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Does Natural Resource Extraction Mitigate Poverty and Inequality? Evidence from Rural Mexico and a Lacandona Rainforest Community

by

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Summary

The potential importance of natural resources for the livelihood of poor rural households has long been recognized but seldom quantified and analyzed. In this paper we examine distributional and poverty effects of natural resource extraction at the national, regional and community levels. To do this, we use new data from a national rural household survey and a community survey implemented in the Lacandona Rainforest (*Selva Lacandona*) of Mexico. First, we explore whether income from natural resource extraction affects poverty and inequality. Then we calculate the marginal impact of a change in the price of natural resources on inequality. Finally, using information from Frontera Corozal, a community in the Selva Lacandona, we evaluate the short-run poverty effects of changes in the price of a non-timber forest product (the *xate* palm), which is extracted from this and other threatened forest areas in Mexico and Guatemala.

Our findings highlight the importance of income from natural resource extraction in alleviating poverty and income inequality in rural Mexico. Results show that the number of poor individuals increases 4.2% and inequality increases 2.4% when natural resource income is not taken into consideration. Inequality in the distribution of natural resource income is relatively high. Nevertheless, an unequally distributed income source may favor the poor. For example, welfare transfers are usually unequally distributed (most households do not receive them), but they are directed disproportionately at poor households. This is the case for natural resource income in all of our samples. A 10% increase in income from natural resources, other things being equal, reduces the Gini coefficient of total income inequality by 0.2% in Mexico. In the South-Southeast region and in Frontera Corozal, a 10% increase in natural resource income reduces the Gini coefficient by 0.36% and 0.11%, respectively.

A doubling of the price of xate fronds in Frontera Corozal is associated with a 6% decrease in the number of poor individuals in Frontera Corozal in the short run. Nevertheless, in the long

run, sustained price increases could lead to overexploitation of the resource, leaving everyone worse off. The interrelationship between extraction decisions and the resource base as well as the institutional setting surrounding price increases will determine whether or not this perverse outcome prevails.

Does Natural Resource Extraction Mitigate Poverty and Inequality? Evidence from Rural Mexico and a Lacandona Rainforest Community

Abstract

The potential importance of natural resources for the livelihood of poor rural households has long been recognized but seldom quantified and analyzed. In this paper we apply poverty and inequality measures to national and community level data sets to explore the impacts of resource extraction on rural welfare. Our findings suggest that natural resource extraction reduces both income inequality and poverty. Results from a simulation analysis at the community level indicate that poverty may be reduced, in the short-run, by increases in the price of a non-timber forest product.

I. Introduction

The potential importance of natural resources for the livelihood of rural households has long been recognized (Cavendish, 1999; Sunderlin et al., 2003). Households in natural resource rich environments often are poor, particularly in developing countries, and although natural resources may prevent or reduce poverty, dependence on these resources also can perpetuate poverty. The empirical evidence to date, mostly from studies of forest activities and poverty, is inconclusive (Wunder, 2001; Angelsen and Wunder, 2003).

This paper explores the impact of natural resource extraction on rural poverty and on the distribution of rural income, using Gini and poverty decomposition techniques, bootstrapping methods, and new data from a national rural household survey and a community survey implemented in the Lacandona Rainforest (*Selva Lacandona*) of Mexico. The research has two objectives. The first is to analyze distributional and poverty effects of natural resource extraction at the national, regional and community levels. To estimate the impacts of natural resource extraction on rural income inequality, we use the Gini decomposition technique presented in Lerman and Yitzhaki (1985). The poverty index proposed by Foster et al. (1984) is used to analyze the poverty implications of resource extraction.

The second objective is to evaluate the short-run poverty effects of changes in the price of a non-timber forest product (NTFP) extracted from the Selva Lacandona. During the last twenty years, the commercialization of NTFPs has been advocated as a strategy that can lead to a win-win combination of poverty alleviation and forest conservation (Ros-Tonen, 2000; Angelsen and Wunder, 2003). The perceived promise of the commercial extraction of NTFPs as a conservation strategy springs from the hypothesis that, if the value of the resource increases, the incentives for conserving the forest will also increase. If those who extract the resource are poor, then an increase in the value of NTFPs could alleviate poverty while promoting conservation.

Nevertheless, at present there is insufficient evidence to support this view. Findings from a number of studies suggest that the effects of extraction on forest conservation and poverty are ambiguous or even negative (Browder, 1992; Wunder, 2001; Lybbert et al., 2002; Angelsen and Wunder, 2003). This paper contributes to the literature by examining a case study in which the commercialization of a NTFP appears to have a positive impact on poverty alleviation, at least in the short run.

The remainder of the paper is organized as follows: In section II we provide a brief account of recent research on poverty, inequality and extraction of natural resources. We describe the data and methods used to quantify and analyze poverty and inequality in section III. In sections IV and V we discuss our findings and present our conclusions.

II. Poverty, Inequality and Natural Resources

Quantitative studies of the relationship between natural resources, poverty and inequality are scarce. Using a data set from Zimbabwe, Cavendish (1999) shows the importance of including natural resources and environmental services when estimating poverty and inequality measures. By calculating these measures with and without considering the income derived from natural resources, he shows that rural poverty and inequality can be overstated using conventional household surveys (by as much as 98% for poverty and 44% for inequality, depending on the poverty line and the specific measure used).

