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Validating policy prescription from benefit-cost assessments of mining through comparative analysis and test of hypotheses*

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The paper proposes that benefit-cost analyses of mining be validated by comparative analyses and tests of hypotheses. Mining and nonmining communities can be compared to assess the contribution of mining to development. Further, tests of hypotheses can be used to determine whether mining communities are significantly different from nonmining communities in terms of poverty rates, health indicators, education, and other social indicators. Applying the said techniques in Benguet, Northern Philippines, the author found that mining communities, despite several years of mining operations, are not significantly different from nonmining communities. Data also suggest that in communities where corporate mining operates as in Benguet, poverty incidence is higher—not lower. This implies that we need to review the Philippine government's policy of promoting mining as an engine of economic growth. The paper proposes that we explore economic strategies that enhance environmental protection at the same time.

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1. Introduction

According to advocates, corporate mining has the potential to bring at least US$ 800 billion in benefits.[1] Although cost figures are often lacking, what

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[1] Peter Wallace, economic analyst, who attended the session of the Philippine Economic Society Annual Meeting during which an initial version of this paper was presented, stated during the open forum following the presentation of this paper that advocates of mining cite a figure of only US$ 8 billion of benefits from mining. However, advocates presented estimates on supposed benefits from mining as high as US$ 800 billion.

advocates imply is that benefits more than compensate for the environmental damage or risks posed by corporate mining. In an earlier work, "Valuation of Benguet Biodiversity and Environmental Cost of Mining",[2] the author articulated that large-scale or corporate mining in Benguet produces an economic loss of Php 92.7 billion at current levels of operation. He argued further that the monetary value of costs overshadows the monetary value of benefits until at least the price of gold shoots up by 55 percent from its price of US$ 634.05 an ounce in May 2006.

The higher yet arguably valid estimate of economic costs can be partly attributed to the assumption of potable water (similar to that used by Dr. Marcelino Dalmacio for the Samar Island National Park in 2003) without mining as well as possible environmental or geohazard risks with mining. In the computation, many intangible costs were not even monetized.

Benefit-cost (b/c) analyses of mining and conclusions adopted can vary based on the b/c analysis perspective adopted, valuation methodology employed, and values used for proxies and valuation of intangibles. This implies a need for developing techniques to validate the policy implications suggested by various b/c analyses of mining.

If mining is indeed good, then this should show in the income, poverty, and health figures. In this attempt at validation, mining and nonmining localities are compared with regard to local government unit (LGU) income growth rate, local government income per hectare, local government income per capita with respect to the population covered by the LGU jurisdiction, and nutrition status of children 71 months and below.

At the same time, test of hypotheses for means and proportions were used. The test statistic employed for the tests of hypotheses on means is $t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}}$,

[2] This is a sequel to "Valuation of Benguet Biodiversity and Environmental Cost of Mining", a work commissioned by the Haribon Foundation in 2005 (edited 2006; the views expressed may or may not necessarily reflect those of Haribon). The 105-page work is available in the Haribon website and can also be accessed through www.geocities.com/haribonartboquirenreport/benguetmining2006.htm. Another unpublished work of the author related to benefit-cost analysis of mining is "Towards a Basic Methodology in the Benefit-Cost Assessment of Mining", which is available through www.geocities.com/artboquirenpaperone/bcminingjan07.pdf. Although this work is self-financed, the author acknowledges with deep and sincere thanks the various types of assistance provided by Action for Economic Reforms through Men Sta. Ana and the Foundation for Philippine Environment (FPE) through Sylvia Mesina and FPE Executive Director Christine Reyes. The author also seizes this opportunity to express his gratitude to Haribon Foundation Director Annabelle Plantilla as well as to Dr. Fernando Aldaba and Dr. Michael Alba, former and incumbent presidents, for welcoming this paper to the 45th annual meeting of the Philippine Economic Society.

which I consider to be most applicable, given the data set at hand. On the other hand, the test statistic utilized for test of hypotheses on proportion or percentage is

$$z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{p}\hat{q}[(1/n_1)+(1/n_2)}}$$

The tests of hypotheses on means and proportions and rules for application are typically found in all statistics reference books, including the classic works in statistics by Walpole [1983] and Freund and Simon [1997]. In this study, the mining communities or localities refer to the municipalities of Itogon, Mankayan, and Tuba where large-scale corporate mining operates. The corporate or large-scale mining companies operating in these municipalities are Lepanto Mining, Benguet Consolidated, and Philex Mines.

