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Abstract: While there is much interest by NGOs and environmental groups in the potential of non-timber forest products (NTFP) programs to simultaneously achieve conservation and poverty alleviation, there is not a great deal of understanding of whether they work in practice, and how incentives and local management do, indeed affect poverty and local resource use. In this paper I propose a methodology to analyze the potential impacts that price increases can have on the income that extractors receive from NTFP extraction. The case study illustrates how one could evaluate the effectiveness of different price scenarios. It also shows the kind of biologic and socioeconomic information that is needed to apply the methodology suggested. The more accurate the information is the more confident one can be about the policy recommendations. This is an area of opportunity where applied research between economists and ecologists can lead to concrete policy applications.

Keywords: Non-timber forest products, poverty, resource extraction

1. Introduction

It has been argued by NGOs and environmental groups that conservation and poverty alleviation might be simultaneously achieved by promoting the local use and stewardship of environmental services that sustain natural systems. In the case of the commercial extraction of non-timber forest products (NTFPs) the two implicit assumptions are: a) harvesting of NTFPs is less destructive, in terms of biodiversity, than timber harvesting, and, b) novel or expanded markets are needed to increase the returns from NTFPs for locals in order to provide better incentives to conserve forests (this works under the assumption that NTFPs need the presence of the trees in order to be able to grow). If, in addition, those who extract the resource are poor, then it is argued that an increase in the price (or the quantity demanded) of NTFPs could alleviate poverty while promoting conservation (Neumann and Hirsch, 2000; Lybbert et al., 2002; Belcher et al., 2005). This is the logic behind programs

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that have encouraged Amazonians to extract NTFPs like Brazil nuts in order to generate local income from activities other than deforestation. Other programs, such as the shade tree coffee program, develop and promote markets that sustain higher prices for products that are both sustainable and that maintain natural ecosystem functions.

While there is much interest in NTFP programs and similar programs in other ecosystems, there is not a great deal of understanding of whether they work in practice, and how incentives and local management do, indeed affect poverty and local resource use. In this paper I leave aside the discussion about deforestation to analyze the potential impacts that price increases can have on the income that extractors receive from NTFP extraction. The next section presents a simple theoretical model and section 3 presents its basic implications. Section 4 concludes.

2. Theoretical model of NTFP extraction

The model that I propose is a modification of the model presented in Lopez-Feldman and Wilen (2008). The resource that is being modeled is a marketable NTFP whose extraction is labor intensive and with minimal capital requirements. Extraction takes place in day trips and the only variable input that extractors control is the allocation of their time.

To represent total NTFP harvest (i.e., harvest by all individuals during a period of time t) I use a model based on Schaefer (1957). That is, total harvest is defined as $H = qLX$, where q is a proportional harvesting coefficient, L is the total number of days worked in NTFP extraction during the period (say one year) by all individuals, and X is the stock of the resource.

I assume that, if left undisturbed, the resource will grow over time according to a logistic function. Other studies have used a logistic function to characterize the growth of harvestable populations of NTFPs (see Bhat and Huffaker, 1991; Bluffstone, 1995; and Gunatileke and Chakravorty, 2003). Therefore, the NTFP growth function under harvesting is represented by:

[1] $$\dot{X} = rX\left(1 - \frac{X}{K}\right) - H$$

where r is the intrinsic growth rate of the NTFP and K is the carrying capacity.

The present analysis focuses on NTFPs that are common-pool resources, that is, for which (a) there is rivalry in appropriation, and (b) exclusion of potential appropriators or limitation of appropriation by existing users is nontrivial though not necessarily impossible (Ostrom et al., 1994). The resource is held under common property, all members of the community have access to it. I assume that although no individual has exclusive property rights to the resource, the community is able to exclude outsiders from appropriation. I assume that this is enforced, and only the local rights-holders harvest the resource. In addition, there is an absence of rules or strategies to manage the resource.

Following Gordon's (1954) seminal paper, under an unmanaged regime effort flows until the rents are dissipated. This implies that labor will be allocated to extraction until total revenue (pH) is equal to total cost (wL), where p represents the price of the resource and w is the opportunity cost of one day of labor. This behavior leads, in equilibrium, to the following amount of labor being allocated to extraction:

[2] $$L^{*} = \frac{r}{q}\left(1 - \frac{w}{pqK}\right)$$

Implicit in this solution is the assumption that there is enough labor locally to drive the system into a bioeconomic equilibrium in which rents are dissipated. The next section explores the implications of local labor constraints that prevent this from happening.