For India, Reddy and Chakravarty (1999) find that if income from forestry were set to zero (under the scenario of restricting access to common property areas), poverty would increase by as much as 28%. They conclude that a 10% increase in other income sources would not be sufficient to neutralize the poverty effect of removing access to common property areas. The reduction in inequality due to forest-related income was found to be negligible (-0.1%). In southern Malawi, Fisher (2004) shows that forest income reduces income inequality (inequality increases 12% when forest income is not considered). Mahapatra et al. (2005) use an India data set to estimate the impacts of NTFP sales on cash income. They show that sales of NTFPs can decrease income inequality. Jodha (1986) finds that the Gini coefficient increases by as much as 36% in dry regions of India when income from common property resources is not considered.

Lybbert et al. (2002) test whether the creation of new markets for a particular NTFP, argan oil in Morocco, has resulted in gains for locals and a reduction in poverty. They find that new markets raise the price for argan fruit (the source of argan oil). However, most of the gains accrue to those who are able to overcome capital and infrastructural constraints, mainly non-locals. The benefits to locals flow primarily to middle-wealth households. Poor households tend to suffer, because they are usually net buyers of the fruit.

To our knowledge there has been no effort to estimate the impacts of natural resource income on poverty and inequality in Mexico. In this paper we examine distributional and poverty effects of natural resource extraction at the national, regional and community level. If income from natural resource extraction reduces poverty and inequality, then poverty and inequality estimates should increase when this income is not taken into account. We measure poverty with and without income from resource extraction using three variants of the Foster-Greer-Thorbecke poverty index. To explore the effect of natural resource income on inequality, we estimate Gini coefficients for household total income with and without this income source.

Comparing indexes with and without natural resource income provides insight into whether the elimination of this income would increase inequality and/or poverty. It also provides upper bounds on the *magnitudes* of these effects if households are able to compensate partially for the loss of resource-extraction income by switching into other activities. The magnitude of poverty and inequality effects can be explored using a marginal analysis, that is, by estimating the impact of a change in price (or income) associated with resource extraction on poverty and inequality, holding other income sources constant. In the case of inequality, this is accomplished using Gini decomposition techniques (Lerman and Yitzhaki, 1985). Using original household survey data from a community in the Selva Lacandona, the short-run poverty effect of an increase in the price of a specific non-timber forest product (the *xate* palm) is evaluated using simulation methods proposed by Reardon and Taylor (1996).

III. Data and Methods

Data for this research are from the Mexico National Rural Household Survey (Encuesta Nacional a Hogares Rurales de México, or ENHRUM) and a household survey conducted by one of the authors (López-Feldman) in a Lacandona rainforest community of the Mexican state of Chiapas. Both surveys provide detailed data on assets, socio-demographic characteristics, production and incomes by source, including natural resource extraction.

The ENHRUM surveyed a nationally representative sample of rural households in January and February 2003. The sample includes 1,782 households from 80 communities in 14 states. INEGI, Mexico's national information and census office, designed the sampling frame to provide a statistically reliable characterization of Mexico's rural population. Reflecting INEGI's standard survey design criteria, the country was divided into five regions: Center, South-Southeast, West-Center, Northwest, and Northeast. To obtain information on household income generating activities as well as other variables, a community level survey was conducted in each community before applying the household survey.

The present research uses the full national rural household sample as well as the sub-sample for the South-Southeast region (372 households). We decided to focus on this region because of its importance in terms of natural resource availability and because it is where the community that serves as our case study is localized. The Selva Lacandona survey was implemented in Frontera Corozal, Chiapas in August 2001. Its sample includes 98 randomly selected households representing approximately 10% of the total community population.

Data from these surveys make it possible to quantify natural resource extraction at the household level, as well as to test for influences of this activity on rural households' total income, income inequality and poverty for all of rural Mexico, the South-Southeast region and Frontera Corozal. The Frontera Corozal data allow us to simulate the impacts that changes in the price of a specific NTFP could have on poverty in this forest community. Results from the analysis of Frontera Corozal provide valuable information not only to those currently involved in the creation of a green market for xate, which is also extracted in other threatened forest areas in Mexico and Guatemala, but also to those interested in the use of price mechanisms as a poverty alleviation tool.

Total income is defined as the sum of net income from five sources: family production (crops, livestock, nonagricultural goods and services); natural resource extraction (firewood, wild fruits, wild animals, plants, etc.); wage labor (agricultural and nonagricultural); migrant remittances (both internal and international); and public transfers (PROCAMPO and PROGRESA/Oportunidades).

Net income from household production activities, with the exception of livestock income, was estimated as the gross value of production minus purchased inputs.[1] Production includes not only commercial production but also output consumed at home and given to other households as

[1] The inputs used by households vary not only across activities but also across communities. For example, fishing in some communities requires buying fuel and maintaining boats, while in other communities the only inputs are family labor and a fishing rod. The community surveys allowed us to capture these differences by adapting the household survey form to the specific characteristics of each community.

gifts. In order to obtain the gross value of commercial production, households were asked the price at which they sold their product. For output consumed at home or given as gifts, households were asked the price they would have received by selling the product. Firewood and other goods produced for home consumption were valued by asking households what price they would have had to pay to purchase these goods.

Income from livestock production was estimated as the change in value of standing herds between the end and start of the survey year, plus (a) sales and gifts to other households of animals and animal products and (b) home consumption of home-produced animals and animal products, minus (c) livestock purchases and (d) livestock input costs (food, medicines, and other costs). Salary and wage income was aggregated across all household members and jobs. Migrant remittances were aggregated across all remitters.