2. Comparison and test of hypotheses on income

Advocacy for mining is strongly premised on the argument that benefits from mining are so significant and, therefore, environmental concerns can be sacrificed. If benefits from mining are indeed so great, then this should reflect in the incomes of local government units hosting corporate mining. Is this the case? Are LGUs hosting corporate mining really earning large revenues compared to those not hosting large-scale or corporate mining? Table 1 is illustrative.

Table 1. Municipal income in 1996 and 2002, growth rate, and rank of growth rate

Municipality	*1996 (in thousand pesos)*	*2006 (in thousand pesos)*	*Annual municipal income growth rate 1996-2006 (%)*	*Rank*
Atok	10,819	32,728	11.71	13
Baguio City	281,110	781,329	10.76	11
Bakun	11,624	47,611	15.14	2
Bokod	13,159	34,564	10.14	14
Buguias	13,192	43,784	12.75	10
Itogon*	33,410	82,126	9.41	12
Kabayan	8,675	31,022	13.59	7
Kapangan	9,408	32,044	13.04	9
Kibungan	9,434	34,110	13.72	5
La Trinidad	29,066	113,090	14.55	3
[illegible]*	19,928	90,121	16.29	1
[illegible]	7,678	27,985	13.81	4
Tuba*	22,402	80,655	13.67	6
Tublay	7,624	26,671	13.34	8

* Municipalities hosting large-scale or corporate-mining activities.

Source: Benguet Profile 2003 (latest provincial profile available) and Commission on Audit (COA).

Doing a one-tail hypotheses test of means on H_0: $\mu_{non-mining} = \mu_{mining}$ versus H_1: $\mu_{non-mining} < \mu_{mining}$ where μ refers to the mean annual income growth rate of local government units that may or may not have corporate mining for 1996-2006, we find that the null hypotheses of equality of means cannot be rejected, given that the value of the applicable test statistics is -0.3546. The value of the test statistics suggests that the LGU income growth rate of nonmining communities and that of mining communities are not significantly different from each other and, thus, based on the theories of statistics, it is valid to say that mining, particularly large-scale mining, will not increase or lead to a significant increase in the income of local government units.

Beyond the test of hypotheses on means, however, one can note that municipalities perceived to be poor like Bakun, Buguias, Kabayan, Kibungan, and Sablan exceeded the LGU income growth rates of municipalities hosting corporate or large-scale mining even if gold price approximately tripled during the period 1996-2006. This indicates that hosting large-scale mining companies need not be the source of income growth for Benguet municipalities. Equally beneficial municipal income growth trend can be obtained if municipalities focus on agriculture, manufacture, educational centers, and other sources of livelihood.

Table 2 divides the LGU income by the land area in hectares covered by the LGU. A pattern similar to the earlier observation can be noted. Table 2 shows that equally respectable LGU income per hectare can be derived from livelihoods other than large-scale or corporate mining. Among such livelihoods, for example, are vegetable, banana, and broom production. This is surprising, considering that millions are invested in mining while other sources of livelihood like banana and broom production require smaller investments in Benguet municipalities

Executing a one-tail hypotheses test of means for H_0: $\mu_{non-mining} = \mu_{mining}$ versus H_1: $\mu_{non-mining} > \mu_{mining}$ where μ refers to the mean annual income per hectare of jurisdiction of local government units that may or may not have corporate mining for 1996-2006, we find that the null hypotheses of equality of means cannot be rejected, given that the value of the applicable test statistic is 0.9935. In this analysis, the mean local government income per hectare of jurisdiction of nonmining communities is actually very large at Php 15,805 per hectare compared to that for mining communities at Php 3,782. However, the value of the test statistic for the hypothesis test was influenced to a very large degree by the high value of the sample standard deviation at Php 40,136. Based on the results, what we are only allowed to say is that the null hypotheses of equality of income per hectare between local governments hosting large-scale or corporate mining and LGUs not hosting large-scale or corporate mining cannot be rejected.

