# NON-RENEWABLE RESOURCE BOOMS AND THE POOR

Graham A. Davis[1]
Division of Economics and Business
Colorado School of Mines
1500 Illinois St.
Golden, Colorado 80401

Arturo Vasquez Cordano
Division of Economics and Business
Colorado School of Mines
1500 Illinois St.
Golden, Colorado 80401

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## ABSTRACT

There are frequent suggestions that economies that specialize in mineral and energy extraction generate a type of growth that fails to concurrently benefit the poor. The dynamic effects creating this outcome could include increasing income inequality associated with extraction-led growth or Dutch Disease effects that inhibit poverty-reducing manufacturing employment. Others claim that resource extraction promotes poverty alleviation. No one, however, has directly examined the dynamics of resource extraction and the poor. This paper uses longitudinal data on income growth by quintile in 57 countries to statistically assess how the level of non-renewable resource extraction and changes in the level of extraction affects the poor. Our results indicate that at the national level there is nothing about extractive activity that overturns the adage that economic growth is concurrently good for the poor. If anything, a resource boom improves the likelihood that a growth spell will benefit the poor.

Keywords: Pro-poor growth, mining, energy, resource booms, international.

[1] Corresponding author.

The economic plight of Botswana's poor has worsened as a direct consequence of the mining sector's success.

Curry (1987, p. 1)

Mining can contribute to poverty reduction in a variety of ways. …In countries such as…Botswana…, substantial positive fiscal impact from mining has contributed to economic and social development.

Klugman (2002b, p. 442)

## 1. Introduction

Mineral and energy extraction can have both concurrent and lagged impacts on a nation's economic development. Most research to date has focused on lagged impacts, investigating the relationship between an initial and possibly ephemeral extractive boom and the rate of economic growth or development over subsequent decades. That research is largely supportive of a "resource curse," whereby long-run economic growth is impeded by earlier extractive activity.[2] Bulte, Damania and Deacon (2005) find that there are also inferior lagged human development outcomes in mineral and energy-based economies.

There is also a prevalent belief, originating in the anti-extractive literature produced by several NGO's, that mineral and energy dependence "produce a type of economic growth that offers few direct benefits to the poor," and "make pro-poor forms of growth more difficult" (Ross 2001, p. 16).[3] It is well understood that non-renewable resource economies experience rapid economic growth as their extractive sectors develop and expand (Davis 2009). It is also thought that growth tends to be good for the poor (Dollar and Kraay 2002; Kraay 2006). The anti-extractive literature simply claims that,

[2] See Stephens (2005) as well as Davis and Tilton (2005) for a review of the literature and theories relating to the resource curse. Recent empirical investigations suggest that the resource curse may be a statistical artifact (Alexeev and Conrad 2008; Brunnschweiler 2008; Brunnschweiler and Bulte 2008; Lederman and Maloney 2007).

[3] See also Christian Aid (2003), Curry (1987), Page (2006), Pegg (2003; 2004), Power (2002; 2008), and Ross (2003).

contrary to expectations, growth in extractive economies is not good for the poor. The alleged concurrent negative impacts variously include a higher probability of increasing income inequality, decreasing employment and real incomes for the poor, and decreasing expenditures on health care and public education. Recommended policy is the prevention of or diversification away from non-renewable extractive activity. The World Bank, on the other hand, continues to promote mining and energy extraction as having positive concurrent impacts on the poor.[4] The lack of agreement is not due to differences in outcomes between different extractive economies; there is not even agreement on the impacts of extraction on the development progress of single countries (e.g., see the quotes at the start of this paper regarding Botswana, a mineral-intensive economy). In this light, there have been several calls for additional research in this area (e.g., Weber-Fahr 2002; Ross 2007).

In an effort to move the debate forward, this paper empirically investigates the impact of extraction levels and extractive booms on the concurrent welfare of the poor. Specifically, it investigates whether countries experiencing a given level of economic growth accompanied by substantial mineral or energy extraction have a greater or lesser tendency towards a pro-poor outcome than do countries whose same level of growth is not accompanied by extractive activity. The results lead us to firmly reject the hypothesis that growth accompanied by extractive activity is less likely to be good for the poor than is growth that is not accompanied by extractive activity. If anything, growth is likely to be better for the poor—or more precisely, less likely to be bad for the poor—when accompanied by increasing extractive activity, though the impact is small. In other words, if the level of extractive activity or changes in the level of extractive activity have any measurable impact on the likelihood of a

[4] See Weber-Fahr (2002), Klugman (2002b) and Pegg (2003; 2004) for a review of the Bank's position regarding mining and energy extraction and the poor.

growth spell being good or bad for the poor, it is not readily evident at the national level given the data that are available to test these claims.

## 2. The Literature on Non-renewable Resource Extraction and the Poor

While there is a small counter-literature that anecdotally extols the potential (Klugman 2002b; Weber-Fahr 2002) and realized (Bill and Springborg 1994, Booth 2003) concurrent benefits to the poor of extractive booms, the belief that extractive economies have unfavorable development outcomes during an extractive boom is now a stylized fact (e.g., Stiglitz 2007, p. 134). Exemplifying the bite that this conventional wisdom has had, the World Bank recently initiated internal and external reviews of its support for mining and oil and gas projects in developing countries (World Bank 2003). The external review found no poverty-reducing impacts of coal mining and petroleum production, and suggested that Bank support for these activities be terminated.

It is quite possible that booming extractive economies, with their unsustainable surge in economic growth, do suffer from a type of growth that is less likely to be favorable for the poor. The cross-country analyses examining growth and the poor have found only that *on average* the incomes of the poor rise with rising average incomes. As Ravallion (1997, p. 1812) notes, "An average is just that," and there are certainly countries in which the incomes of the poor have fallen despite long periods of economic growth (Lal and Myint 1996; Page 2006).[5] But the early analyses of disparities in the pro-poorness of growth have not found any statistical regularity that explains the relatively high variation in cross-country poverty outcomes for a given growth rate (Chen and Ravallion 2001; Dollar and Kraay 2002), and certainly have not singled out extraction as being significant. The analyses instead

[5] Page (2006) measures progress for the poor as increasing income of the bottom 20th percentile of income, while Ravallion (1997) defines the poverty rate as the headcount index of those living on less than $1/day at 1993 Purchase Power Parity.

found that variations in poverty outcomes associated with distributional effects are unimportant compared to the impacts of variation in growth rates. This leads Kraay (2006, 220) to state that "the search for pro-poor growth should begin by focusing on determinants of growth in average incomes."

