AN EMPIRICAL INVESTIGATION OF MINING AND SUSTAINABLE DEVELOPMENT

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ABSTRACT

The definition of sustainable development is often taken from the so-called "Brundtland" report, requiring that activities of the current generation not detract from the potential welfare of future generations. Mining is often held up as unsustainable in this regard since the extracted resource is non-renewable. Yet Brundtland's definition of sustainable development also requires that the current generation address the disparity in welfare across the globe, a facet of Brundtland's report that most have ignored. This paper examines the impact of mining on the welfare of the poor. It finds that poverty levels in the poorest mining and oil intensive economies are lower than expected given these economies' geographical location and level of income, and that extractive activities are therefore completely consistent with sustainable development.

INTRODUCTION

> "We believe the best course of action for poor states would be to avoid export-oriented extractive industries altogether, and instead work to sustainably develop their agricultural and manufacturing sector—sectors that tend to produce direct benefits for the poor, and more balanced forms of growth." (Ross, 2001, p. 17)

There is widespread agreement that many developing countries have not made the most of their mineral resource endowments. While mining often creates substantial profits for mining companies, a large tax base for local, regional, and national government, employment for thousands of workers, and positive local and regional development impacts, many economies with a large mining industry continue to have widespread poverty.

Two recent publications have brought this phenomenon to the attention of a wide audience. The first, a study of the 49 Least Developed Countries (LDCs) by the United Nations Conference on Trade and Development (UNCTAD 2002), asserts that dependence on mineral production is responsible for the large and rising levels of extreme poverty in the mineral exporting LDCs: Central African Republic, the Democratic Republic of the Congo (formerly Zaire), Guinea, Liberia, Niger, Sierra Leone, and Zambia. These are estimated to be among the most poverty-stricken countries in the world. It is by now widely accepted that mineral economies have not grown as quickly as non-mineral economies

[1] I would like to thank John Tilton and Martin Schonger for helpful comments on an early draft of this paper. I also thank Massoud Karshenas for providing me with his poverty data sets and Nick Swerdfeger for his research assistance.

within the past few decades (e.g., Sachs and Warner 1997). The UNCTAD report suggests that the mineral economies' slow rate of economic growth is causing their high and even rising levels of poverty. It should be of great concern to those in the mining industry that their industry is being blamed for this outcome.

The second is a report by OXFAM America, authored by University of California at Los Angeles political scientist Michael Ross (Ross 2001). Ross contends that countries with large mining sectors have higher poverty rates than non-mineral dependent states even after controlling for differences in the average consumption level. That is, mining-dependent countries tend to have more, rather than less, inequality compared with resource-poor countries at the same level of consumption, resulting in mining-dependent countries having a larger fraction of impoverished citizens than the norm.

In this paper I take a fresh look at the relationship between mining and poverty using a new poverty data set. I find that amongst the poorest countries in the world mining is not associated with increased poverty, and that if anything mineral exporters have lower poverty levels than non-mineral exporters. The result has implications for the role of mining and sustainability, which I elaborate upon in the final sections of the paper.

INCOME LEVEL, INCOME DISTRIBUTION, AND POVERTY

Mining activity can impact poverty through two avenues. First, poverty is less prevalent in countries with higher levels of income per capita (Karshenas 2001, 2003, UNCTAD 2002). There is some evidence that mining economies tend on average to have a higher level of income per capita than non-mining economies with similar developmental and economic characteristics (Davis 1995, Rodriguez and Sachs 1999), but other work shows that the relationship disappears once one controls for colonial origins and their impact on development (Acemoglu et al. 2001). Thus, there is no clear evidence to date that mining economies have higher or lower incomes per capita than non-mining economies after controlling for the standard economic variables that affect income. In this sense, and contrary to UNCTAD's claim, there is no empirical evidence that mining is responsible for the low income levels and corresponding high poverty rates that we see in many mining economies.

Second, poverty levels are a function of income distribution, with higher levels of poverty for a given income level when income is unequally distributed. For clarity, I'll call this distributional poverty. Mining is often located in rural areas, providing employment and economic stimulus in some of the poorest regions of a country (e.g., Wallace 1999). Evidence from Cote d'Ivoire shows that rural incomes increase with decreased distance to paved roads and public markets (Klugman 2002, p. 45), infrastructure associated with mining activities. In this sense, we might expect mineral economies to have less, rather than more, distributional poverty. The OXFAM report appears to show just the opposite: after controlling for level of income, mining-intensive developing economies have more income inequality and more poverty than non-mining economies. Ross (2001) explains the negative relationship by asserting that mining influences government behavior in ways that are harmful to a nation's poor. Leamer et al. (1999) also posit that some sectors promote equality and some do not. They find that tropical agriculture concentrates wealth among few landowners, creating income inequality, while manufacturing activities result in a more equitable income distribution. There is some indication that mining and oil production promote inequality, but the statistical evidence is weak (see Leamer et al., Table 7). On the other hand, Freudenburg and Wilson (2002) find that mining within rural counties in the United States is associated with increased distributional poverty in these areas.