Table 2. Estimate of municipal income per hectare and rank of Benguet municipalities in 2006

Municipality	*Area in hectares*	*Municipal income in 2006 (in thousands)*	*Income per hectare (pesos)*	*Rank in income per hectare*
Atok	13,700	32,728	2,389	7
Baguio City	5,749	781,329	135,907	1
Bakun	23,740	47,611	2,006	10
Bokod	43,530	34,564	794	14
Buguias	19,310	43,784	2,267	9
Itogon	42,370	82,126	1,938	11
Kabayan	17,750	31,022	1,748	13
Kapangan	13,640	32,044	2,349	8
Kibungan	19,210	34,110	1,776	12
La Trinidad	6,140	113,090	18,419	2
Mankayan	13,170	90,121	6,843	3
Sablan	9,160	27,985	3,055	5
Tuba	31,438	80,655	2,566	6
Tublay	8,490	26,671	3,141	4

For the next discussion, we construct Table 3. We derive the population growth rate by comparing population figures in 1990 and 2000. Notice that we have decreasing population growth figures for Mankayan, Itogon, and Tuba—the municipalities hosting large-scale or corporate-mining activities. These data alone can be interpreted as indicative of the limited opportunities in the mining areas during the period. The data possibly reflect the vulnerabilities of local governments hosting largescale or corporate mining (but of course, a deeper study is in order). In particular, Table 3 indicates that when mining is not doing well in the international market, the municipalities can become out-migration areas, with possible consequences on economic and income figures.

Based on Table 3 and earlier tables, we can construct Table 4. In particular, we are able to derive from Table 3 and earlier tables the LGU income per capita population of the Benguet LGUs. Again the same pattern in earlier tables can be observed in Table 4.

In particular, Table 4 indicates that LGUs producing vegetable, banana, and broom can beat those hosting large-scale or corporate mining in terms of per capita income. Bakun is considered or widely known as a poor municipality, yet it defeated Mankayan, a gold producer, in terms of per capita income.

Table 3. Projected population of Benguet municipalities in 2006

Municipality	*Population in 2000*	*Annual growth rate in %*	*Projected population in 2006*
Atok	16,657	2.33	19,126
Baguio City	252,386	3.26	305,955
Bakun	12,213	-0.82	11,624
Bokod	11,705	2.2	13,338
Buguias	33,177	3.43	40,618
Itogon	46,705	-0.43	45,513
Kabayan	12,344	3.25	14,955
Kapangan	18,137	3.59	22,412
Kibungan	15,036	1.23	16,180
La Trinidad	67,963	1.95	76,313
Mankayan	34,502	-0.08	34,337
Sablan	9,652	1.1	10,307
Tuba	38,366	-0.47	37,297
Tublay	13,672	1.02	14,530

Implementing a one-tail hypotheses test of means for H_0: $\mu_{non-mining} = \mu_{mining}$ versus H_1: $\mu_{non-mining} < \mu_{mining}$ where μ refers to the mean annual LGU income per capita population of the local government units that may or may not have corporate mining for 1996-2006, we find that the null hypotheses of equality of means cannot be rejected, given that the value of the applicable test statistic is -0.1797. The value of the test statistics implies that even if the mean per capita income of LGUs with corporate mining is slightly higher than that of LGUs without mining, the null hypothesis of equality of means cannot be rejected. Thus, we have a good basis to argue that corporate mining will not result in higher per capita income among local government units.