An anti-poor bias in extractive economy growth may nevertheless arise due to a series of concurrent dynamic sectoral mechanisms as the extractive resource sector grows, and Dutch Disease pressures ensue. These have been suggested to be: a crowding out of jobs for unskilled or semi-skilled workers (Ross 2003, p. 7); the lack of demand for labor due to low labor intensity of production (Loayza and Raddatz 2006); a crowding out of natural resources that the poor rely upon (Curry 1987, Power 2008); downward pressure on wages due to a capital-intensive export base (Lal and Myint 1996, pp. 187-88); and a reduction in agricultural sector jobs, a sector that is suggested to have special importance in reducing poverty (Loayza and Raddatz 2006; Ross 2003, p. 8, 2007; World Bank 2008). Extractive booms are also suggested to result in a reduction in manufacturing jobs that favor women, older workers and the poor (Collier 2007; Ross 2004, 2007). Some empirical studies have found manufacturing-led growth to be especially favorable to the poor (Birdsall and Londoño 1997a, 1997b), though others have not (Ravallion and Datt 1996).

On the other hand, extraction takes place mainly in rural areas, providing employment opportunities where poverty rates tend to be the highest (McMahon and Remy 2001). It generates infrastructure and markets, shown to reduce regional poverty (Klugman 2002a; Escobal and Ponce 2002). Extraction also has positive spill-over effects. In South Africa, multiplier decomposition shows agriculture, mining, and services to be the sectors whose growth will be most beneficial to the poor (Khan 1999). A regionalized computable general equilibrium simulation of copper-led growth in Zambia predicts the national poverty rate to fall from 75% to 57% over a 15-year copper boom (Thurlow and Wobst 2006).

As opposed to these dynamic effects, static sectoral effects reflect development conditions created by the presence of, rather than changes in the level of, a booming extractive sector. Political economy models suggest that rent-seeking, corruption, and the possibility of civil wars associated with booming extractive activity in an economy can cause growth spells from which the poor do not benefit (Ross 2004; Stiglitz 2007).[6] In addition, the socio-economic conditions for pro-poor growth may not exist in booming extractive economies. For example, extractive economies may have high income inequality (Gylfason and Zoega 2003; Leamer et al. 1999; Ross 2001; Sokoloff and Engerman 2000), and there is empirical evidence that income inequality reduces the pro-poorness of current growth (Bourguignon 2003; Ravallion 1997).

There is not much empirical work investigating these static or dynamic sectoral impacts, but that which exists tends to support the proposition that resource booms are good for the poor. We first review the research on static sectoral effects. In Botswana, mining revenues funded the government's drought relief program that prevented rural poverty from increasing during the 1979-to-1988 drought (Valentine 1993). State-owned extractive companies sometimes fund massive social programs directly (Ellsworth 2004). Interviews of more than 1,500 households in 35 villages in northern India found diversification away from agricultural income sources to be the single most important factor in households moving out of poverty (Krishna 2004). Working for wages in the mining sector is specifically mentioned as an income-diversifying household activity. Davis (1995) examined the development performance of 22 developing economies specializing in mining and energy extraction. These economies had on average higher mean and median income levels and superior development

[6] Brunnschweiler and Bulte (2008) argue that weak institutions create extractive economies, rather than the other way around. If this is the case, one would still expect to see extractive economies have a higher frequency of anti-poor growth outcomes, although one would not blame resource extraction activities in this case.

indicators and trends in those indicators than 57 developing countries that had never experienced a resource boom. Sachs (2007) finds that oil-producing nations are better off than oil-poor nations. Booth (2003) finds the dame for states within Indonesia with high levels of mining activity.

In an analysis of dynamic sectoral effects, Ravallion and Datt (1996) use a time-series study of 23 growth spells in India to show that primary sector growth statistically reduced three measures of poverty in both rural and urban areas, while secondary sector growth did not.[7] Loayza and Raddatz (2006), who perform a more disaggregated sectoral analysis on a cross-section of single growth spells in 51 countries, find that mining sector growth is positively correlated with reductions in the headcount poverty index, but that mining sector growth has no statistically reliable impact on that index after controlling for the impacts of growth in other sectors.[8] They argue that the lack of mining sector impact arises from its low labor intensity.

This paper supplements and extends these empirical analyses in several ways. First, since there is no prima facie reason to believe that anti-poor effects from mining would differ from anti-poor effects of oil extraction, we combine mining and energy into an aggregate extractive sector. Second, where Davis (1995) and Booth (2003) categorized economies or states as either extractive or non-extractive, we allow for a continuous measure of extractive intensity such that changes in extractive intensity can be mapped during a growth spell. Third, while Ravallion and Datt (1996) and Loayza and Raddatz (2006) looked only at growth in incomes of those below a specified poverty line, we adopt an unambiguous qualitative measure of poverty reduction that holds for all poverty levels. We also expand the development space to look at changes in income inequality, both in addition to poverty

[7] The primary sector includes agriculture, forestry, fishing, mining, and quarrying. The secondary sector includes manufacturing, construction, electricity, gas, and water supply.

[8] It is not clear whether the mining sector includes energy extraction.

reduction and as a separate measure of the quality of economic growth. Fourth, where Ravallion and Datt (1996) and Loayza and Raddatz (2006) only controlled for dynamic effects (sectoral growth), we simultaneously control for both the dynamic (sectoral growth) and static (sectoral level) effects of mining and energy extraction on the poor. Finally, the past studies have used either large-sample cross sectional or small-sample time series estimation techniques. We use a large-sample panel data set to examine the longitudinal effects of extraction-led growth. The need for longitudinal studies of resource extraction and poverty outcomes is identified in Freudenburg (1992) and Ross (2007). Easterly (1999) also makes a general case for longitudinal study of development outcomes during growth.