This latter area, the impact of mining on income inequality and distributional poverty, is thus an area for further research, and the one that I focus on in the rest of the paper.

MEASURING DISTRIBUTIONAL POVERTY

In cross-sectional studies of poverty, it is important that the poverty measure be comparable across countries. Several measures of poverty exist. Those considered most applicable to inter-country analyses are “dollar-a-day” and “two-dollar-a-day” absolute expenditure measures, which count the percentage of a country’s population living below these respective expenditure levels (Karshenas 2001, 2003, UNCTAD 2002, p. 47). Least applicable are relative poverty measures, such as nationally derived poverty rates, since these are normed according to a country’s total income level and do not permit country by country comparisons. This paper therefore uses the World Bank’s new household survey-based dollar-a-day and two-dollar-a-day poverty data (Chen and Ravallion 2001), available on the World Bank web site http://www.worldbank.org/research/povmonitor/. This poverty data reports the percentage of people in each nation living on $1.08 or $2.15 per day in 1993 purchase-power-parity (PPP) US dollars. This is approximately equivalent to $1/day and $2/day in 1985 (PPP) US dollars. To get a feel for just how poor these people are, the $1/day poverty line is equivalent to a person in the average African Least Developed Country living on $US 0.51/day at current prices and exchange rates (UNCTAD 2002, p. 44). The World Bank also reports the average consumption levels per capita, based on these same surveys, and provides an index of inequality called a Gini coefficient.

Figure 1 plots the rate of $1/day poverty against per capita consumption for 54 of the poorest countries of the world. In some cases a country is surveyed in more than one year, creating 153 data points, or an average of three annual data points per country. The data spans measurements from 1981 through 1998. The poorest country in the data set is Zambia in 1993 ($319/yr.), and the richest Colombia in 1991 ($3,888/yr.). The most poverty-stricken is Zambia in 1996 (72.6% of the population living on less than $1/day) and the least poverty-stricken is Jordan in 1987 (0% living in poverty). In the plot, for any level of consumption, countries that are higher on the vertical axis have more distributional poverty than countries that are lower on the axis. That is, the vertical scatter around the trend corresponds solely to differences in consumption inequality.

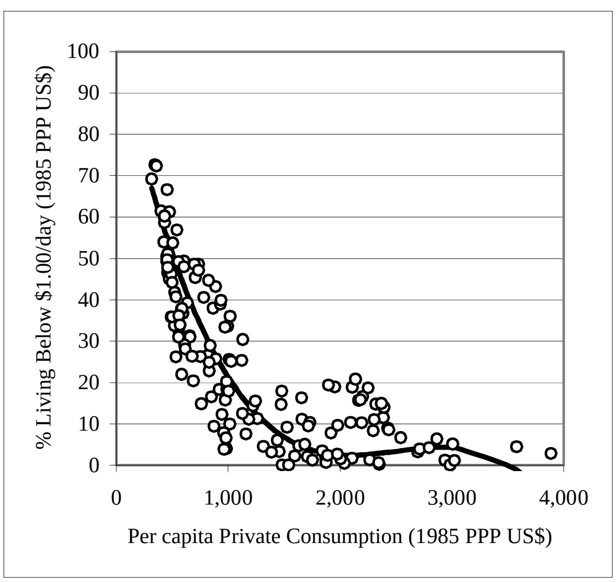

Figure 1. Survey-based $1/day Poverty Rates as a Function of Annual per Capita Consumption

