>
<td>-3.23 -1.48</td>
</tr>
<tr>
<td>Rich &amp; Poor Ladder</td>
<td>1.05</td>
<td>0.15</td>
<td>6.84</td>
<td>0.000***</td>
<td>0.75 1.36</td>
</tr>
<tr>
<td>Constant</td>
<td>-4.18</td>
<td>0.68</td>
<td>-6.15</td>
<td>0.003</td>
<td>-5.51 -2.84</td>
</tr>
</tbody>
</table>

Number of observations 604  
Pseudo R-squared 0.68  
LR test ($\chi^2$) 565.97  
P-value 0.0000  
Log likelihood -135.51  

Note 1: ***, **, and * indicate 1 %, 5%, and 10% of the significance level, respectively

Social assets were the next variables included as predictors of differences between mining and non-mining villages. Social capital may reflect indigenous social values and their impacts on the safety net “Wantok System”. The variables included: village participation to help and information volunteering. Village participation to help is a variable constructed from survey questions related to whether: (1) the household member has participated in an association, (2) the villagers are regarded by the household as honest and can be trusted, (3) the community or village people are considered to be willing to help and support others, and (4) the community
or the village supports your household when your household or other community members have a problem. Village participation to help is a social capital as it involves the community and its social engagement with the people generally. This is an important part of the social safety net where the villagers participate to help each other. However, on the other hand, in mining villages distressed household members looking for opportunities in mining or in wage employment may have little time to participate in village obligations. Nevertheless, support services in mining villages can be strengthened through the community relations office within the mining company as part of their community service. The results of the estimation show that, as indicated by the significant coefficient (1% level) for village participation to help and controlling for other variables, that there is a direct relationship between the probability of an observation being from a mining household and village participation to help.

Information volunteering is also an aspect of social capital and consists of: speaking to the media about an issue or problem, involvement in an information campaign about certain issues and volunteering to help or support the community. The media outlets within the mining community and the country at large have a great responsibility in informing the people about what is important to their livelihoods. In the mining communities, sharing information with
stakeholders is paramount for decision making. This can inform the indigenous people about the changes, improvements, and other related news so that appropriate actions can be taken where appropriate. The mining company through the community affairs department is responsible for mining affairs, while leaders in the villagers are responsible within their communities. The social safety net in the community is natural for Melanesian people (Carnigie et al., 2013). A family within a household and interacting among themselves has more influence and is a tradition and custom that has been passed on from generations. Local people like to volunteer in social groups, church groups, and community organisations for the betterment of their society. Therefore, it is expected that more people interacting among themselves in groups and societies have more influence in the community.

The results of the estimation show an inverse relationship between the probability of an observation being from a mining household and information volunteering.

Food security, measured by food eaten in 30 days, and food quality, measured by three-square meals per day over 12 months, were included as predictors of the probability of being a mining household. Most indigenous communities don’t have access to full meals for breakfast, lunch and dinner every day. The foods are generally high in sugar content and carbohydrates, and have limited protein. A high proportion of children become malnourished and die.

The results show a direct relationship between the probability of an observation being from a mining household and both food eaten in 30 days and three-square meals per day over 12 months. This result suggests that there is much more food eaten per person in the mining villages.

Income security measured as income satisfaction was included as predictor of the probability of being a mining household. Income satisfaction attempts to measure the level of satisfaction gained from a given level of income. The results of the logistic model estimation show that the probability of a household being from a mining community is inversely related to income satisfaction. Hence a given level of income provides a higher level of satisfaction for a typical non-mining household than a typical mining household.

A mining household’s income satisfaction may result from several different causes. First, the mere availability of more items to purchase seems to make a demand on a household’s income. Hence, even though mining households may have more income on average than non-mining households, it may not be enough to satisfy their daily activities. Second, the cost of living in
The mining communities is high compared to non-mining communities. Often their farm land is destroyed, their homes are relocated, and their environment is polluted. There is limited free water. The income they have received as part of their compensation may not balance what they have given away. Whereas in many of the non-mining communities’ material needs are provided without money income. There is free food from the garden, free water from the creeks, and free houses on their land. Therefore, the non-mining communities can generally be more satisfied from a given money income than the mining communities.