It is not clear how to value family inputs like labor, animals and equipment used in specific production activities. Because of this we did not try to impute values of family inputs. We did allow for the possibility of zero or negative net incomes in specific activities. The poverty line used in our analysis was established by the Mexican government as the monthly per capita income necessary to purchase a basic basket of food in rural areas, 495 pesos in 2002 (SEDESOL 2002).[2]

In table 1 we present some basic characteristics of the households included in our samples. We group households into those that receive income from natural resources and those that do not. Data reveal lower levels of average schooling of heads of households that derive a portion of their income from natural resources. For example, in the national and community

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[2] Two other poverty lines are available from SEDESOL. The first includes income necessary to purchase a basic basket of food plus health and education services (587 pesos). The second also includes clothing, shelter, utilities and transportation (947 pesos).

surveys, schooling averages 3.9 and 2.5 years, respectively, for heads of households with income from natural resource extraction, and 5 and 3.5 years in households without. This may reflect the low skill requirements for resource extraction activities, as well as the absence of more remunerative alternatives for uneducated households.

On average, at the national and community level households without income from natural resources have higher endowments of land; however, the opposite is true in the resource rich South-Southeast region (the differences in unconditional means are not statistically different from zero in any case). Frontera Corozal was created in the late 1970s as a result of a policy of the Mexican government to relocate and congregate eight indigenous (Chol) communities into a new settlement. The household heads were allocated 50 hectares each. Because of this, there is a wide difference between average landholdings in Frontera Corozal and the rest of the region and country. Households with income from natural resources in Frontera Corozal own less livestock (oxen, horses and cattle), both in quantity and value, than those that do not extract natural resources. At the national and regional levels the opposite is the case. These disparities could be explained by the different roles that livestock plays in different settings. In Frontera Corozal, for example, livestock are raised predominantly by relatively rich households that are less likely to participate in resource extraction.

Table 2 shows that, on average, wage income and income from family production activities are lower in households that extract natural resources than in those that do not. Total per capita net income is lower for non-extractors in the national and regional samples but not in Frontera Corozal (none of the differences in unconditional means is statistically different from zero, however). From these basic descriptive statistics we can expect the impact of income from natural resources on poverty and inequality to be different at each level of data aggregation.

Poverty Measures

To measure poverty we use three variants of the Foster-Greer-Thorbecke (FGT) poverty index. The FGT index is calculated using the formula:

$$FGT(\alpha) = \frac{1}{N}\sum_{i=1}^{N} I_i \left(1 - \frac{y_i}{z}\right)^{\alpha} \quad (1)$$

where $I_i = 1$ if $y_i \le z$ and zero otherwise. Per capita income is represented by y_i, z is the poverty line, N is the population size and α is a weighting parameter that can be viewed as a measure of poverty aversion. When $\alpha = 0$ the formula collapses to the incidence or headcount index of poverty, that is, the percentage of poor in the population.

The headcount index, while intuitive and easy to interpret, has some drawbacks. Among other things, it treats poverty as a discrete rather than continuous characteristic. The headcount measure of poverty does not change if the incomes of very poor individuals increase but not enough to put them above the poverty line. Similarly, the headcount measure does not increase if only those below the poverty line face a negative shock that decreases their income, no matter how severe this shock might be.

To provide a more complete picture of how poverty changes under different scenarios, the poverty gap and sensitivity (poverty gap-squared) measures are commonly used in addition to the headcount measure. The poverty gap measure corresponds to $\alpha = 1$. It reflects how far below the poverty line the average poor household's income falls (i.e., the depth of poverty). If the income of a poor household increases but not enough to nudge it above the poverty line, total poverty as measured by this index will decrease (even though the headcount measure does not change.[3]

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[3] In addition, one can recover the minimum cost to eliminate poverty with perfect targeting by multiplying the depth of poverty by Nz.

When $\alpha = 2$ we obtain the poverty severity index. Like the poverty gap measure, it is sensitive both to the headcount and to changes in incomes of households that remain in poverty. However, it accords a greater weight to poor individuals who are further away from the poverty line. Poverty measured by this variant of the FGT index will decrease more if the individual receiving the income is extremely poor.

Foster, et al. (1984) present a decomposition of the poverty index by population subgroup while Reardon and Taylor (1996) propose a simulation method to decompose the FGT poverty coefficient by income source. This second method is used in our simulations of the impacts of natural resource extraction income on poverty in Frontera Corozal.

Inequality Measures

Of the various inequality indices that satisfy the five basic properties mentioned by Ray (1998), we opt for the Gini coefficient, which is arguably the most intuitive, with its neat correspondence to the Lorenz curve, and lends itself to easy-to-interpret decompositions of income effects.

Following Lerman and Yitzhaki (1985), the Gini coefficient for total income inequality, *G*, can be represented as:

$$G = \sum_{k=1}^{K} S_k G_k R_k \tag{2}$$

where S_k represents the share of component k in total income, G_k is the source Gini, corresponding to the distribution of income from source k , and R_k is the Gini correlation between income from source k and the distribution of total income.

Equation (2) allows us to decompose the influence of any income component, in our case natural resources, upon total income inequality, as the product of three easily interpreted terms:

a) How important the income source is in total income (S_k);

b) How equally or unequally distributed the income source is (G_k); and

c) How the income source and the distribution of total income are correlated (R_k), that is, the extent to which the income source does or does not favor the poor.