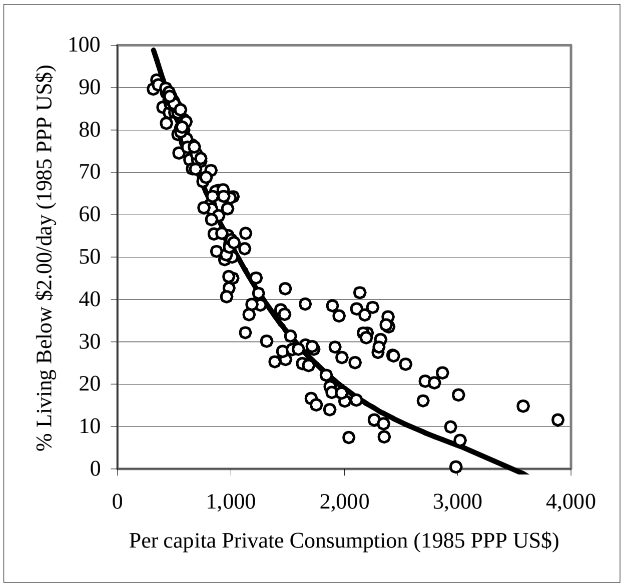

Figure 2. Survey-based $2/day Poverty Rates as a Function of Annual per Capita Consumption

The data in Figure 1 provide some useful insights into the nature of distributional poverty for per capita consumption levels of up to $4,000/year. At low levels of consumption, the majority of a country's population is living at consumption levels below $1/day. This is called generalized poverty. With generalized poverty, the low level of average consumption in the nation is the main reason for poverty, and there is not much variation in poverty rates across nations due to the differences in inequality. This is demonstrated by the relatively low level of scatter around the trend line at consumption levels of less than $1,000/yr, despite wide differences in inequality across these countries. As consumption levels increase, and as poverty rates consequently drop to less than 50%, there is more vertical scatter across countries, with distributional impacts causing a wide range of poverty outcomes at a given level of per capita consumption. More equitable distribution results in lower poverty rates, and inequitable distribution results in higher poverty rates.

Figure 2 shows a similar pattern for the $2/day measure of poverty, only with a more extensive segment of generalized poverty. Again, distributional poverty is reflected in the vertical scatter of data points at any given level of per capita consumption.

The logistic trend pattern in each diagram comes from the fact that per capita consumption tends to be distributed in a lognormal or even Weibull distribution. As mean per capita consumption increases from very low levels, the poverty rate at first decreases rapidly as the poverty cut-off level moves from the right hand tail of the distribution through the middle mass of the distribution. As mean consumption increases further, the rate of poverty reduction slows, since the poverty cut-off is now moving along the left hand tail of the distribution. Finally, poverty is eliminated when all households experience consumption levels greater than $365/yr. (in the case of $1/day poverty) or $730/yr. (in the case of $2/day poverty), which occurs at average consumption levels of roughly $4,000/yr. and $5,000/yr. respectively.

THE LINK BETWEEN MINING AND DISTRIBUTIONAL POVERTY

Several of the economies in the World Bank data set depicted in Figures 1 and 2 are mining-intensive. Using the country listing in Table 1 of Ross (2001), I specify Botswana, Sierra Leone, Zambia, Mauritania, Niger, Chile, Jordan, Bolivia, Central African Republic (C.A.R.), Peru, Ghana, and Zimbabwe to be the mining-intensive economies in the data set.[2] This includes the majority of the poorest mining nations in the world.

Figures 3 and 4 show the same plots as in Figures 1 and 2, only with these mining economies identified as solid black circles, and with the trend lines removed for visual clarity. If mining economies tend to have increased distributional poverty, this would be indicated by the solid black circles being clustered at the upper end of the scatter across the various consumption levels. There is no visual evidence that the mining economies have higher levels of distributional poverty than other poor countries.

This visual determination is supported in a statistical analysis of the data reported in Tables 1 and 2. Regressions 1 and 5 report an ordinary least squares regression of the impact of consumption level and inequality on poverty measured at both the $1/day and $2/day levels, respectively. In this data set, poverty is completely determined by consumption level and inequality. Since the theoretical relationship between poverty and consumption is a logistic function, I estimate the relationship using a 3^{rd}-order Taylor series expansion of consumption. Deviation from the trend should be completely identified by income inequality, which is proxied by the Gini coefficient. In theory, given the definition of poverty and the distribution of income, inequality differences will be a non-constant function of consumption, with least impact at very low and very high levels of consumption. To model this, I include both a Gini coefficient a cross product term. The regression R^2s are high, but are not the expected 1.00 due to the Gini coefficient being an imperfect measure of inequality and because the logistic trend is not perfectly modeled by the 3^{rd}-order Taylor series. The residuals in these regressions suffered from heteroskedasticity. This causes the coefficient estimates to be inefficient but unbiased. The *t*-statistics, however, are biased. I therefore report the White heteroskedasticity-consistent *t*-statistics, which are unbiased.