2.1. Labor constraints

In most settings of pure open access the natural assumption to make is that there are no labor constraints. However, this is not necessarily the case with all common property, particularly in cases where isolated villages with fixed labor utilize local common resources. To illustrate this, I add the assumption of relative shortage of local or community labor to the assumption that outsiders are excluded from extracting the common-pool resource. To clarify what is meant by a relative shortage of labor consider a case where, given the values of all parameters in the optimization problem, the amount of labor that leads to rent dissipation is greater than the labor available from the right-holders of the resource. That is, there is a relative shortage of labor if $L^{*} > \bar{L}$, where L^{*} is defined as in equation (2) and $\bar{L}$

is total local labor available. It can be shown that under these circumstances the returns from a day of work are higher than the opportunity cost of time.

2.2 Labor heterogeneity

Up until now I have assumed that labor is homogenous in the sense that all individuals have the same opportunity cost of time and the same productivity in extracting the natural resource. This need not be the case. Individuals can have access to different labor alternatives and therefore have different opportunity costs of time, depending on their individual and household characteristics. Those characteristics might also affect productivity in the extractive activity. In this section the assumption of homogeneous productivity in the extractive activity is maintained but heterogeneity in the opportunity cost of time is considered.

Assume that there are two types of individuals with opportunity costs w_1 and w_2 where $w_1 < w_2$. Type-1 individuals, the low opportunity cost type, will allocate labor to extraction until the value of an additional day of work is equal to the opportunity cost of time. Under these conditions type-2 individuals will not find it profitable to participate in NTFP extraction. Therefore, if the resource is not managed and labor is heterogeneous, only those with a low opportunity cost of time participate in NTFP extraction, and they receive w_1 as payment for every time-unit of work.

Nevertheless, this is not the case when there is a relative shortage of type-1 labor (i.e., if $L^* > \bar{L}_1$). Under these circumstances even though all type-1 labor is allocated to resource extraction, revenues for a unit of labor (θ) are higher than w_1. If in fact the value of the marginal product of a unit of labor is higher than w_2, then type-2 individuals will participate in NTFP extraction, as well. This requirement is captured by the following participation condition:

[3] $$\theta \geq w_2$$

If the condition holds, then type-2 individuals allocate labor to extract the NTFP until their returns are equal to w_2, assuming that there is no labor shortage of type-2 individuals. Although the generalization of this problem to include more than two types of individuals as well as labor constraints in more than one type of individuals is straightforward, it is arithmetically tedious and would add little by way of insight. Therefore, throughout this analysis I concentrate on the case in which there are two types of labor, only one of which is labor constrained.

3. Income received from NTFP extraction

As discussed in the introduction, one policy that some conservationists are promoting is market development for products that are considered compatible with preservation of natural resources. This raises the question: what impacts might a successful "green marketing" campaign have on extractors of a NTFP?

From the extractor's welfare point of view, the most important impact is the effect of the price change on revenue per-day of work. When the resource is not managed, rent is dissipated, implying that the revenue per-day of work is equal to the opportunity cost. This means that price increases have no impact on the revenue that individual extractors receive from a day of extraction.

Under these circumstances, a successful green marketing campaign that raises NTFP prices may not improve the per capita welfare of NTFP extractors. A policy whose main objective is to alleviate poverty via higher product prices will, without community management, result in an increase in the number of days allocated to extraction. Nevertheless, extractors receive the same net revenue as before (i.e., w) for a day of work. If w is the wage earned in an alternative employment activity, then the only effect of the NTFP premium will be a reallocation of more labor from the alternative activity to resource extraction.

3.1. Extractors' income under labor constraints and heterogeneity

In spite of these pessimistic results, under some circumstances it is possible for a price increase in an unmanaged common property resource to contribute towards poverty alleviation via an increase in revenues per-day of work. When the resource is not managed and there is a binding labor constraint price changes do not have an effect on the quantity extracted but they do affect revenues. If, in addition, labor is heterogeneous, price increases will result in revenue increases for low-opportunity-cost individuals as long as the high-opportunity-cost individuals do not participate in extraction.