For example, if resource extraction income represents a large share of total income, it may potentially have a large impact on inequality. However, if it is perfectly equally distributed (G_k = 0), it cannot influence inequality even if its magnitude is large. If it is large and unequally distributed (S_k and G_k are large), it may either increase or decrease inequality, depending upon which households, at which points in the income distribution, receive income from this activity. If income from natural resources is unequally distributed and flows disproportionately towards households at the top of the income distribution (R_k is positive and large), its contribution to inequality will be positive. However, if it is unequally distributed but flows disproportionately to poor households, it may have an equalizing effect on the rural income distribution, and the Gini coefficient may be lower when natural resource income is included.

Using the Gini decomposition proposed by Lerman and Yitzhaki (1985), we also estimate the effect of changes in natural resource income on inequality, holding income from all other sources constant. Consider a percentage change in income from source k equal to e_k. It can be shown (see Stark et al., 1986) that the percentage effect on the Gini coefficient (that is, the Gini elasticity) is equal to:

$$\frac{\partial G / \partial e_k}{G} = \frac{S_k R_k G_k}{G} - S_k \qquad (3)$$

where G denotes the Gini coefficient of total income inequality prior to the income change. The percentage change in inequality resulting from a small percentage change in income from source k equals the initial share of the income source in inequality minus the initial share in total income.

IV. Empirical Analysis

If income from natural resource extraction reduces poverty, then measured poverty will be higher when income from this source is taken into consideration than when it is not. We begin by calculating each of the three FGT poverty measures with and without income from natural resources. We perform these calculations for Mexico, the South-Southeast region and Frontera Corozal. We then concentrate on the case study of Frontera Corozal, analyzing the impacts that changes in the price of a particular non-timber forest product, the xate palm, have on poverty at the community level.

We analyze the role that income from natural resource extraction plays in income inequality using two strategies. The first is to calculate the Gini coefficient with and without income from natural resources. The second is to decompose inequality by income sources to obtain the percentage change in inequality due to a percentage change in each source of income. This analysis is done using the data at the national, regional and community levels. Other researchers have used similar approaches to analyze the impacts of natural resource income on poverty and/or inequality; however, we do not know of any study that has applied this method to Mexico or simulated the impacts of price changes of a particular NTFP.

Finally, to test the statistical significance of the poverty and inequality measures, we obtain confidence intervals using bootstrapping techniques. Davidson and Flachaire (2004) have shown that the bootstrapped standard errors of the FGT poverty measures perform very well and give accurate inference in finite samples. The bootstrapped standard errors of the Gini coefficient, according to Mills and Zandvakili (1997), are expected to perform better than asymptotic standard errors in small samples.

Natural Resources and Poverty

Table 3 presents results for the poverty experiments using the national, regional and community samples. When income from natural resources is ignored, poverty increases in all three cases, and the poverty increases are all significantly different from zero. Nevertheless, the effect on poverty is substantially lower for all of rural Mexico than for the other two samples. For example, for Mexico the FGT index with $\alpha = 2$ increases by 10.8% as a result of not considering natural resources, compared with increases of 17.1% and 18.4% for the region and community, respectively. Using the headcount measure, the incidence of poverty increases 4.2 percentage points at the national level and 4.5 percentage points in both Frontera Corozal and the South-Southeast region. The poverty gap measure reveals a similar pattern of greater sensitivity of poverty at the regional and community levels than at the national level.

These differences are explained by the fact that in the national sample a smaller proportion of household income derives from natural resource extraction than in the South-Southeast region and in Frontera Corozal. This is not surprising when one considers that households in this region and community have access to a greater abundance of natural resources than rural households in Mexico as a whole.

Simulation of Poverty and NTFP Price Changes in Frontera Corozal

The data from Frontera Corozal make it possible to simulate the short-term impacts of changes in the price of a non-timber forest product on poverty at the community level. The leaves of the xate palm (*Chamaedorea* spp.) are used by the floral industry as a backdrop for flowers in wedding and funeral displays and during the Easter season, particularly on Palm Sunday. The current interest of governments, non-governmental organizations, and the scientific community in the conservation and development potential of xate palm leaves makes xate an ideal case study.

Recently, the Commission for Environmental Cooperation of North America (CEC) began to evaluate the possibility of establishing a green market for xate under the presumption that it will lead to the conservation of forests and at the same time improve local economic conditions (CEC, 2002; Bowman, 2003). A pilot project to purchase xate fronds harvested in Mexico and Guatemala from communities interested in achieving sustainable production took place during March 2005 as part of this effort (CEC, 2005). The efforts of USAID, the Rainforest Alliance, other NGOs, and the local government to promote sustainable xate extraction in the Peten Region of Guatemala are another example of the interest in xate as a conservation and development tool (Rainforest Alliance, 2005).

Xate is the most important NTFP in the Lacandona region in terms of its contribution to households' cash income (Vásquez-Sánchez et al., 1992). In Frontera Corozal, members of the community have exclusive rights to extract natural resources from the contiguous rainforest; nevertheless, there are no community rules on how these resources, including xate, should be managed (Sánchez-Carrillo and Valtierra- Pacheco, 2003; Tejeda, 2004). Xate can therefore be considered *de facto* as an unmanaged common property resource.

The difference between the price paid by the consumer and what the xate extractor receives is substantial; according to CEC (2002) the price paid to xate extractors is less than 7% of the final price. In our analysis we concentrate on changes in the price received by extractors instead of on changes in the price paid by the consumer of the product.

To evaluate the potential poverty effects of changes in the price received by xate extractors, we calculate the three FGT measures for a variety of simulated price changes. Three price decreases (25%, 50% and 100%) simulate a hypothetical situation in which the demand for xate decreases, including an extreme scenario in which no xate is demanded at all. The simulation of price increases (25%, 50% and 100%) represents a first approach toward understanding the potential impacts that the creation of a green market for xate could have on terms of poverty alleviation.