The estimated trend line from regressions 1 and 5 is shown in Figures 1 and 2, respectively. The trend line is based on the average level of inequality over the sample, with a Gini coefficient value of 44.51. In that sense, the trend line shows the estimated rate of poverty as consumption increases were inequality to remain constant. The vertical scatter from the trend then shows the poverty impacts of differences in inequality.

The next step is to replace the Gini coefficients with structural determinants of income inequality. This will reveal whether and to what extent the vertical deviations from the trend displayed in Figures 1 and 2 can be explained by mining activity. Ideally, one would want to measure annual mining activity by some kind of index. Indices such as mining as a percent of GDP or mining as a percent of exports are available, but are subject to considerable criticism as to the extent to which they provide

[2] Ross defines mining and energy economies as those with high levels of non-fuel mineral exports as a share of GDP. Davis (1995) shows that mineral dependence is persistent, and so even though Ross's index of mining and energy economies pertains to 1995 data, that same set of countries can be considered to be mineral economies throughout my 1981 - 1998 sample period.

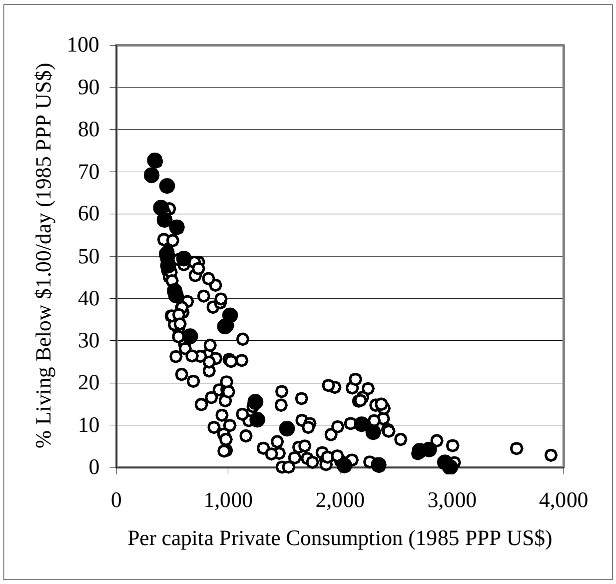

Figure 3. Survey-based $1/day Poverty Rates as a Function of Annual per Capita Consumption, with Mining Economies Shown as Solid Black Circles.

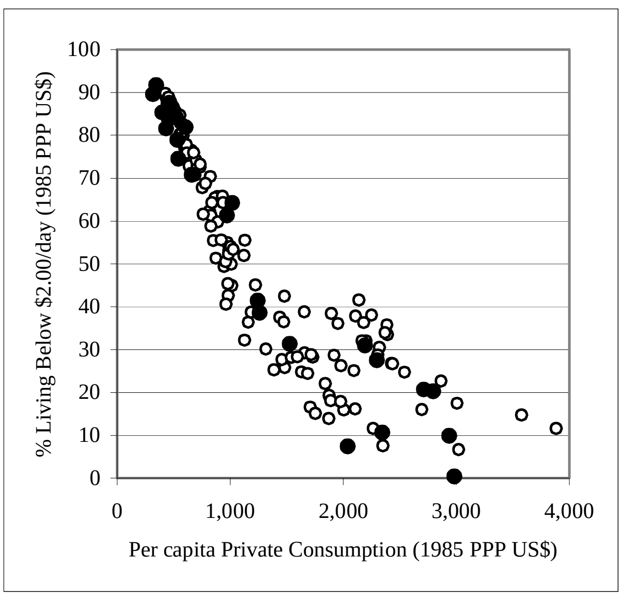

Figure 4. Survey-based $2 /day Poverty Rates as a Function of Annual per Capita Consumption, with Mining Economies Shown as Solid Black Circles.

Table 1: Regression of $1/day Poverty Rate on per Capita Consumption and Economy Dummies