## 3. Defining Pro-poor and Anti-poor Growth

White and Anderson (2001) argue that those who refer to pro-poor growth are implying that a given level of positive growth increases the absolute income of the poor *and* decreases income inequality. International development organizations also equate development progress with the twin outcomes of reduced income poverty and reduced income inequality (Asian Development Bank 2004; United Nations Development Programme 2003). Sen (1997, p. 212) notes that "*relative* deprivation in terms of *incomes* can yield *absolute* deprivation in terms of *capabilities*," and argues for distribution-adjusted poverty measures, even if it removes some of the precision of the standard income-based poverty measures. The literature criticizing resource-dependent growth, referred to in the Introduction of this paper, also suggests that a change in income inequality matters, not only for its effect on current poverty reduction, but also for its impact on social unrest and educational and health spending. We therefore initially qualitatively define a pro-poor growth outcome as one that simultaneously decreases absolute income poverty *and* decreases relative income inequality. An anti-poor outcome is one that

increases income poverty *and* increases income inequality. We then go on to a more traditional analysis and separately examine poverty and inequality changes associated with extractive activity.

## 4. Measuring Pro-poor and Anti-poor Growth

The inclusion of income inequality effects in our definition of pro-poor growth brings with it challenges with respect to the quality of longitudinal data on income inequality. We have elected to use the World Income Inequality Database v1 (WIID1) and v2 (WIID2) compiled by the World Institute for Development Economics and Research at the United Nations University (UNU – WIDER).[9] WIID is a secondary database which consists of a checked, corrected, and updated version of Deininger and Squire (1996) database from the World Bank, and includes new estimates from the Luxembourg Income Study and TransMONEE database, as well as other new sources as they have became available.[10] Atkinson and Brandolini (2001) have noted not only the problems with secondary income inequality data, but also the problems when trying to examine changes in inequality over time using this data given the lack of uniform income survey practices. Our own experience building this data set confirms that the comparability of the data across the various income surveys, even within a single country, leaves much to be desired. The compilation of WIID has taken into account most of the recommendations made by Atkinson and Brandolini (2001) regarding the proper building of secondary

[9] UNU-WIDER *World Income Inequality Database*, Version 1.0, September 2000, http://website1.wider.unu.edu/wiid/download.htm, and Version 2.0c, May 2008, http://www.wider.unu.edu/research/Database/en_GB/wiid/.

[10] See UNU-WIDER (nd) and Mukhopadhaya (2004) for further details about this dataset.

data sources for income distribution studies. It is recognized in the literature that the WIID is the best available source to carry out income distribution and growth studies at a country level.[11]

Given the lack of consistent survey methods over time, we sought to generate a measure of pro-poorness that was fairly insensitive to variations in income inequality measurements due to inconsistent survey designs. We also sought a measure of pro-poor growth that included both income and distribution effects, and settled on White and Anderson's (2001) definition that pro-poor growth is growth where the poor's share of incremental income exceeds their current share.[12] White and Anderson give the example where the poor, defined as those in the lower 20% of income in an economy, initially have an income share of 6%, and the rich, defined as those in the upper 20% of income, initially have an income share of 35%. If 7 cents of a dollar's worth of growth goes to the poor and 34 cents goes to the rich, this is pro-poor growth.

We implement this definition of pro-poor growth using Son's (2004) method of measuring pro-poor growth, which satisfies the need for a robust measure of growth spell quality. Son's method relies on the generation of a poverty growth curve measure, $g(p)$,

$$g(p)_{i,t} = \frac{1}{\tau}\ln\left(\frac{RGDPCH_{i,t+\tau}\ I(p)_{i,t+\tau}}{RGDPCH_{i,t}\ I(p)_{i,t}}\right) = \frac{1}{\tau}\ln\left(\frac{RGDPCH_{i,t+\tau}}{RGDPCH_{i,t}}\right) + \frac{1}{\tau}\ln\left(\frac{I(p)_{i,t+\tau}}{I(p)_{i,t}}\right), \qquad (1)$$

where $g(p)$ is the real per capita growth in cumulative income quintile $p$ during a growth spell, $I(p)$ is the cumulative income share at the $p^{th}$ percent level in the $i^{th}$ country at time $t$, *RGDPCH* is the

[11] According to Mukhopadhaya: "The quality of the inequality database [WIID1] for OECD and other developed countries is quite high. For the developing countries, the researchers made considerable efforts to cleanse the data and calculate quite reliable inequality figures. Despite its minor limitations, the WIID is perhaps the best data set available now for time series inequality examination. For cross country investigation as well this data set, within its limitation, is immensely helpful" (2004, p. 233).

[12] In a growing economy this definition results in rising income shares for the poor.

Table 1: Qualitative, unambiguous characterizations of positive and negative growth spells

| Positive growth spells ($g(100) > 0$) | Characterization | Description |
|---|---|---|
| $g(p) > g(100) > 0 \ \forall \ p < 100$ | unambiguously pro-poor | income of poor increases, inequality decreases |
| $g(100) > 0 > g(p) \ \forall \ p < 100$ | unambiguously anti-poor | income of poor decreases, inequality increases |
| $g(p) > 0 \ \forall \ p < 100$ | unambiguously pro-poverty | income of poor increases |
| $g(p) < 0 \ \forall \ p < 100$ | unambiguously anti-poverty | income of poor decreases (immiserizing growth) |
| $g(p) > g(100) \ \forall \ p < 100$ | unambiguously pro-equality | inequality decreases |
| $g(p) < g(100) \ \forall \ p < 100$ | unambiguously anti-equality | inequality increases |
| | | |
| Negative growth spells ($g(100) < 0$) | Characterization | Description |
| $g(p) > 0 > g(100) \ \forall \ p < 100$ | unambiguously pro-poor | income of poor increases, inequality decreases |
| $0 > g(100) > g(p) \ \forall \ p < 100$ | unambiguously anti-poor | income of poor decreases, inequality increases |
| $g(p) > 0 \ \forall \ p < 100$ | unambiguously pro-poverty | income of poor increases |
| $g(p) < 0 \ \forall \ p < 100$ | unambiguously anti-poverty | income of poor decreases |
| $g(p) > g(100) \ \forall \ p < 100$ | unambiguously pro-equality | inequality decreases |
| $g(p) < g(100) \ \forall \ p < 100$ | unambiguously anti-equality | inequality increases |

real GDP per capita in that country, and $\tau$ is the length of the growth spell. Since $I(100) = 1.00$, $g(100)$ is the growth of real GDP per capita during the spell. Using the poverty growth curve, the quality of certain growth spells may be characterized as unambiguously pro-poor or anti-poor using the algorithms described in the first two rows of Table 1. The characterizations are unambiguous because they hold for all additive poverty measures and poverty lines (Son 2004), avoiding the need to specify

an arbitrary definition of who is poor and who is rich.[13] Patterns for $g(p)$ that are not listed in Table 1 are indicative of the growth spell having an ambiguous quality, meaning that the characterization either depends on the poverty measure or the poverty line used, or that income and inequality measures move in opposite directions. Despite the strong criteria for growth spell categorization, 45% of our sample of 169 growth spells can be characterized as either unambiguously pro-poor or anti-poor. The rest are characterized as having ambiguous effects on the poor.