The labor constraint could be binding depending on the specific values of the parameters of the problem. Consider the case where all parameters except price are fixed. Then there is a price that makes the amount of total labor allocated to extraction equal to the labor available from the rights-holders of the resource. That is, there is a price p^* at which $L^* = \bar{L}$, therefore, if outside labor is effectively excluded from extracting the resource, a price increase above p^* will increase the income received by individuals above and beyond their opportunity cost of time. Using equation 2 we have that:

[4] $$p^* = \frac{wr}{qK\left(r - q\bar{L}\right)}$$

Figure 1 illustrates these results. Earnings per-day remain constant at the level w for $w/qK < p < p^*$. On the other hand, when $p > p^*$ earnings per-day become an increasing function of price. Under this institutional setting a policy that introduces a NTFP price premium can in fact have a positive impact on the income received by extractors, even without the need to coordinate behavior.[1]

Another possible setting is the one with labor being not only constrained but also heterogeneous. The relative scarcity of low opportunity cost labor (i.e., $L^* > \bar{L}_1$) implies that type-1 individuals receive a return for their participation in NTFP extraction that is higher than their opportunity cost of time. In this situation, price increases can reduce poverty, although earnings per-day of work do not increase continuously with respect to price as they do when labor is scarce but homogeneous (and $p > p^*$).

Figure 2 illustrates this situation with two types of individuals. Along the price range $\left(\frac{w_1}{qK}, p^*\right)$ individuals receive w_1 for a day of work. Beyond p^*, all type-1 labor is allocated

[1] Even though the model I propose is not designed to directly analyze deforestation one could argue that the pressure on forests could be reduced if labor used to extract timber or to clear land for agriculture is now diverted to NTFP's extraction. If that is the case then as price goes up the pressure on the forest goes down. In the context of Figure 1 if price is greater or equal to p^* then there is no deforestation as all labor is allocated to NTFPs extraction. I thank an anonymous reviewer for pointing this out.

to extraction and although type-2 individuals could reallocate labor from other activities to extraction, they do not do so until the price is right, that is, until price is such that earnings per-day are equal to w_2. The price at which this happens in Figure 2 is p^{**}.

Therefore, in the price range [p^{*}, p^{**}] the supply of labor remains constant, while earnings per-day increase with price. When the price surpasses p^{**}, type-2 individuals enter into extraction, and earnings per-day are constant at w_2. That is, type-1 individuals do not experience any further gains from price increases once type-2 individuals begin to supply labor.[2]

Although the level that revenue per-day of extraction can reach is bounded by w_2, a price premium can have a positive impact on the income received by extractors as long as the original price is below p^{**} (and the new price is above p^{*}). Under relative scarcity of heterogeneous labor we have that:

[5] $$p^{*} = \frac{w_1 r}{qK\left(r - q\bar{L}_1\right)}$$

[6] $$p^{**} = \frac{w_2 r}{qK\left(r - q\bar{L}_1\right)}$$

In the end, the role that price premiums can have on the income received by extractors under a situation of unmanaged common property, like the one described above, depends on the specific values of the biologic and economic parameters.

3.2. An example using the extraction of xate palm

Xate (Chamaedorea spp.) is a marketable NTFP that grows under the cover of forests. Xate palm leaves are used by the floral industry as a backdrop for flowers in wedding and funeral displays. They are also in demand during Easter season, particularly on Palm Sunday. Xate extraction is an important income generating activity for rural communities located in or around forests in México and Guatemala (Endress et al. 2004; Sanchez-Carrillo and Valtierra-Pacheco 2003).

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[2] The situation here is similar to that described in footnote 1 but in this case zero deforestation will be reached when prices is greater or equal to *p***.

The data to obtain the socioeconomic parameters of the model come from two household surveys applied in Frontera Corozal, Mexico, during 2001 and 2004. In the first round of the survey 100 randomly selected households (approximately 10% of the population) were interviewed; these households were visited again during the summer of 2004. Frontera Corozal is a village in the Selva Lacandona (Lacandona Rainforest) in the Mexican state of Chiapas. In Frontera Corozal, Community members have exclusive rights to extract natural resources from the contiguous rainforest; nevertheless, there are no community rules (formal or informal) on how these resources, including xate, should be managed (Sanchez-Carrillo and Valtierra- Pacheco 2003; Tejeda 2004). Xate can therefore be considered as an unmanaged common property resource.