	Dependent variable: $1/day poverty rate			
	1	**2**	**3**	**4**
Constant	55.57 (15.72)**	89.75 (20.58) **	90.69 (23.41) **	91.05 (23.41) **
Cons	-0.12 (-21.90)**	-0.11 (-10.76)**	-0.12 (-13.46)**	-0.12 (-13.53)**
$Cons^2$	5.13E-05 (14.63)**	4.58E-05 (7.68)**	5.14E-05 (9.64)**	5.15E-05 (9.64)**
$Cons^3$	-6.81E-09 (-10.35)**	-6.30E-09 (-6.15)**	-7.14E-09 (-7.64)**	-7.11E-09 (-7.60)**
Gini	1.040 (13.87)**			
Gini∗Cons	-1.11E-04 (-2.34)*			
Mining Dummy		1.87 (1.01)	-1.06 (-0.62)	-1.42 (-0.79)
Oil, Gas and Coal Dummy		-6.55 (-4.33)**	-6.48 (-5.30)**	-6.51 (-5.48)**
LatAm/C Dummy			11.98 (5.47)**	13.07 (7.74)**
Africa Dummy			9.35 (9.15)**	9.88 (5.50)**
MENA Dummy				3.11 (1.12)
n	153	153	153	153
R^2	0.961	0.806	0.872	0.873
Adjusted R^2	0.960	0.800	0.865	0.866

Note: White heteroskedasticity-consistent *t*-statistics given in parentheses.
** = significant at the 1% level of confidence.
* = significant at the 5% level of confidence.

Table 2: Regression of $2/day Poverty Rate on per Capita Consumption and Economy Dummies

	Dependent variable: $2.00/day poverty rate			
	5	**6**	**7**	**8**
Constant	143.58 (56.23)**	135.62 (43.24)**	137.51 (40.13)**	136.13 (42.41)**
Cons	-0.14 (-33.36)**	-0.12 (-15.36)**	-0.13 (-15.53)**	-0.12 (-15.84)**
$Cons^2$	3.13E-05 (10.26)**	4.41E-05 (9.17)**	4.74E-05 (9.64)**	4.69E-05 (10.13)**
$Cons^3$	-3.50E-09 (-7.48)**	-5.54E-09 (-6.83)**	-6.01E-09 (-7.34)**	-6.09E-09 (-7.82)**
Gini	-0.33 (-3.94)**			
Gini∗Cons	7.35E-04 (10.68)**			
Mining Dummy		-4.13 (-2.40)*	-5.00 (-3.02)**	-3.63 (-2.50)*
Oil, Gas and Coal Dummy		-4.09 (-2.96)**	-3.77 (-3.01)**	-3.66 (-3.23)**
LatAm/C Dummy			7.46 (5.15)**	3.30 (1.99)*
Africa Dummy			3.25 (2.54)*	1.26 (1.11)
MENA Dummy				-11.79 (-6.27)**
n	153	153	153	153
R^2	0.985	0.936	0.947	0.955
Adjusted R^2	0.985	0.934	0.944	0.952

Note: White heteroskedasticity-consistent *t*-statistics given in parentheses.
** = significant at the 1% level of confidence.
* = significant at the 5% level of confidence.

an appropriate numerical indication of resource dependence (Wright and Czelusta 2003). There is also the question as to whether one would want to measure contemporaneous mining activity and poverty or use a lagged relationship. To avoid these empirical issues, as a first cut I instead identify the mining economies in the data set using dummy variables. Since oil and gas economies have also been linked with higher distributional poverty, I include separate dummies for those countries in the data set that Ross (2001) identifies as energy intensive (Cote d'Ivoire, Indonesia, Algeria, Venezuela, Ecuador).

Regressions 2 and 6 (Tables 1 and 2) replace the Gini inequality terms with these dummies. As expected from the visual inspection of Figures 3 and 4, the mining economies in the sample do not have higher than average distributional poverty; the Mining Dummy coefficient in regression 2 is positive but statistically insignificant, and the coefficient in regression 6 is negative and significant. The energy economies have lower distributional poverty than average in both regressions.

Given the Latin American/Caribbean and Sub-saharan African countries' high levels of inequality (Besley and Burgess 2003), Regressions 3 and 7 add regional dummy variables. This is to control for the possibility that the coefficients on the economic activity dummies in Regressions 2 and 6 are being influenced by region-specific factors (culture, history, government policy) rather than the type of economic activity. As expected, both regions have significantly higher levels of distributional poverty than average. Adding these regional dummies causes the sign on the mining dummy in the $1/day to become negative, but the coefficient is still statistically insignificant.

Finally, another region that has attracted attention, this time for its low income inequality, is the Middle East and North Africa (MENA) countries: Algeria, Egypt, Iran, Jordan, Morocco, Tunisia, and Yemen (Adams and Page, 2003). Adding this region as a dummy in the regressions (Algeria, Egypt, Jordan, Morocco, and Tunisia are the five MENA countries in the sample) verifies that the region has low distributional poverty when measured at the $2/day level. Adams and Page argue that high government employment and high remittances from workers in the nearby oil fields are the reason for the low inequality in Egypt and Jordan. Here, then, at the $2/day poverty measure, is additional evidence that oil extraction in the Persian Gulf is having a positive impact on poverty in surrounding economies. The fact that oil production in one economy can have positive impacts on poverty in another country, via remittances, is often overlooked in the literature and is not captured in the regressions in Tables 1 and 2.