Considering that xate is not used or consumed in any form by households in Frontera Corozal, the price changes have no direct negative effect on household expenditures. In addition, xate extraction does not require any capital investments or infrastructure that could prevent the poor from participating in this activity. This contrasts with the case of the argan oil analyzed by Lybbert et al. (2002), in which most of the local poor were excluded from the benefits of new markets (because of capital and infrastructure constraints) or even negatively affected (because of the higher prices they had to pay as consumers of the argan fruit).

In principle it can be argued that price increases provide incentives to substitute extraction of xate from the rainforest to a more reliable system like local plantations. Our simulations are based on the assumption that price increases do not change the system of xate production. In particular, we assume the price premium to be available only for xate that is extracted from wild populations in a biologically sustainable way. We concentrate on this scenario to avoid the complications that a change in the production system has on our analysis, but more importantly, because this is the scenario on which plans for certification and eco-labeling for xate palm are based.

As can be seen in figure 1.a the extreme case of no xate market implies an increase of almost 5% in the poverty headcount measure. This means that the percentage of persons below the poverty line would rise from 77% to 81%. Figures 1.b and 1.c show that a zero demand for xate would increase the poverty gap by 11% and the severity of poverty by 18%. The greater sensitivity of the poverty gap and severity measures is an indication that xate price changes have a large impact on the poorest of the poor compared with those close to the poverty line.

Figure 1.a shows that a 100% price increase implies a 6% decrease in the headcount measure (i.e., the percentage of the population below the poverty line changes from 77 to 72).[4] Figures 1.b and 1.c show an 8% and 11% decrease in the poverty gap and severity measures when the price of xate doubles. The changes in these two measures reveal that the price increases have a significant impact on the welfare of some of the poorest members of the community, even when it is not enough to bring them above the poverty line. The confidence bounds for the three figures show that all these changes are statistically different from zero.

It is important to recognize that these results assume that households do not change their allocation of labor in response to xate price changes. That is, during the simulation exercise the intensity of xate extraction (and other activities) is held constant. Even though the assumption of no labor reallocation is a strong assumption, the resulting changes in poverty measures due to a price decrease can be seen as short-run upper bounds, and the changes due to price increases as short-run lower bounds, on poverty reductions. Another implicit assumption in this analysis is that in the short-run xate availability remains unchanged. In order to obtain long-run conclusions we

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4 A 100% price increase is not too extreme considering the results of a survey that shows that Christian congregations in the US would be willing to double the price they pay for palms harvested in a sustainable way (CEC, 2005). Furthermore, the 'eco-palm' project, a pilot project that took place in March 2005 resulted in extractors receiving a price premium well above 100% (Dean Current and Bryan Endress, personal communication, 2006). A project in the Peten region of Guatemala that is based on direct exportation (i.e., on bypassing the intermediaries) of leaves from the extractors to a U.S. wholesaler resulted in a doubling of the price paid to extractors (Rainforest Alliance, 2005).

would need to simulate the impacts that changes in prices have not only on labor allocation and intensity of extraction but also on the stock of xate available. This requires biological data and will be the subject of future research.

Natural Resources and Inequality

Table 4 presents a decomposition of the contributions of resource extraction and other income activities to per capita total net income and income inequality. The first column, labeled S_k, presents the share of each income source in the per capita total income for each of the three samples. Wages are the principal source of income for rural households in Mexico as well as in the South-Southeast region (54% and 44%, respectively), while in Frontera Corozal the primary income source is family production activities (34%). The contribution of income from natural resources ranges from 2.3% (for all of rural Mexico) to 7.3% (for the community sample). Government transfers are an important income source in Frontera Corozal, accounting for 27% of income. Meanwhile, remittances represent 13% of per capita income at the national level and 10% in the South-Southeast region.

The second column of table 4, G_k, presents the Gini coefficient for each income source. Inequality in the distribution of natural resource income is relatively high; G_k for natural resource income is 0.80, 0.71, and 0.77 in the national, regional and community samples, respectively. These high values for the source specific Gini coefficients can be explained partially by the fact that many households do not participate in extraction; thus, there are many zero incomes from this activity in the source Gini calculations (the same is true for other income sources, e.g., remittances).

The national and regional data suggest that the most unequally distributed income source is family production. This is in part due to the presence of negative net-income from agriculture for some households in the sample.[5] At the community level the income source that is most unequally distributed is remittances from internal and international migrants; few households in Frontera Corozal had migrants in 2001.

As indicated earlier, a high income source Gini (G_k) does not necessarily imply that an income source has an unequalizing effect on total income inequality. An income source may be unequally distributed yet favor the poor. This is the case for natural resources in all of our samples. The Gini correlation between natural resources and the distribution of total per capita income (R_k) ranges from 0.11 (national sample) to 0.34 (community sample), and it is the lowest of all income sources in the national sample. At the national level, because of the low Gini correlation between natural resources and total-income rankings, the percentage contribution of this income source to inequality (0.3%) is smaller than the percentage contribution to income (2.3%). Thus, natural resources have an equalizing effect on the distribution of total rural income.