When we look separately at poverty and inequality impacts, we will similarly be able to characterize growth spells as pro-poverty, anti-poverty or ambiguous, and pro-equality, anti-equality or ambiguous using the poverty growth curve and the algorithms described in rows 3 through 6 of Table 1.

## 5. Assessing the Quality of Growth in Extractive Economies

In this section we propose a reduced-form econometric framework to examine the influence of extractive activity on the quality of economic growth. The framework is constrained in part by the quality of the income inequality data; we need a method that is robust to inequality measurement error and which can handle binary growth-quality categorizations.

Assume that the impact of a growth spell on the poor is an unobserved (latent) variable $d^*_{i,t}$ affected by certain explanatory variables $X_{i,t}$ (country "$i$" in period "$t$"):

[13] These algorithms are based on second-order pro-poor judgments using relative pro-poor standards. For more on these classifications see Son (2004), Davis (2007), and Duclos (2009). The algorithms address the ambiguity that arises, for example, when in White and Anderson's example the rich get the remaining 93 cents, rather than 34 cents. White and Anderson would still classify this as pro-poor growth at the 20% income level, but as anti-poor growth at the 40%, 60%, or 80% income levels. The algorithm in Table 1 appropriately classifies this as a growth spell of ambiguous quality.

$$d^*_{i,t} = \alpha + X'_{i,t}\beta + u_i + \varepsilon_{i,t} \tag{2}$$

where $u_i$ represents the specific non-observed attributes that characterize each growth spell for country $i$ and $\beta$ is a vector of coefficients. While it is not possible to observe the latent variable, it is possible to qualitatively characterize a growth spell. For instance, a growth spell in a certain country could be unambiguously pro-poor. Suppose that a given categorization occurs when the latent variable, $d^*_{i,t}$, exceeds certain unobserved threshold, $\varphi$. We define a dichotomous variable that assigns a value of one if the latent variable surpasses the threshold and zero otherwise:

$$d_{i,t} = \begin{cases} 1 & \text{if } d^*_{i,t} > \varphi \\ 0 & \text{if } d^*_{i,t} < \varphi \end{cases}$$

It is now possible to build a probabilistic model in order to analyze the probability of a given growth spell having specific characteristics. Let the probability that $d_{i,t}$ equals one be:

$$\Pr(d^*_{i,t} > \varphi | X_{i,t}) = \Pr(\alpha + X'_{i,t}\beta + u_i + \varepsilon_{i,t} > \varphi | X_{i,t})$$

$$\Pr(d^*_{i,t} > \varphi | X_{i,t}) = \Pr\left( \varepsilon_{i,t} > -(\alpha - \varphi) - X'_{i,t}\beta - u_i | X_{i,t} \right)$$

$$\Pr(d^*_{it} > \varphi | X_{i,t}) = \Pr\left( \varepsilon_{i,t} < a + X'_{i,t}\beta \,|\, X_{i,t}, u_i \right) = F\left[ a + X'_{i,t}\beta \right]$$

where $F$ is a cumulative distribution function and $a = (\alpha - \varphi)$. The binary model which results from this derivation is:

$$P_{i,t} = \Pr(d_{i,t} = 1 | X_{i,t}, u_i) = \Pr\left( \varepsilon_{i,t} < a + X'_{i,t}\beta \,|\, X_{i,t}, u_i \right), \tag{3}$$

where $P_{i,t}$ is the probability that a country $i$ experiences a given outcome in period $t$.

The probability $P_{i,t}$ is conditioned on the explanatory variables and the non-observed specific attributes of the country. White and Anderson (2001) suggest that sectoral impacts on growth quality are likely to be country-specific. In that regard, to further control for omitted variable bias and to

emphasize the longitudinal aspect of pro-poor growth, we use a random effect Logit panel regression.[14] If $u_i \mid X_{i,t} \sim N(0, \sigma^2_u)$ and $\varepsilon_{i,t}$ follows a logistic distribution, equation (2) represents a random effect Logit model (Wooldridge 2001):

$$F(d_{i,t}, z) = \begin{cases} \dfrac{1}{1+\exp(-z)} & if\ d_{i,t} = 1 \\ \dfrac{1}{1+\exp(z)} & otherwise \end{cases} \tag{4}$$

where $z = \alpha + X'_{i,t}\beta + u_i$.

The estimation procedure of this model is not straightforward. It requires integration over the values of the random intercept effects, $u_i$, which cannot be analytically solved because the integral does not have a closed form. However, it is possible to use numerical methods to estimate this integral (Greene 2002; Wooldridge 2001).[15] In this paper we use STATA v9.2 to generate the Logit results.

We now discuss our selection of the vector of conditioning variables, *X*. White and Anderson (2001) test how various conditioning factors affect the share of incremental income received by the poorest 20% and 40% quintiles during 68 positive growth spells.[16] The higher the incremental income share (their measure), the higher the probability that a growth spell will be pro-poor (our measure).[17] They find that very few conditioning variables are statistically significant determinants of incremental

[14] We also tested a fixed effects model. Using a Hausman test, we fail to reject any difference in the regression coefficients. Since the random effects model has asymptotically more efficient estimators, we prefer it to the fixed effects model.

[15] The literature suggests using the Gauss-Hermite's quadrature method, which consists of a polynomial approximation of the integral. See Geweke (1996).

[16] This is SH20 and SH40 in their paper.

[17] Growth meets our definition of pro-poor if the incremental income share exceeds the current income share for all income percentiles less than 100. The higher the incremental income share of those in the lower 20% and 40% income quintiles, the greater the probability that it will exceed the initial income share.

income share. This result motivates them to recommend the use of a parsimonious model. Following their recommendation, we build a parsimonious model with a reduced number of conditioning factors.