The objective of this section is to use xate extraction in Frontera Corozal as an example of how the model can be used to estimate the values of p^* and p^{**}. It is important to emphasize that the results presented here are only illustrative. According to equations 5 and 6 the socioeconomic parameters needed are w_1, w_2 and $\bar{L}_1$. The assumption is that the working population of the community can be divided in two groups according to their opportunity cost of time.

Using the data available from the information collected in the surveys we calculate annual net earnings for every household in the sample. Then, following Fisher et al. (2005), we estimate the opportunity cost at the household level as the quotient of annual net earnings in non-xate activities and total days of work allocated to those activities. The average opportunity cost of time at the household level is 60 Mexican pesos per-day (the equivalence rate at the time of the survey was approximately 10 Mexican pesos per US dollar).[3]

Almost half of the households have opportunity costs of time of 40 pesos per-day or less while for almost 15% the opportunity cost is above a 100, those are the values used to

[3] Agricultural labor wage in the area was 50 pesos per-day.

estimate the price bounds ($w_1 = 40$ and $w_2 = 100$).[4] The amount of type-1 labor available in the community was estimated as $\bar{L}_1 = 55{,}800$, where labor is measured in days per-year.[5]

The values for the biologic parameters were estimated using information from Martinez (2002) that studied xate in the region of the case study as well as from research done in other areas of Mexico and Guatemala (see Endress et al., 2004 and Heinzman and Reining, 1990). The parameter values, in terms of palm leaves, are: $K = 676{,}800{,}000$, $r = 0.181089$ and $q = 0.0000013978$.

Therefore, using the biologic and socioeconomic parameters calculated for Frontera Corozal the price range [p^*, p^{**}] is [0.0743,0.1857]. The price of a palm leave in the region was 0.0625. Considering that the price is below p^* the model predicts that in equilibrium all extractors will be type-1 individuals and more importantly they will be earning their opportunity cost of time (40 pesos). To reach the price range where earnings per-day start to be above the opportunity cost of time the price has to increase in 19%. Price increases above that level will improve earnings per-day. For example, a price premium of a 100% will imply that earnings per-day will increase in almost 70% (going from 40 pesos to 67 pesos per-day). If the price premium is 197% (or more) earnings will equal the opportunity cost of type-2 labor (100 pesos).

4. Conclusions

The findings from this analysis have important implications for policies with the dual goal of alleviating poverty and promoting conservation. A key objective of recent conservation initiatives has been to increase the price paid to NTFP extractors. However, under an unmanaged common property regime, an increase in the price of the natural resource, say due to a 'green product' price premium, does not necessarily help alleviate

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[4] Clearly there are more precise ways of finding w_1 and w_2 but the objective here is simply to illustrate how to apply the model proposed in the previous sections. For an econometric estimation of the relationship between the opportunity cost of time and labor allocation see Lopez-Feldman and Taylor (2009).

[5] To get this number I calculated the number of male adults (female and children very rarely work in xate extraction) in the survey that lived in a household with an opportunity cost below 40 and multiplied it by 100 (the maximum number of days anybody will allocate to extraction in a given year considering the seasonality of demand). The result, 5,580, is a conservative estimation of the maximum number of days that could be allocated to xate extraction by type 1 individuals in the sample. In order to extrapolate the sample value to the population I multiplied 5,580 by ten. The same caveat as in footnote 4 applies.

poverty. Irrespective of how much the price increases, the revenue per-day of work is always equal to an individual's opportunity cost of time, if labor is abundant and responsive with open access behavior. On the other hand, if there are constraints on the availability of local labor, price increases can in fact raise extraction income above the opportunity cost of time and help alleviate poverty even under local open access. That is to say, if a relatively small group utilizes the resource, its members can earn from extraction more than their opportunity cost of time even if they do not have any internal rules to manage it, provided that they can exclude outsiders from extracting.