Regressions 4 and 8, which contain consumption, region, and economic activity as independent variables, explain 87% and 95% of variation in $1/day and $2/day poverty rates, respectively. Remaining variation did not disappear with alternative functional forms for consumption, and is likely to be due to other factors that cause inequality in consumption and that I have not modeled.

These results suggest that after controlling for the level of consumption and regional location, mining activities within a nation have no significant impact on its $1/day poverty rate. Oil and gas extraction lowers the rate of poverty by about 6 percentage points.

When poverty is instead measured by the percentage of the population consuming less than $2/day, mining and energy activities have positive impacts on poverty, more than offsetting the negative Africa and Latin America effects. In this sense, and given the large literature devoted to the Latin America's income inequality problem, the extractive sector effect is not only statistically significant, but large.

The analysis reveals that when examining international differences in poverty, using the correct data matters. Ross (2001, 16) finds that mining dependence is correlated with *higher* levels of poverty, and concludes his analysis by stating that "oil and mineral dependence produce a type of economic growth that offers few direct benefits for the poor..." While there are many problems with Ross's empirical analysis (see Davis and Tilton 2002), his use of nationally-determined poverty data precludes the international comparisons that he carries out. He also controls for consumption levels using national accounts-based per capita GDP, inadvisably mixing survey-based poverty data with national accounts-based income data (Deaton 2003a). The proposed relationship between distributional poverty and mineral-dependence is most likely a spurious result attributed to the use of inappropriate data.[3]

I now return to the seven countries identified by UNCTAD as being among the most poverty-stricken in the world: Central African Republic, Congo, Guinea, Liberia, Niger, Sierra Leone, and Zambia. Four of these countries (Central African Republic, Niger, Sierra Leone, and Zambia) are included in the World Bank poverty data set. All are located within Sub-saharan Africa, and all are mining economies. The expected rates of $1/day and $2/day poverty for these countries in selected years are given in Tables 3 and 4, calculated from the countries' levels of per capita consumption and regional location using the results in Regressions 4 and 8, and, in the case of $2/day poverty, including the statistically significant mining dummy impact. Also given in Tables 3 and 4 is these countries' actual poverty rates. The expected poverty levels are high, but they can in large part be explained by these countries' low levels of consumption and their location within Sub-saharan Africa.

Table 3: Actual and Expected $1/day Poverty Rates in Selected Poor Mining Economies

Country	**Year**	**Per Capita Consumption ($/yr.)**	**Expected Poverty Rate (%)**	**Actual Poverty Rate (%)**
C.A.R.	1993	$455	55.7	66.6
Niger	1992	$523	50.6	41.7
Niger	1995	$402	60.0	61.4
Sierra Leone	1989	$544	49.0	56.8
Zambia	1991	$434	57.4	58.6
Zambia	1993	$319	67.3	69.2
Zambia	1996	$346	64.9	72.6

[3] Michael Ross has kindly shared some of his data with me, but I am unable to replicate his original results, and am therefore unable to reliably test this proposition.

Table 4: Actual and Expected $2/day Poverty Rates in Selected Poor Mining Economies

Country	**Year**	**Per Capita Consumption ($/yr.)**	**Expected Poverty Rate (%)**	**Actual Poverty Rate (%)**
C.A.R.	1993	$455	86.1	84.0
Niger	1992	$523	80.5	84.1
Niger	1995	$402	90.8	85.3
Sierra Leone	1989	$544	78.8	74.5
Zambia	1991	$434	87.9	81.5
Zambia	1993	$319	98.6	89.5
Zambia	1996	$346	96.0	91.7

ANOTHER LOOK AT ECONOMIC GROWTH, POVERTY, AND INEQUALITY

This analysis shows that the extreme poverty in the poorest mining countries appears to be due to a combination of low consumption levels and income inequality brought about by regional factors. It is not a result of some institutional “anti-poor” sentiment associated with extractive activities. If anything, once one controls for the negative distributional poverty found in the regions in which mining tends to be located, mining activity is correlated with reduced, rather than increased, distributional poverty.[4] The mechanism by which this happens is not clear. It could be that mining gets income into the hands of the poorest members of a nation, either directly, through wages, or indirectly, through remittances to family members or multiplier spending effects.