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[5] In table 4, the income-source Gini coefficient for family production is higher than 1.0. This does not imply perfect income inequality, but rather reflects the presence of some negative income values. Income-source Gini coefficients greater than 1.0 have been reported elsewhere in the literature (e.g., Lerman and Yitzhaki, 1985). The Gini coefficient is a measure of dispersion, similar to a coefficient of variation; it is equal to the expected difference between two randomly drawn observations divided by the mean. One can view the mean as the expected difference between each observation and zero. If all observations are positive, zero is outside the range of observations, so the ratio is lower than one. However, if some observations are negative, zero is not outside the range of the group, and the ratio depends on the location of zero in the range. Wodon and Yitzhaki (2002) argue that the ability to handle negative incomes is an advantage of the Gini coefficient over Atkinson's index.

A 10% increase in income from natural resources, other things being equal, reduces the Gini coefficient of total income inequality by 0.2%, and this change is statistically significant.

Income from natural resources is also equalizing in the South-Southeast region and in Frontera Corozal; a 10% increase in natural resource income reduces the Gini coefficient by 0.36% and 0.11%, respectively, in these two samples. The change is statistically significant at the regional level but it is not statistically different from zero in Frontera Corozal.

In our three samples, income from family production has a high Gini coefficient and a high Gini correlation with total income rankings ($R_k = 0.79$, 0.80 and 0.77 in the national, regional and community samples, respectively). This income source accounts for more than 25% of total income in all the cases. Income from family production is associated positively with inequality; a 10% increase in this source increases the Gini coefficient by 0.9, 1.3 and 1.4 percentage points at the national, regional and community levels. All impacts are statistically different from zero.

In the national sample, government transfers are unequally distributed ($G_k = 0.77$). However, the Gini correlation between transfers and total income is low ($R_k = 0.24$), indicating that transfers favor households at the bottom of the income distribution. Other things being equal, a 10% increase in government transfers is associated with a 0.3% decrease in the Gini coefficient of total income. At the regional level, government transfers are less unequally distributed ($G_k = 0.59$) and the correlation between this income source and total income ($R_k = 0.18$) is lower than at the national level. A 10% increase in this income source has an equalizing effect; the Gini coefficient decreases by 0.8%. Government transfers have the highest equalizing impact at the community level; a 10% increase in transfers reduces the Gini coefficient by 1.7%. All of these impacts are highly significant. Wages have an equalizing effect on the rural income distribution at the national level, but their effect is not significantly different from zero at the regional and community levels.

Table 5 presents the Gini coefficients resulting from the simulation exercise of excluding income from natural resources. This exercise points out the importance of natural resource extraction in reducing rural income disparities. At the national level, the Gini coefficient increases by 2.4% when natural resource income is ignored. The effect is higher in the South-Southeast region, where the Gini increases 5%. In Frontera Corozal the Gini increases by 4.3%. All of these effects are statistically different from zero.

V. Conclusions

Our findings highlight the importance of income from natural resource extraction for the alleviation of poverty and income inequalities in Mexico as well as in the resource-rich South-Southeast region and the Lacandona Rainforest community of Frontera Corozal. Natural resource extraction is an important source of income for many rural households. Without it, many households' ability to satisfy their basic needs would be jeopardized.

Price simulations reveal that poverty in Frontera Corozal can be reduced in the short-run by programs that raise the price that households receive for xate. In the long run, however, sustained price increases could lead to overexploitation of the resource, leaving everyone worse off. The biological relationship between extraction and the resource base, the incentives and disincentives that this creates for future extraction, and the institutional setting surrounding price increases will jointly determine whether this seemingly perverse outcome occurs. Both long and short-run considerations should be weighed carefully when assessing the potential to promote the green marketing of xate or other natural resources as a poverty alleviation and forest conservation tool.

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Table 1. Descriptive Statistics

Variable	Households That Extract Natural Resources Mean (μ_1)	SD	Households That Do Not Extract Natural Resources Mean (μ_0)	SD	Difference in Means (μ_1-μ_0)
Mexico					
Household size	4.29	2.09	3.88	1.88	0.41***
Age of the household head	49.56	15.59	47.77	16.53	1.79***
Schooling of household head (years)	3.87	3.18	5.01	4.11	-1.14***
Landholdings (hectares)	4.56	19.95	5.03	28.96	-0.47
Livestock (2002 pesos)	9786.50	37169.39	7162.86	38184.43	2623.64*
Livestock (number of animals)	3.27	14.34	2.30	12.80	0.97*
Total per capita net income (2002 pesos)	12411.92	20835.06	17374.70	35359.36	-4962.78***
	N = 846		N = 936		
South-Southeast Region					
Household size	4.23	1.96	3.95	1.77	0.28*
Age of the household head	48.20	15.25	49.17	15.81	-0.97
Schooling of household head (years)	3.99	2.88	4.55	4.05	-0.56*
Landholdings (hectares)	5.28	8.35	5.08	11.94	0.2
Livestock (2002 pesos)	4011.37	8254.51	3402.87	8699.56	608.5
Livestock (number of animals)	1.29	4.25	0.74	2.28	0.55*
Total per capita net income (2002 pesos)	5821.14	5788.98	11388.77	31395.83	-5567.63**
	N = 251		N = 121		
Frontera Corozal					
Household size	5.73	2.85	5.67	2.20	0.06
Age of the household head	36.90	10.59	42.89	12.40	-5.99***
Schooling of household head (years)	2.49	2.41	3.48	3.51	-0.99*
Landholdings (hectares)	36.38	23.31	40.54	18.63	-4.16
Livestock (2002 pesos)	2118.75	8103.49	15265.86	36078.31	-13147.114***
Livestock (number of animals)	0.87	3.11	5.67	13.44	-4.8***
Total per capita net income (2002 pesos)	4860.00	3377.36	4638.46	3271.27	
	N = 52		N = 46		