3. Comparison and test of hypotheses on poverty incidence

The National Statistical Coordination Board (NSCB) religiously tabulates poverty incidence data. However, as of November 2007, the latest available data for poverty incidence at the municipal level are the poverty incidence for 2000. National poverty incidence data on specific sectors but not for the total population are available for 2003. Similarly, official 2003 poverty incidence data at the municipal level are still not available as of November 2007. Table 5 reflects the poverty incidence per municipality while Table 6 aggregates the data for mining versus nonmining (non-large-scale mining) LGUs.

Table 4. Estimate of municipal income per capita and rank of Benguet municipalities in 2006

Municipality	*Projected population in 2006*	*Municipal income in 2006 (in thousands)*	*Municipal income per capita*	*Rank in municipal income per capita*
Atok	19,126	32,728	1,711	11
Baguio City	305,955	781,329	2,554	5
Bakun	11,624	47,611	4,096	1
Bokod	13,338	34,564	2,591	4
Buguias	40,618	43,784	1,078	14
Itogon	45,513	82,126	1,804	10
Kabayan	14,955	31,022	2,074	8
Kapangan	22,412	32,044	1,430	13
Kibungan	16,180	34,110	2,108	7
La Trinidad	76,313	113,090	1,482	12
Mankayan	34,337	90,121	2,625	3
Sablan	10,307	27,985	2,715	2
Tuba	37,297	80,655	2,163	6
Tublay	14,530	26,671	1,836	9

Table 5. Poverty incidence in Benguet and rank in terms of lowest poverty of areas

Municipality	*Population in 2000*	*Poverty incidence in 2000*	*Rank in having the lowest poverty incidence*
Atok	16,657	54.35	10
Baguio City	252,386	6.73	1
Bakun	12,213	60.72	13
Bokod	11,705	46.44	7
Buguias	33,177	48.91	8
Itogon	46,705	30.13	3
Kabayan	12,344	57.87	12
Kapangan	18,137	57.16	11
Kibungan	15,036	68.55	14
La Trinidad	67,963	14.41	2
Mankayan	34,502	42.53	6
Sablan	9,652	49.10	9
Tuba	38,366	36.88	5

Table 6. Mining and nonmining communities of Benguet and poverty incidence, 2000

Mining Localities of Benguet		
	Total population	119,573
	Poverty incidence	35.87%
Nonmining localities of Benguet		
	Total population	462,942
	Poverty incidence	22.11%

If corporate or large-scale mining is indeed good for Benguet municipalities, then poverty incidence should be very low in corporate-mining municipalities of Mankayan, Tuba, and Itogon. After all, large-scale or corporate mining has been in Mankayan for at least 71 years, in Tuba for about 49 years, and in Itogon for about 91 years. (See the poverty incidence figures in Benguet in Table 5.)

Table 5 suggests that the elimination of poverty appears to be correlated with urbanization because the LGUs that have lower poverty rates compared to the mining communities are those that are urbanized: Baguio City, La Trinidad, and Tublay. In turn, urbanization in these municipalities is the result of a focus on the establishment of manufacturing, schools, and service industries.

Nevertheless, testing H_0 (*pmining=pnonmining* or that poverty rate in mining communities are not different from poverty rate in nonmining communities) versus H_1 (or that poverty rates in mining communities are higher compared to poverty rates in nonmining communities), we obtain a value of 98.0461 for the applicable test statistic. The value of the applicable test statistic strongly suggests that poverty rates in communities with corporate mining are significantly higher than those of communities without significant corporate mining. The probability of committing a type I error (or error committed in accepting the alternate hypotheses when the null hypothesis is, in fact, true) is low at less than one in a trillion or, more precisely, less than one out of $1x10^{30}$, with 30 as the maximum number of zeros that Excel 2000 can cover to the right of the decimal point.

The result came as a surprise, but a possible explanation for the phenomenon can be found in the Leontieff input-output table for the Philippines [NSCB 2006]. Analyzing the input-output table, the NSCB produced a table, which is captured in this work as Table 7.