The model presented provides very valuable information in terms of the potential implications that price premiums can have on extractors' income. The case study illustrates how one could evaluate the effectiveness of different price scenarios. It also shows the kind of biologic and socioeconomic information that is needed to apply the methodology suggested. The more accurate the information is the more confident one can be about the policy recommendations. This is an area of opportunity where applied research between economists and ecologists can lead to concrete policy applications.

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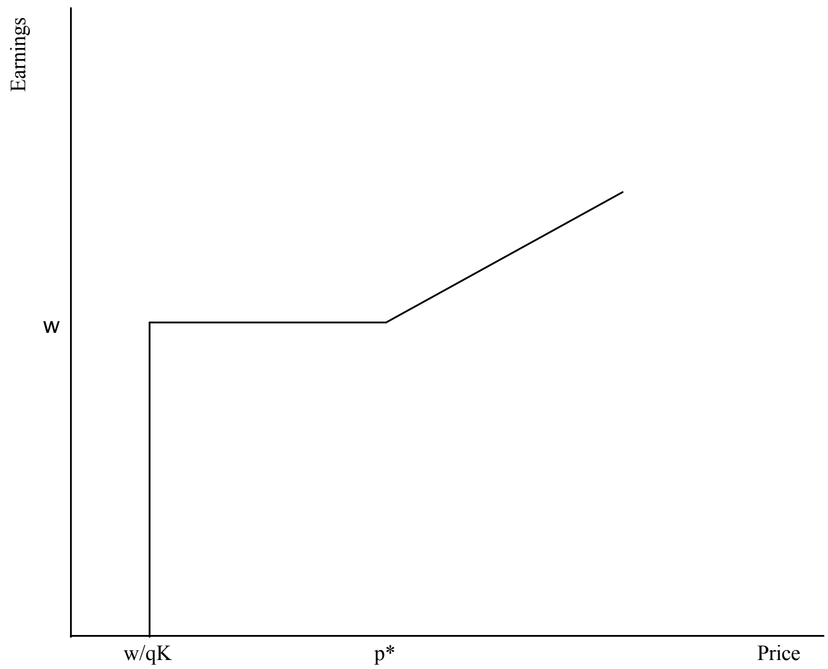

Figure 1. Earnings per-day under relative scarcity of labor

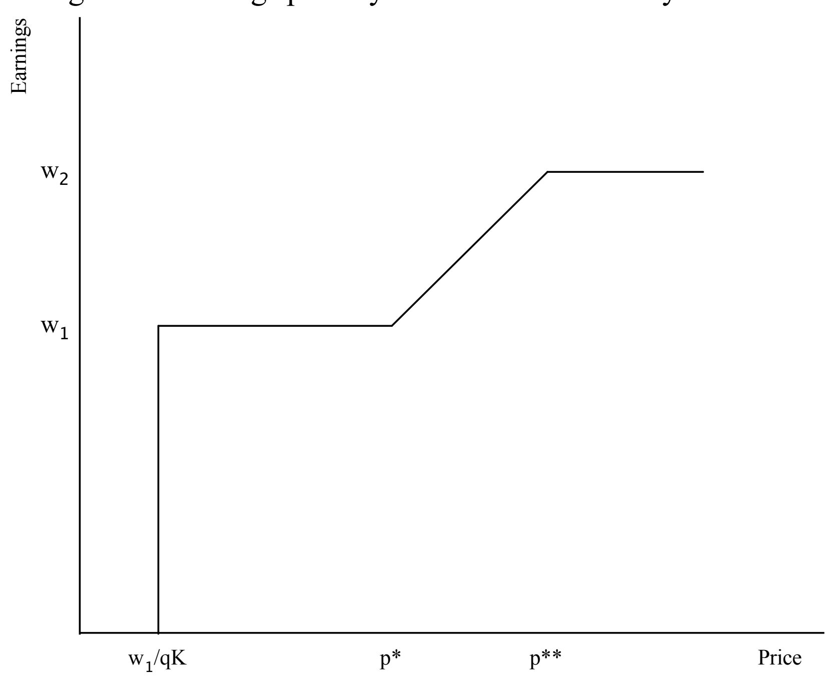

Figure 2. Earnings per-day under relative scarcity of heterogeneous labor