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2. Composition of the Per Capita Net Income
(2002 pesos)

Income Source	Households That Extract Natural Resources		Households That Do Not Extract Natural Resources		Difference in Means
	Mean (μ_1)	SD	Mean (μ_0)	SD	(μ_1-μ_0)
Mexico					
Government Transfers	852.94	1724.80	546.01	1798.32	306.93***
Remittances	2914.84	15082.87	1944.66	12742.61	970.18*
Natural Resources	759.91	1250.74	0.00	0.00	
Family production	2528.03	9791.37	5139.58	30929.85	-2611.55***
Wages	5356.20	10824.70	9744.46	17112.89	-4388.26***
Total Income	12411.92	20835.06	17374.70	35359.36	-4962.78***
	N = 846		N = 936		
South-Southeast Region					
Government Transfers	761.35	1010.19	561.60	646.66	114.69***
Remittances	760.74	3566.92	979.31	4251.10	-218.57
Natural Resources	706.54	1039.57	0.00	0.00	
Family production	1210.22	3139.04	4987.26	27976.78	-3777.04*
Wages	2382.29	3444.32	4860.60	15214.77	-2478.31**
Total Income	5821.14	5788.98	11388.77	31395.83	-5567.63**
	N = 251		N = 121		
Frontera Corozal					
Government Transfers	1252.80	651.29	1103.92	740.65	148.88
Remittances	60.39	435.49	39.44	213.53	20.95
Natural Resources	820.37	1086.24	0.00	0.00	
Family production	1554.82	1845.21	1795.38	2153.31	-240.56
Wages	1171.61	1552.54	1699.72	2744.04	-528.11
Total Income	4860.00	3377.36	4638.46	3271.27	221.54
	N = 52		N = 46		

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3. FGT Index With and Without Income from Natural Resources (NR)

Index	Mexico	South-Southeast Region	Frontera Corozal
FGT (α = 0)			
Without NR	0.446	0.717	0.810
With NR	0.428	0.686	0.775
Difference	0.018	0.031	0.035
	(0.015, 0.022)	(0.023, 0.040)	(0.020, 0.054)
FGT (α = 1)			
Without NR	0.257	0.406	0.389
With NR	0.235	0.364	0.350
Difference	0.022	0.042	0.039
	(0.020, 0.023)	(0.037, 0.046)	(0.034, 0.046)
FGT (α = 2)			
Without NR	0.205	0.288	0.219
With NR	0.185	0.246	0.185
Difference	0.020	0.042	0.034
	(0.019, 0.022)	(0.037, 0.046)	(0.028, 0.040)
N =	7047	1515	559

Notes: All measures use household per capita income attributed to individuals and are calculated on an individual basis.
95% bootstrapped percentile confidence intervals in parentheses.

Table 4. Gini Decomposition by Income Source

Income Source	Share in Total Income (S_k)	Income Source Gini (G_k)	Gini Correlation with Total Income Rankings (R_k)	Share in Total-Income Inequality	% Change in Gini from a 10% Change in Income Source
Mexico					
Family production	0.265	1.015	0.786	0.357	0.92 (0.70, 1.21)
Wages	0.541	0.667	0.804	0.491	-0.51 (-0.75, -0.23)
Natural resources	0.023	0.803	0.109	0.003	-0.20 (-0.23, -0.18)
Government Transfers	0.044	0.766	0.236	0.013	-0.30 (-0.35, -0.26)
Remittances	0.127	0.927	0.681	0.135	0.08 (-0.05, 0.24)
Total income		0.592			
N = 7047 individuals					
South-Southeast Region					
Family production	0.293	0.992	0.799	0.418	1.26 (0.62, 2.02)
Wages	0.442	0.672	0.766	0.411	-0.32 (-0.99,0.44)
Natural resources	0.062	0.711	0.326	0.026	-0.36 (-0.45, -0.28)
Government Transfers	0.099	0.587	0.178	0.019	-0.80 (-0.98, -0.62)
Remittances	0.104	0.937	0.722	0.127	0.23 (-0.06, 0.57)
Total income		0.555			
N = 1515 individuals					
Frontera Corozal					
Family production	0.343	0.552	0.769	0.479	1.36 (0.48, 2.79)
Wages	0.296	0.628	0.585	0.359	0.63 (-0.80, 1.55)
Natural resources	0.073	0.772	0.335	0.062	-0.11(-0.55, 0.32)
Government Transfers	0.273	0.295	0.377	0.100	-1.73 (-2.21, -1.03)
Remittances	0.015	0.971	-0.014	-0.001	-0.15 (-0.60, 0.31)
Total income		0.304			
N = 559 individuals					

Notes: All measures use household per capita income attributed to individuals and are calculated on an individual basis. Gini decomposition and bootstrapping was done using the Stata command descogini, which is described in López-Feldman (2006). 95% bootstrapped percentile confidence intervals in parentheses.