There is a lack of theory as to what the conditioning variables should be once one gets away from headcount measures of poverty reduction (Bourguignon 2003). Aggregate economic growth is the first candidate. By our definition of unambiguous pro-poor growth, and given that our data measure income by quintiles, pro-poor growth requires increasing income and decreasing inequality across the bottom four income quintiles. Increasing income is more likely the higher the level of economic growth. Deininger and Squire (1996) find a strong positive correlation between aggregate growth and changes in income at each income quintile, and Davis (2009) finds a positive correlation between the quality of growth as measured here and aggregate growth level. In Deininger and Squire's sample, in three of the four cases of growth leading to declines in the absolute income of the each income quintile, annual growth was less than 2%. We want to remove this possibility that a growth spell fails the poor because its growth is either small or negative, rather than being of poor quality due to extractive activity. Our first conditioning variable is therefore *the rate of average per capita growth* during the growth spell. This variable also helps control for non-extraction related institutional capability given the widespread belief that better institutions promote better growth,[18] and for the effect other omitted variables could have on the probability of a pro-poor outcome (Sachs and Warner 2001). For instance, openness appears to impact quintile income growth (White and Anderson 2001), and overall growth is also likely related to openness. To maintain consistency between our growth spell quality measures and overall changes in consumption, our per capita income growth measure is the $g(100)$ variable from the income share survey data. Although our sample includes both positive and negative values of growth,

[18] See Alexeev and Conrad (2008) and the references therein.

we pool these spells given past findings that the poverty elasticity of growth appears to be consistent across positive and negative growth (Dollar and Kraay 2002; Ravallion 1997).

Since our aim is not to explain the pro-poorness of growth, but rather to simply test whether deviations from pro-poor growth can be explained by extractive activity, our other conditioning variables are related to extractive activity. As noted above, extractive economies can suffer a type of growth that is unfavorable to the poor either because of i) dynamic sectoral effects, where an extraction-led growth spell is not the same quality as a growth spell driven by, say, increased manufacturing activity, and ii) static sectoral effects, where political economy creates unequal sharing of growing prosperity or unfavorable socio-economic conditions create conditions that cause growth spells to be bad for the poor. The second conditioning variable is then the *average increase in real extractive exports per capita* during the growth spell. This variable is intended to capture the dynamics of growth spells that are extraction-led. For example, the variable can measure the likelihood that increasing extraction leads to increasing income inequality, which, as we noted above reduces the chance that a growth spell will be pro-poor.[19] To construct this variable, we first compute the level of real non-renewable exports per capita at the start of the growth spell:

$$RNREp_{i,t} = \frac{\left(\%O_{i,t} + \%F_{i,t}\right) ME_{i,t}}{PRICE_{i,t}\ POP_{i,t}} ,$$

where *ME* represents the F.O.B. value of manufactures exported to the rest of the world in current $US (World Bank 2007), *PRICE* is the price level of GDP in 1996 US$ as measured by the Penn World Table PPP deflator (ver. 6.1) (Heston, Summers and Aten 2002), and *POP* is population, taken from the World Development Indicators (WDI-2007) (World Bank 2007). $\%O_{i,t}$ represents the percentage

[19] It reduces it on two fronts: by decreasing the income growth of the poor, and by increasing the chance that the growth spell will fail the test of reduction in inequality.

of merchandise exports that are made up of ores and metals. This variable comprises the commodities in SITC sections 27 (crude fertilizer, stones, sand, gravel, sulphur and unroasted iron pyrites, natural abrasives including industrial diamonds, and other crude minerals), 28 (metalliferous ores, scrap), and 68 (non-ferrous metals). It excludes gold and precious stones.[20] $\%F_{i,t}$ represents the percentage of merchandise exports that are made up non-renewable fuels. The variable comprises the commodities in SITC section 3 (oil, coal, and natural gas). These variables have been taken from WDI-2007 as well. The average increase in real non-renewable exports per capita in a particular country over a growth spell that starts in period $t$ and is $\tau > 0$ years in length is then:

$$\Delta RNREp_{i,t} = \frac{RNREp_{i,t+\tau} - RNREp_{i,t}}{\tau} \ .$$

This variable, measured in 1996 PPP dollars per capita, constitutes a proxy of the extent to which domestic extraction is increasing or decreasing during a growth spell. With no reason to believe that there are asymmetric impacts of changes in extractive output on the poor—shrinking extractive activity should be pro-poor if expanding extractive activity is anti-poor—we include both positive and negative values of $\Delta RNREp_{i,t}$ in the sample.

The third conditioning variable is an *extraction intensity variable*, ($\%O_{i,t} + \%F_{i,t}$), that controls for the possibility that extractive economies have static, unfavorable socio-economic (high inequality) or political economy (poor institutions) conditions for pro-poor growth. The variable measures the percentage of merchandise exports that are made up of ores, metals, and non-renewable energy.

[20] Not capturing rents that arise from gold and gem production is clearly undesirable, but not readily remedied. However, the countries in our data set are not large exporters of gold and gems.

Because of the volatility in this measure, we follow Brunnschweiler and Bulte (2008) and average it over the time span of each growth spell.[21]

The final conditioning variable is a cross-product term that multiplies the growth in per capita extractive exports by the growth in real GDP per capita. Those who suggest that booming extractive sectors are bad for the poor are likely thinking of adverse inequality effects during positive growth episodes. It would be difficult to imagine that a booming extractive sector, even with its meager employment stimulus and possibly negative effects on equality, would be seen to be bad for the poor in a recessionary period. It cannot, for example, be crowing out employment in other sectors. Based, on this argument, the cross-product term is included to control for asymmetric extractive sector growth effects between positive and negative growth spells. These conditioning variables produce the following regression specification for a growth spell for country *i* beginning in year *t*:

$$\ln\left(\frac{P_{i,t}}{1-P_{i,t}}\right) = \beta_0 + \beta_1 g(100)_{i,t} + \beta_2 \Delta RNREp_{i,t} + \beta_3(\%O_{i,t} + \%F_{i,t}) + \beta_4(g(100)_{i,t}\Delta RNREp_{i,t}) + u_i + \varepsilon_{i,t} \quad (5)$$

We do not condition on initial level of income per capita, as others have, for two reasons. First, when longitudinal data is examined, there is no evidence of a Kuznets curve that may create a relationship between level of income and inequality (and hence the poverty elasticity of growth) (Deininger and Squire 1996). Second, because extractive economies tend to be booming developing economies, conditioning on income per capita is problematic, as it sets up an extractive economy peer group that consists of developed economies (Alexeev and Conrad 2008; Davis 2009).