The rich-poor ladder was a variable elicited during the survey questionnaire to measure a household’s overall perception of wellbeing within the mining and non-mining communities. The question reads: “please imagine a 9-step ladder where the bottom, the first step, stands for the poorest people, and on the highest step, the ninth, stand the rich. On which step are you today?” It is called the “Economic Ladder Question”. It does not presume that “income” is the relevant variable for defining who is “poor” and who is not, but leaves that up to the respondent. It is a subjective living standard measure. By definition, this instrument should be related to underlying living standards. The results of the estimation suggest that, as indicated by the significant coefficient (1% level) and controlling for other variables, the rich-poor ladder was directly related to the probability of an observation being from a mining household. The results indicate that there are more mining households higher up the rich-poor ladder (see Figure 4).
At the second stage, the results revealed that there was a significant region of common support. This made it reasonable to progress to the third stage of Propensity Score Matching.

The third stage was to estimate the average treatment effect on the treated (ATT). Focusing on the 9-point scale of the rich-poor ladder as the index of poverty, the impact of mining on the mining households was estimated. The results are shown in Table 2. The dummy variable regression shows that the difference between the mean position on the rich poor-ladder of mining and non-mining households is 2.234 (on a 9-point scale) without any other explanatory variables. Inclusion of the other x variables reduces this to 1.231. Then calculation of the ATT adjusts these estimates further for the non-random effect of households being either in mining or non-mining villages. The value of the ATT ranges between 0.138 (and insignificant) and 0.674 (and significant) for the various matching methods. This indicates that mining has had an unconvincingly positive impact on this index of poverty when the Ok Tedi and Porgera datasets are combined, and relative to the 9-point scale the impact could be considered small.

Examining the two regions separately provides additional insights. At Ok Tedi, the ATT is significant for both matching methods. Its value of 1.15 to 1.18 indicates that the impact of mining has been to shift households up the rich-poor ladder by this number of steps. The results for the ATT at Porgera are statistically insignificant. This indicates that either that the introduction of mining had no impact on the poverty levels of the Porgera indigenous mining households, or that there was an impact, but our approach to measurement did not discover it.

Table 2: Average Treatment Effects on the Treated (ATT) and t-statistics for Different Matching Methods, with the Rich-Poor Ladder as the Performance Index

| Model 1: Combined OK Tedi and Porgera Mining | ATT  | Standard Error | t    | P>|t| |
|---------------------------------------------|------|----------------|------|------|
| Radius                                      | 0.674| 0.212          | 3.181|      |
| Kernel                                      | 0.138| 0.323          | 0.431|      |
| Regression                                  | 1.231| 0.138          | 8.900| 0.000|
| Dummy Variable Regression                   | 2.324| 0.105          | 22.100| 0.000|

| Model 2: Regional Ok Tedi Mining            | ATT  | Standard Error | t    | P>|t| |
|---------------------------------------------|------|----------------|------|------|
| Radius                                      | 1.153| 0.417          | 2.762|      |
| Kernel                                      | 1.184| 0.451          | 2.623|      |
Regression | 1.653 | 0.208 | 7.940 | 0.000
Dummy Variable Regression | 2.193 | 0.135 | 16.170 | 0.000

| Model 3: Regional Porgera Mining | ATT | Standard Error | t | P>|t| |
|----------------------------------|-----|----------------|---|--------|
| Radius                           | 0.453 | 0.440 | 1.029 |
| Kernel                           | 0.703 | 1.280 | -0.549 |
| Regression                       | 1.155 | 0.225 | 5.120 | 0.000 |
| Dummy Variable Regression        | 2.457 | 0.125 | 19.750 | 0.000 |

**Conclusions**

This research is at a preliminary stage, and the results presented here are indicative only. The observation from our results so far for Ok Tedi is that mining has reduced poverty when measured using the rich-poor ladder. For Porgera, the ATT results are insignificant and therefore there is no indication that poverty levels have been reduced by mining. When the datasets are combined, there are some significant and some insignificant results for the ATT.

With respect to methods, propensity score matching has been employed to correct for the non-randomness in the selection process in alternative methods. In the current analysis, propensity score matching produces smaller coefficient estimates for the impact of mining on the rich-poor ladder that are less significant than for the logistic regression.

Hence, the results support the hypothesis that there is a general improvement in living conditions at Ok Tedi as you move from non-mining to mining villages. For Porgera, the results are inconclusive.

**References**


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