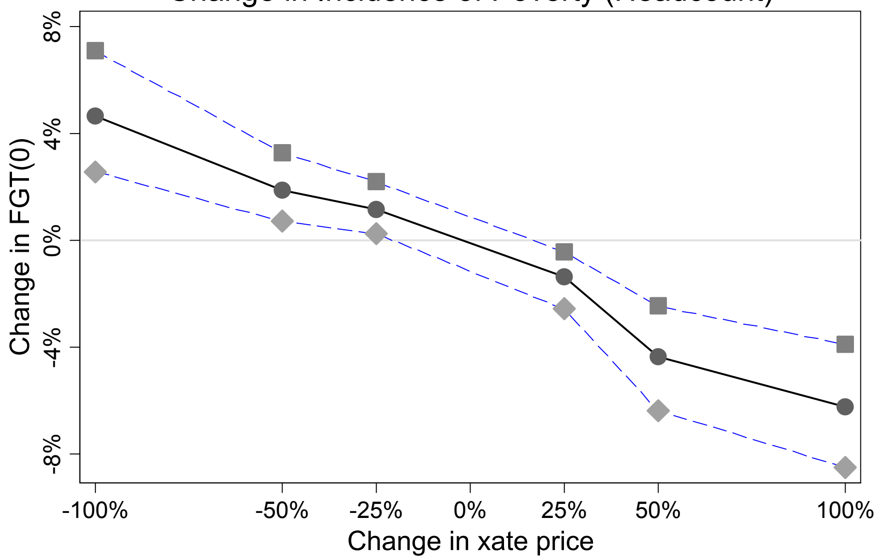
Table 5. Gini Coefficients With and Without Income from Natural Resources (NR)

Index	Mexico	South-Southeast Region	Frontera Corozal
Gini without NR	0.606	0.583	0.317
Gini with NR	0.592	0.555	0.304
Difference	0.014	0.028	0.013
	(0.013, 0.015)	(0.025, 0.031)	(0.007, 0.021)
N =	7047	1515	559

Notes: All measures use household per capita income attributed to individuals and are calculated on an individual basis.
95% bootstrapped percentile confidence intervals in parentheses.

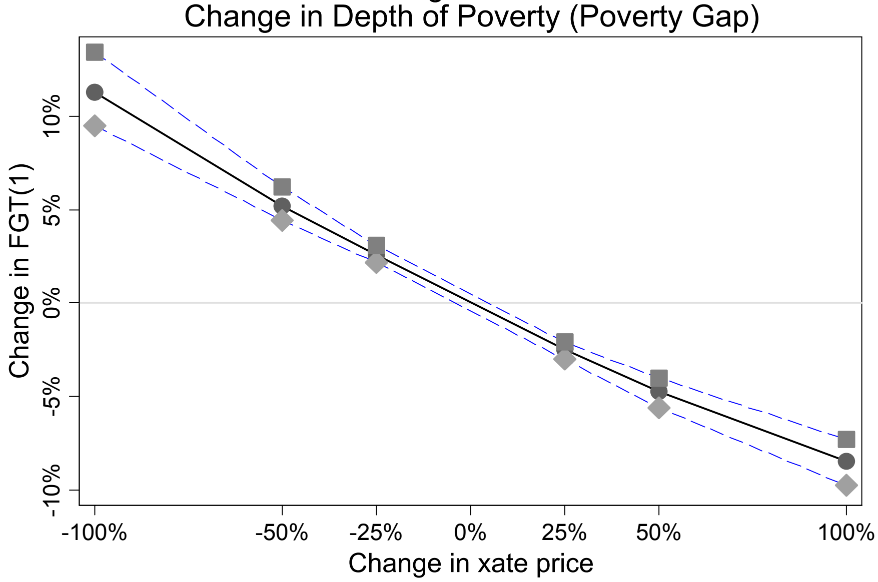
Figure 1. Percentage Changes in Poverty

Figure 1.a
Change in Incidence of Poverty (Headcount)



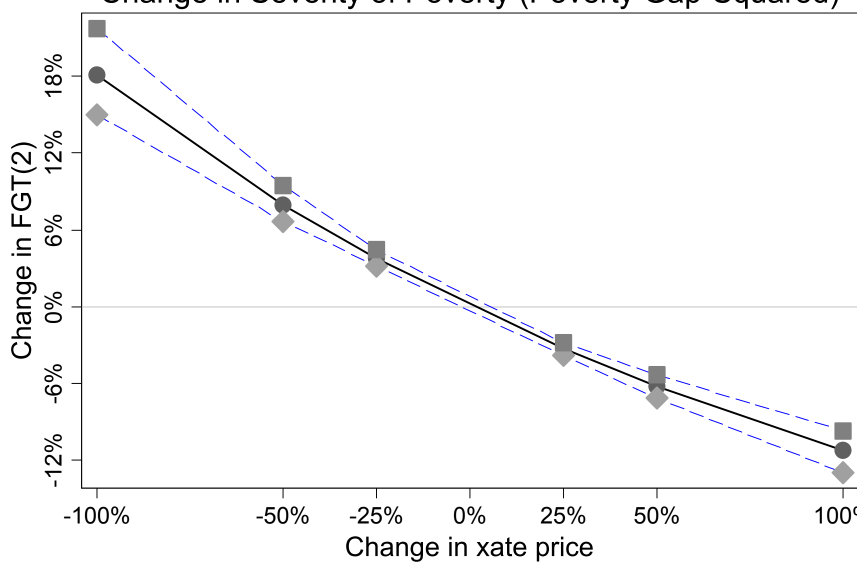
Note:Dashed lines represent 95% bootstrapped percentile confidence bounds

Figure 1.b
Change in Depth of Poverty (Poverty Gap)



Note:Dashed lines represent 95% bootstrapped percentile confidence bounds

Figure 1.c
Change in Severity of Poverty (Poverty Gap-Squared)



Note:Dashed lines represent 95% bootstrapped percentile confidence bounds