We initially perform two analyses, the first using a binary (1,0) "pro-poor, other" characterization of the growth spells, where other includes ambiguous and anti-poor growth outcomes. The second uses

[21] Extractive intensity and institutional capacity are likely co-determined, and so an average value of this variable is also more likely to capture the general institutional capability of an economy than would a single observation at the start of the growth period. Since there is no suggestion that anti-poor growth creates poor institutions, endogeneity is not a concern.

a binary (1,0) "anti-poor, other" characterization of the growth spells, where other includes pro-poor and ambiguous growth outcomes. Since growth is good for the poor, the coefficient $\beta_1$ in equation (5) would be expected to be positive in the first analysis and negative in the second. Dynamic sectoral impacts will be picked up by $\beta_2$ and $\beta_4$, and static socio-economic and political economy forces associated with extraction will be picked up by $\beta_3$. In the first analysis, the hypothesis of less frequent pro-poor growth in extractive economies or during extraction-led growth would be affirmed by negative values of $\beta_2$ and $\beta_3$. In the second analysis, the hypothesis of more frequent anti-poor growth in extractive economies would be met by positive values of $\beta_2$ and $\beta_3$. The coefficient $\beta_4$ is a priori negative in the first analysis and positive in the second under the hypothesis that extractive sector growth is bad for the poor during positive growth spells and good for the poor during negative growth spells. The alternative hypothesis is that there is no unambiguous impact of extractive activity level or change in level on the quality of a growth spell: $\beta_2 = \beta_3 = \beta_4 = 0$.

## 6. Data

Our sample contains 169 growth spells across 57 developed and developing economies. The limiting factor in including more growth spells in the sample was the availability of extractive activity data in some of the poorer countries and the availability of income inequality data in the extractive economies. The fourteen extractive economies for which we have complete data are listed in Table 2.

The 169 growth spells range from 5 to 28 years, and average 6.9 years. They are computed in real dollars, using chain-indexed 1985 PPP exchange rates.[22] The earliest growth spell starts in 1967 and the latest ends in 1997, the time period that has generated the resource pessimism noted at the

[22] In some cases the growth spells extend beyond the 1985 PPP series, in which case we used 1996 PPP data to index real growth in the later years in a continuous series.

Table 2: Extractive economies in the dataset

| Country | Main exporting products | Minerals as % of merchandise exports, 1991 |
|---|---|---|
| Algeria | Oil and Natural Gas | 97.4 |
| Nigeria | Oil and Natural Gas | 96.0 |
| Jamaica | Bauxite | 62.3 |
| Peru | Gold, Copper, Silver, Zinc, Lead | 54.0 |
| Trinidad & Tobago | Gas | 65.4 |
| Chile | Copper, Molybdenum, Iron | 52.2 |
| Bolivia | Tin, Silver, Antimony, Natural Gas | 66.4 |
| Venezuela | Oil | 91.7 |
| Indonesia | Oil and Natural Gas | 42.7 |
| Ecuador | Oil | 40.5 |
| Mexico | Silver, Bismuth, Strontium, Molybdenum, Gypsum, Oil | 41.0 |
| Tunisia | Phosphate Rock, Zinc | 15.4 |
| Zambia | Copper, Cobalt | 98.0 |
| Norway | Natural Gas, Oil, Aluminum, Iron | 57.6 |

Sources: The Encyclopedia of the Nations (http://www.nationsencyclopedia.com), US Geological Survey (http://www.usgs.gov), Infomine (www.infomine.com).

beginning of the paper. Many of the growth spells of the extractive economies encompass the periods over which these countries were dramatically increasing their extractive activity and growing rapidly, providing a very relevant set of data for the analysis at hand. Data for mineral and energy extraction is from the World Bank (2007).

As we noted above, the income distribution data, $I(p)$, used to calculate $g(p)$ in equation (1) are secondary survey data reported by WIID1 and WIID2. Income inequality data are infrequent or missing for many extractive economies (Ross 2007), and so in some of the early year growth spells for these economies we have had to use inequality surveys that are ranked as "unreliable" by WIID given that there was not much to choose from. Even so, most of the survey data the we use are identified as "quality" data, and only 2% of the growth spell data are considered unreliable. We elect to keep these early growth spells in the data set as they are vital to capturing the early booming periods of the

extractive economies in the sample. An advantage of our classifying growth spells on a binary basis that reflects the probabilistic beliefs on pro-poor growth is that there will be fewer dependent-variable estimates in the sample that are sensitive to variation across different income surveys. For example, from equation (1) and row 1 of Table 1, survey data that indicates $I(p)_{t+\tau} > I(p)_t$ for each of the first four income quintiles during a growth spell results in that growth spell to be characterized as pro-poor, regardless of the specific profile of $I(p)_{t+\tau}$ and $I(p)_t$ across the income quintiles. A continuous poverty measure such as the poverty gap would be sensitive to the profile of $I(p)_{t+\tau}$ and $I(p)_t$ below the poverty line, and thus sensitive to errors in the measurement of that profile.

Of the 169 growth spells, 61 are characterized as pro-poor. In all but three cases these growth spells have positive growth. There are 15 anti-poor growth spells, nine of which occur during negative growth. The other six occur during positive but lackluster growth, mainly below 2% per year.

## 7. Empirical Results

*Correlation Analysis*

As a first pass at assessing dynamic sectoral impacts, a simple correlation analysis shows that increasing per capita domestic extractive activity, as proxied by increasing mining and energy exports per capita, is positively correlated with increasing income at each cumulative income quintile (Table 3). Conversely, decreasing per capita domestic extraction activity is positively correlated with decreasing real income for the poor. The strongest and most statistically reliable correlations are at the bottom income quintiles, indicating that increasing extractive activity does not tend to hurt the poor in terms of absolute income level. Our results are consistent with those of Loayza and Raddatz (2006), who find that mining sector growth is negatively correlated with $1/day poverty headcount.