These results prove troubling to criticisms that economic growth in mining economies tends to be anti-poor. Economic growth, quite naturally, is expected to reduce income poverty through the very fact that average national incomes rise during growth periods, and World Bank data bears this out: positive real economic growth spells unambiguously reduce income poverty 78% of the time, and negative growth spells increase poverty 86% of the time (Davis 2004).[5] Parsing the data into extractive and non-extractive economies using Ross’s (2001) categorizations shows no evidence that growth episodes in extractive economies are any worse for the poor than in non-extractive economies (Table 5); positive growth spells were pro-poverty in 74% (25 of 34) of the episodes in extractive economies, and in 79% (128 of 173) in non-extractive economies.

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[4] Causality in not proved, but it is hard to think of mechanisms by which reduced distributional poverty could impact resource endowments. Resource endowments are, however, necessary but not sufficient for mining activity, and there is some endogeneity that remains at issue. Heemskerk (2001), for example, finds that economic recession and unemployment increase small-scale mining activity in the Amazon.

[5] Davis examines 270 growth spells in 87 countries.

Table 5: Summary of Growth and Poverty

	Positive Growth Spells		Negative Growth Spells		Total
	Count		Count		
	Extractive Economies	Non-extractive Economies	Extractive Economies	Non-extractive Economies	
Pro-poverty	25	128	0	3	156
Not pro-poverty	2	7	12	25	45
Inconclusive	7	29	1	2	39
Total	34	163	13	30	240

Table 6: Summary of Growth and Inequality

	Positive Growth Spells		Negative Growth Spells		Total
	Count		Count		
	Extractive Economies	Non-extractive Economies	Extractive Economies	Non-extractive Economies	
Pro-poor	15	61	3	8	87
Not pro-poor	9	69	7	16	91
Inconclusive	10	43	3	6	62
Total	34	163	13	30	240

As mentioned earlier, there is also the concern that mineral economies have higher than normal levels of income inequality (Leamer 1999, Ross 2001), creating heightened distributional poverty. Again turning to World Bank data, positive growth spells create decreased income inequality (growth is "pro-poor") about as often as they create increased income inequality (the growth is not "pro-poor") (Davis 2004). If we again parse the growth spell data into extractive and non-extractive economy cohorts, positive growth spells in the extractive economies have a higher tendency to be pro-poor (15 of 34 cases) than in non-extractive economies (Table 6). Though the sample is small, the message is persistent: while mineral economy growth may be slower than expected, that growth has, if anything, been favorable to the poor, reducing poverty directly through higher incomes for the poor, and reducing poverty indirectly by reducing income inequality and by this reducing distributional poverty.

MINING, POVERTY, AND SUSTAINABLE DEVELOPMENT

The common interpretation of sustainable development comes from the Brundtland Report (WCED 1987, p. 43):

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Discussions of mining and sustainable development often take off from this point, with concerns about extraction and consumption of minerals now impacting the welfare of future generations, either through exhaustion of the resource (e.g., Otto and Cordes 2000), or through impacts on long-term economic growth (e.g., Sachs and Warner 2001). But the full paragraph from the Brundtland Report is:

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of "needs," in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

In fact, the very next page of the Brundtland Report states, "*Sustainable development requires meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for better living*" (italics added). In its full context, sustainable development is as much concerned with poverty today as it is with future impoverishment (Rao 2000, pp. 85-87), and it is clearly the intent of current development initiatives that sustainable development have as its goal a reduction in poverty (UNDP 2003). Any examination of the role that mining plays in sustainable development must therefore consider not only the role that shrinking mineral endowments and the environmental consequences of their extraction play in the uncertain welfare of future generations, but also the role that current mineral extraction plays in reducing contemporary poverty.

The role for mining in sustainable development is to at least do no harm to the poor. From a distributional standpoint, this condition appears to be satisfied within the mining economies themselves; my analysis shows that past and current mineral exploitation strategies have not made poverty worse in the poorest mining economies, and, at the $2/day poverty level, may have made it better. Coal, oil, and gas extraction also appear to have decreased distributional poverty in the energy exporting economies. In this sense, extractive activities are not inconsistent with enhancing sustainable development. If there are sectors that are desirable within sustainable development and sectors that are not, mining activities are certainly not within the latter group. Not only does mining activity appear to increase the distribution of consumption towards the poorest households in a nation, but it may impact intragenerational sustainable development, the second aspect of the Brundtland definition, through consumption-induced interest in long term human capital formation, preservation of the environment, and reduced family size.