Table 7. Backward-forward linkage based on latest Leontief input-output table for Philippines

Sector	*Backward linkage*		*Forward linkage*	
	Index of dispersion	*Rank*	*Index of sensitivity*	*Rank*
1. Agriculture, fishery, and forestry	0.8616	10	1.0307	3
2. Mining and quarrying	1.0003	5	0.8162	7
3. Manufacturing	1.2648	1	2.8780	1
4. Construction	1.1382	3	0.6292	10
5. Electricity, gas, and water	0.9208	8	0.8237	6
6. Transportation, communication, and storage	1.1383	2	0.8859	4
7. Trade	0.9745	6	0.8800	5
8. Finance	0.9697	7	0.7624	8
9. Real estate and ownership of dwellings	0.7034	11	0.6482	9
10. Private services	1.1275	4	1.0581	2
11. Government services	0.9009	9	0.5875	11

Source: NSCB 2006:17.

Tables 5, 6, and 7 imply that several alternatives other than large-scale mining are available toward lowering poverty incidence, and these alternatives are far better ones. For instance, if a little urbanization or diversification of livelihood can be better in lowering poverty incidence, then a review is in order if corporate or large-scale mining is, in fact, an obstacle to diversification because once an area is converted into a mining site, its conversion to other uses can become difficult.

4. Comparison and test of hypotheses on nutrition status

Table 8 examines the nutrition status of children 71 months and below in Benguet. What is scandalous in Table 8 is that Mankayan, which is hosting a company engaged in the production of gold, is among the municipalities that have the lowest rank in terms of having children 71 months and below that are not underweight. Baguio City is not included because its data are not comparable to that of other municipalities. Baguio City weighs children 72

months and below instead of 71 months and below as adopted by the Benguet municipalities.

Nevertheless, doing a test of proportion similar to that for poverty, a test statistic equal to 1.0088 is obtained. This implies that even if mining communities have a slightly higher percentage of children 71 months and below who are underweight, it is not significantly different from the rate of communities that are not hosting large-scale or corporate mining. The proportion of underweight children in mining communities is 3.84 percent while that for nonmining communities is 3.66 percent.

Table 8. Nutrition status of children 71 months and below in Benguet

Municipality	*Children 71 months and below*	*Count of underweighted (including severely underweight)*	*% Underweight (including severely underweight)*	*Low malnutrition rank*
Atok	2,047	86	4.20	6
Bakun	1,608	126	7.84	13
Bokod	1,339	94	7.02	10
Buguias	4,869	78	1.60	1
Itogon	7,916	325	4.11	5
Kabayan	1,390	99	7.12	11
Kapangan	1,758	133	7.57	12
Kibungan	2,066	81	3.92	4
La Trinidad	11,682	251	2.15	3
Mankayan	5,189	292	5.63	9
Sablan	1,315	59	4.49	7
Tuba	5,107	82	1.61	2
Tublay	1,910	90	4.71	8
Benguet	48,196	1,796	3.73	n.a.

Note: The "Operation Timbang" covered 46,061 children 71 months and below out of 52,055 (88.5 percent of target).

Source: Benguet Provincial Health Office.

5. Conclusion and postscript

Overall, it can be said that nonmining areas perform at least just as well as mining areas and, thus, communities or local government units that want

their cities or municipalities to take off and take a higher growth path need not embrace large-scale mining. There is a strong basis, therefore, to explore more environment-friendly alternatives to development, and, given the threats posed by mining on the environment, mining need not be an option for municipalities and cities seeking a higher growth path.

Meanwhile, based on figures cited in this work, it is also valid to conclude that in communities where corporate mining operates as in Benguet, poverty incidence is in fact higher and not lower. Related to this, I anticipate that advocates of mining would interpret the data set as a case where sharing of benefits between mining companies and local government units can be explored. Against this, I would like to reiterate the point I made earlier—a better interpretation is that the data highlight the need to explore alternative paths to development other than that proposed by large-scale or corporate mining. Development can be on a higher growth path and be environment-friendly at the same time.

It will be interesting to replicate or do a study similar to this work in many mining municipalities nationwide and all over the world. My guess is that the results will not be radically different from the one I have for Benguet Province, Philippines.

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