Table 3: Correlation between average percentage increase in real (PPP) per-capita non-renewable exports, $\Delta RNREp_{i,t}$, and real (PPP) per capita percentage income growth by cumulative income quintile, $g(p)_{i,t}$ across 169 pooled growth spells.

| Income Quintiles | Correlations | Bootstrap St. Error* | z-statistics | p-value |
|---|---|---|---|---|
| 20% | 0.2633 | 0.082 | 3.19 | 0.00 |
| 40% | 0.3544 | 0.119 | 2.98 | 0.00 |
| 60% | 0.2189 | 0.078 | 2.81 | 0.01 |
| 80% | 0.1968 | 0.085 | 2.31 | 0.02 |
| 100% | 0.1320 | 0.091 | 1.46 | 0.15 |

*Standard Errors based on 500 bootstrap replications.

Table 4: Association between type of economy and the number of pro-poor growth spells in that type of economy.

| Mineral Economy? | Type of Growth | | |
|---|---|---|---|
| | OTHER | PRO-POOR | Total |
| NO | 86 | 49 | 135 |
| YES | 22 | 12 | 34 |
| Total | 108 | 61 | 169 |
| LR $\chi^2(1)$ | 0.012 | | |
| p-value | 0.913 | | |

Table 5: Association between type of economy and the number of anti-poor growth spells in that type of economy.

| Mineral Economy? | Type of Growth | | |
|---|---|---|---|
| | OTHER | ANTI-POOR | Total |
| NO | 124 | 11 | 135 |
| YES | 30 | 4 | 34 |
| Total | 154 | 15 | 169 |
| LR $\chi^2(1)$ | 0.412 | | |
| p-value | 0.521 | | |

In Table 4 we test for static sectoral impacts, looking for any statistical regularity between an economy being extractive (see Table 2) and the probability of pro-poor growth in that type of economy. In a Likelihood Ratio Chi-Square test for a two-way table, the null hypothesis is that the rows and columns in the table are independent. The Chi-Square p-value of 0.913 indicates a failure to reject the null. When we perform the same test for anti-poor growth spells (Table 5), we also fail to reject that the rows and columns are independent. These results indicate that the extractive economies in the sample did not have a reliably higher frequency of unambiguously pro-poor or anti-poor growth spells.

So far, there is some evidence of dynamic sectoral effects, where increasing extractive activity reduces poverty, but no evidence of static sectoral effects, where extractive activity in and of itself is good or bad for the poor. The next section tests for these static and dynamic sectoral effects more rigorously using a panel regression.

*Regression Analysis*

Table 6 presents the results of the random-effect Logit regression (equation 5) that tests the pro-poorness of growth. We cannot reject that the regression coefficients are jointly insignificant. There is no evident relationship between level of extractive activity and the pro-poorness of growth spells in an economy. Increasing resource extraction is significant at the 10% level, with booming (falling) extraction increasing (decreasing) the probability of pro-poor growth after controlling for the overall level of growth. As expected given notions that growth is good for the poor, the level of growth is positively related to the pro-poorness of growth, but only weakly, so we cannot reject that it has no statistical significance in explaining pro-poorness of growth. This low statistical significance is likely due to the fact that our definition of pro-poor growth requires an unambiguous reduction in income

Table 6: Mineral and energy resource intensity and its relation with pro-poor growth, panel analysis, regression equation (5)

Binary Dependent Variable: Pro-Poor Growth Spell = 1, Otherwise = 0

| Variable | Coefficient | Std. Err. | t-statistic | p-value | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| $g(100)$ | 0.0882 | 0.0787 | 1.12 | 0.26 | -0.0660 | 0.2424 |
| $(\%O + \%F)$ | -0.0015 | 0.0088 | -0.17 | 0.87 | -0.0187 | 0.0158 |
| $\Delta RNREp$ | 0.0123 | 0.0074 | 1.65 | 0.10 | -0.0023 | 0.0269 |
| $g(100)\Delta RNREp$ | 0.0007 | 0.0022 | 0.32 | 0.75 | -0.0036 | 0.0051 |
| Constant | -0.9324 | 0.3427 | -2.72 | 0.01 | -1.6041 | -0.2607 |
| Wald $\chi 2$ (4) | 5.29 | | | | | |
| p-value | 0.26 | | | | | |
| Log-Likelihood | -105.35 | | | | | |

Table 7: Mineral and energy resource intensity and its relation with anti-poor growth, panel analysis, regression equation (5)

Binary Dependent Variable: Anti-Poor Growth Spell = 1, Otherwise = 0

| Variable | Coefficient | Std. Err. | t-statistic | p-value | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| $g(100)$ | -0.7362 | 0.1802 | -4.09 | 0.00 | -1.0893 | -0.3831 |
| $(\%O + \%F)$ | -0.0056 | 0.0117 | -0.48 | 0.63 | -0.0285 | 0.0173 |
| $\Delta RNREp$ | -0.0122 | 0.0125 | -0.98 | 0.33 | -0.0368 | 0.0123 |
| $g(100)\Delta RNREp$ | -0.0049 | 0.0031 | -1.58 | 0.11 | -0.0109 | 0.0012 |
| Constant | -1.4043 | 0.4455 | -3.15 | 0.00 | -2.2775 | -0.5312 |
| Wald $\chi 2$ (4) | 18.39 | | | | | |
| p-value | 0.00 | | | | | |
| Log-Likelihood | -35.00 | | | | | |

inequality, and in this dataset about half of the positive growth spells unambiguously increase income inequality.[23]

Table 7 presents the results of the same analysis for anti-poor growth. The level of growth is now statistically significant, with positive growth decreasing the chance of an anti-poor outcome. Neither the level of extractive activity nor change in extractive activity during a growth spell influences the probability of that spell being anti-poor. The cross-product coefficient is negative and statistically significant at 11%, indicating that increasing extractive activity in fact helps to prevent anti-poor outcomes when growth is positive, while it tends to increase the probability of anti-poor outcomes when growth is negative. This is contrary to any reasonable theory of the effect of extraction booms on the poor, and so we must look for a second interpretation of this cross-product coefficient. Taking the derivative of the regression equation with respect to $g(100)$, a negative cross-product coefficient can also mean that higher growth is more effective at reducing the probability of a growth spell being anti-poor when that growth is accompanied by or led by increasing extractive activity, as compared with when it is accompanied by a shrinking extractive sector. This is consistent with the results from Table 6, where increasing extractive activity was good for the poor.