Taking a broader geographic perspective, the lower incidence of poverty in the selected MENA countries may be indicative of an additional benefit of extractive activities in surrounding countries. If mining also stimulates worker remittances and through this increases consumption of the poorest peoples in neighboring countries—an example might be South Africa's remittances to Lesotho and Swaziland, which, despite being small, landlocked countries have medium levels of human development (UNDP 2003)—this would further motivate the role for mining in sustainable development. Moreover, and a point that is often overlooked, increased availability of mineral resources decreases the scarcity of consumables. By lowering the real prices of mineral-intensive goods in both mineral exporting and mineral importing economies, mining activities have an additional, indirect effect on the welfare of the poor by increasing the purchasing power of income.

Finally, several mining economies are clustered at the lower levels of consumption per capita (see Figures 3 and 4). While increased mining activity may serve to equalize consumption, there is little scope for this to reduce poverty in these countries. Mining's impact here is more subtle. Figure 5 provides a representation of the distribution of consumption for Zambia in 1996. Poverty is generalized, with the majority of the population living under $1/day. With an average consumption

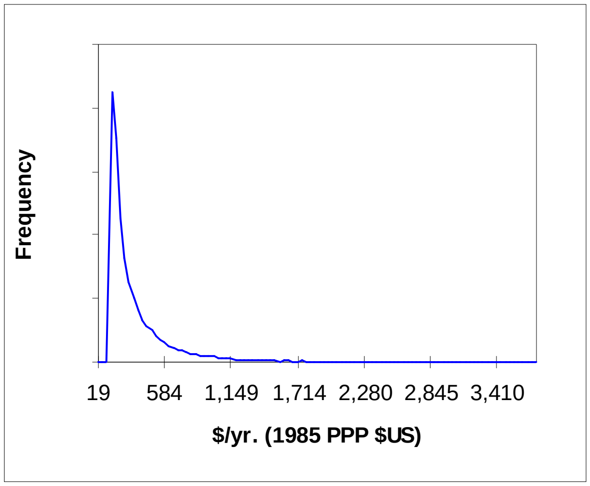

Figure 5. Representation of the Distribution of per Capita Consumption for Zambia, 1996, Based on World Bank Household Survey Data.

level of $346/yr., there is no redistributive policy that could eliminate $1/day poverty. Indeed, if consumption were equally divided, with each citizen consuming $346/yr., Zambia would have 100% of its population living on less than $1/day. In fact, it is only because consumption is unequally divided that the $1/day poverty head count is less than 100%. In Zambia and in other poor mining nations poverty is endemic, and it exists because of nationally low consumption levels. If poverty is to be reduced, the economy must grow. Mining's influence on economic growth may have been negative in the past, but it may prove positive in the future via the impacts of reduced income inequality on subsequent economic growth (UNDP 1996, Ranis et al. 2000, Ravallion, 1997), in turn reducing poverty even in a country like Zambia.

AREAS FOR FUTURE RESEARCH

The absolute poverty lines used in this paper are only a uni-dimensional and monetary indicator of poverty. Poverty is also reflected in non-monetary ways, such as health, which may depend on relative rather than absolute consumption levels (Deaton 2003b). For this reason, in 1997 the United Nations created the Human Poverty Index (HPI) for a group of 78 developing countries (UNDP 1997). That index takes into account premature death rate, adult illiteracy, population without access to safe water and proper health services, and underweight children. In 1998, it created a parallel Human Poverty Index (HPI-2) for selected industrial countries (UNDP 1998). As the United Nations points out, "Regression analysis indicates a weak relationship between the headcount index of income poverty and HPI. So, in monitoring progress, the focus should not be on income poverty alone, but on indicators of human poverty as well" (UNDP 1997, p. 22). Further work will require examining the link between mining activity and this broader index of human poverty and development.

Most nations have mineral resources, but not all of these resources are of sufficient grade or quantity to sustain a large formal mining sector. Near-surface resources that can be exploited by artisanal mining are, however, common. Where there is high incidence of extreme poverty, there is a large motivation for unskilled labor to be involved in artisinal mining. Artisinal mining, in turn, can create environmental problems that impact human health (Heemskerk 2001). Mining within this context is a result of poverty, and possibly sets up a vicious circle of local underdevelopment. Additional research in this regard is likely to yield fruitful insights into the links between small-scale mining, poverty, and sustainable development.

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