Due to the non-linear nature of the random-effect logit model, the coefficient values of $g(100)*\Delta RNREp$ and $\Delta RNREp$ in Tables 6 and 7 do not have a direct economic interpretation. However, it is possible to calculate the total marginal effect of $\Delta RNREp$ on the probability of pro-poor or anti-poor growth, the derivative of the probability function with respect to $\Delta RNREp$, around certain values of the explanatory variables. The mean of these variables is employed to calculate the marginal

[23] White and Anderson (2001) also find that positive growth tends to increase income inequality. When we use poverty reduction as the independent variable, growth has a statistically significant coefficient of the expected sign.

Table 8: Total marginal effect of an increase in real extractive exports per capita on the probability of pro-poor and anti-poor growth

| Explanatory Variable | Dependent Variable | Total Marginal Effect | Std. Err. | z-statistic | Normal-based p-value |
|---|---|---|---|---|---|
| $\Delta RNREp$ | Prob[Pro-Poor] | 0.00320 | 0.00206 | 1.55 | 0.12 |
| | Prob[Anti-Poor] | -0.00063 | 0.00035 | -1.80 | 0.07 |

effect.[24] The total marginal impacts of changes in extractive activity on the pro-poorness and anti-poorness of growth are given in Table 8.

In the first case, we calculate that the total marginal impact of $\Delta RNREp$ on the probability of pro-poor growth is only statistically significant at the 12% level, and so come to the conclusion that there is not enough evidence to assert that changes in extractive activity have any statistically reliable impact on the pro-poorness of growth. On the other hand, the total marginal effect of $\Delta RNREp$ on the probability of anti-poor growth is statistically significant at the 7% level. The value of -0.00063 implies that at the average sample growth rate of 2.28%, a 1/10$^{th}$ standard deviation increase in extractive activity ($5.93/capita/year) during a growth spell results in a statistically significant but economically unimportant 0.4% decreased probability of that spell being anti-poor.

These regression results—that there is no static sectoral impact of extraction on quality of growth and at best a marginally statistically significant but relatively weak relationship between resource booms and improved quality of growth—are robust to the choice of price deflator for extractive output growth (we also tested CPI and PPI deflators), and to the choice of extractive intensity index (we also

[24] See Wooldridge (2001) for further details.

tested real dollars of extractive exports per capita, *RNREp*, at the start of the growth spell). We also ran a cross-sectional version of the regression that pools the time dimension of the panel dataset,

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 g(100)_i + \beta_2 \Delta RNREp_i + \beta_3(\%O_i + \%F_i) + \beta_4(g(100)_i \Delta RNREp_i) + \varepsilon_i, \qquad (6)$$

since there is some concern that a panel data approach to measuring the quality of growth has a low signal to noise ratio that may be hiding statistically significant relationships in the data (Easterly 1999). These regressions did not reveal any additional relationships between extraction and growth quality.

We also tested separately for the influence of extractive level and changes in extractive level on the pro-poverty and pro-inequality of growth spells (see Table 1 for the definitions of these spells).[25] We find no statistically significant impact of the level of extractive activity or the change in level of extractive activity on the probability that a growth spell will be unambiguously pro-poverty or anti-poverty. Level of economic growth is the only statistically significant and important variable here.

Neither economic growth nor level of extractive activity have any impact on whether or not a growth spell will be pro-equality or anti-equality. The only statistically significant result in the analysis of equality is that at the margin, an increase in extractive activity during a growth spell reduces that spell's probability of worsening income inequality at a 5% level of significance, with a reasonable level of importance. This is consistent with the correlations in Table 3 showing that resource booms have a stronger correlation with income growth of the poor than with income growth of the rich.

[25] In the interest of space, and given that they do not overturn our previous results, we do not present them here. They are available from the authors upon request.

## Conclusions

Our longitudinal analysis of 169 growth spells across 57 developed and developing countries from 1967 to 1997 finds no evidence to support the hypothesis that economies with growing extractive sectors tend to experience a type of growth that is less frequently pro-poor or more frequently anti-poor than in economies whose growth is not accompanied by an extractive boom. The lack of statistical significance of static sectoral effects (extraction level effects) on growth quality is consistent with Alexeev and Conrad's (2008) finding that extractive activity has no negative impact on institutions. The lack of firm evidence of important dynamic sectoral effects (extraction boom effects), other than a possible tendency for extractive booms to slightly reduce the chance that a growth spell will be a anti-poor, support's Loayza and Raddatz's (2006) finding that mining sector growth has no special impact on headcount poverty given a level of overall economic growth. It is also consistent with Kraay (2006), who finds that cross-country differences in changes in poverty are mainly related to differences in the level of growth.[26]

There is no doubt that certain mineral and energy economies have experienced anti-poverty outcomes over the past 40 years. UNCTAD (2002) and Davis (2009) make a point of noting that these economies have in common low or negative rates of economic growth. Our analysis confirms that negative growth significantly decreases the prevalence of unambiguously pro-poverty outcomes and increases the prevalence of unambiguously anti-poverty outcomes. It also increases the prevalence of unambiguously anti-poor outcomes (see Table 7), which includes decreasing incomes *and* increasing income inequality. Where slow or negative growth is accompanied by declining resource extraction,

[26] Kraay's sample includes many extractive economies, including Nigeria, Chile, Indonesia, Niger, Venezuela, and Peru. Visual inspection of the residuals in the middle panel of his Figure 4 does not reveal any particular clustering of the mineral economies as outliers. Nor does Lal and Myint's (1996) case study analysis identify extractive economies as being subject to any systematic deviation from the normal growth and poverty reduction relationship.

the chances for a negative outcome for the poor are, if anything, enhanced (Table 8). Policy aimed at the poor in extractive economies should therefore continue to focus on both economic growth in the medium term, which faces the challenge of eventual depletion of the resource base and its corresponding anti-poor impacts, and growth in the long term, which faces the challenge of possible lagged resource curse impacts.

We end with several caveats. This paper has limited its attention to unambiguous poverty and inequality outcomes associated with a growth spell. It may well be that ambiguous measures of the pro-poorness of growth, such as those that select an arbitrary poverty line and poverty measure, do worsen when that growth is accompanied by extractive activity or an extractive boom. There may also be regional impacts that are not picked up in the national-level data used here. Finally, the data on income inequality at the national level are problematic given that there is no agreed standard for its construction. While we have endeavored to construct an empirical methodology that minimizes the impacts of imprecise data, future analysis could further investigate these issues using higher-quality micro-level data over a larger set of countries or regions.

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