Evolving Patterns of Firewood Collections in Nepal: A Household Panel Analysis 1995-2003[1]

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Abstract:

Deforestation poses serious developmental and ecological problems. Most of research has focused on two key issues: the link between economic growth and deforestation and the potential of communities to sustainably manage their forests. We use longitudinal dataset to evaluate changes in the pressures on the forest in Nepal over time and how these related to observed contemporaneous changes. Firewood collection decreased of 12% between 1995 and 2003. Collection time fell by 23%. Evidence indicates that these reductions are not explained by rising living standards, nor by the widespread transfer of state forests to community forest groups. Falling collection owed to a shift away from traditional livestock rearing occupations, as well as the effects of the civil war. The fall in collection times resulted from the civil war and was therefore temporary in nature, rather than reflecting a decline in deforestation.

Keywords:

Nepal -Panel - Firewood collection - Himalayan forest - Kuznets curve - PEH

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1. Introduction

It is well known that deforestation in South Asia and sub-Saharan Africa, two of the poorest parts of the world, poses serious developmental and ecological problems. Large sections of neighboring populations of these countries rely on forests for household fuel, timber and fodder, and spend a disproportionate amount of time in collecting these products. The ecological problems pertain to increased soil erosion, water salinity, siltation in rivers, and increased likelihood of landslides and floods which affect large non-neighboring populations adversely.[5]

Policy discussions as well as academic research on this topic have focused on two key issues: (1) whether economic growth and development will accelerate or reverse deforestation, and (2) whether deforestation may be alleviated by reforming forest property rights to allow local communities a role and stake in managing forests. With the exception of Foster and Rosenzweig (2003), the empirical studies are based on cross-sectional datasets. Such studies infer how the pressure on forests change over time, from observing how they vary at any given point of time across households, communities, regions or countries with varying levels of living standards or property right regimes. This is based on the implicit assumption that variations associated with cross-sectional differences form an accurate basis to predict changes over time. Moreover, problems of unobserved heterogeneity inherent in cross-sectional data raise the possibility of serious biases in estimating effects of cross-sectional variations in assets or property rights. It is therefore important to utilize longitudinal data to directly examine changes over time in forests and pressures imposed on them by neighboring populations. Apart from the intrinsic advantages of directly observing changes in forest pressures and conditions and how they interact with processes of growth, development and property rights, this would provide an opportunity to test the validity of assumptions that underlie traditional cross-sectional studies.

This paper utilizes a household panel from the Nepal Living Standards Measurement Surveys carried out by the World Bank in 1995 and 2003 for a relatively small (but representative) sample of households residing in the mountainous regions of

[5] For detailed references concerning these problems, see Arrow et al (1995), Dasgupta and Mäler (1995, 2005) and Dasgupta et al (2000), and various references cited in Baland et al (2010a).

Nepal (i.e., excluding the low-lying *Terai* regions). In the 80s and 90s, forest cover in Nepal has declined at an annual rate of 1.9% and the state of the forest was heavily degraded (UNEP 2011). We use the longitudinal dataset to evaluate changes in the pressures on the forests in Nepal over time and how these related to observed contemporaneous changes in living standards, household assets and community forest management rights in neighboring areas.

This region experienced substantial reductions in firewood collected by households between 1995 and 2003, by about 12%. At the same time, the time needed by the average households to collect firewood also fell considerably, by approximately 23%. The period between 1995 and 2003 was also marked by rising living standards, shrinking household sizes, a transition towards modern occupations relying less on livestock rearing and more on education and non-farm assets, and a large transfer of forests owned by the state to management by local forest user groups. To what extent was the declining dependence of households on forest firewood the result of falling poverty, as postulated by proponents of the poverty-environment hypothesis (PEH)? Or did economic growth enable Nepal to pass the threshold for the declining portion of the inverted-U between deforestation and living standards predicted by the environmental Kuznets curve (EKC)? Or were neither of these explanations true, the declining pressure on the forests owing instead to the massive increases in forest areas transferred to forest user groups (FUGs).

In a panel setting, one of the key questions concerns the change in collection times over time, as it itself results from the extent of deforestation. It is then no longer legitimate to take collection times as given, as is customary in cross-sectional analysis. We therefore modify the econometric approach to treat changes in collection time as endogenous outcomes of interest, which is of some methodological interest in its own right. Our model includes interdependence of collection activities of households within a village through both congestion and peer effects. The congestion effect reflects the fact that increasing collections by the other households in the village results in a depleted forest and an increase in collection time, which tends to reduce firewood collected by a household. This mechanism runs counter to complementarities between collection activities in the village owing to peer or conformity effects. Our model shows how we can then treat household collections as well as collection times as endogenous outcomes, determined by individual household characteristics as well as those of others in the same

village through a combination of the congestion and peer effects. Changes in individual and village characteristics over time can then help explain observed changes in firewood collection levels and collection times.

Taking this model to the data, our principal empirical findings are as follows. First, collections are essentially rising with individual consumption levels, until the 95th percentile of the consumption distribution, after which they tend to decline. Hence growth in living standards *per se* tended to accelerate the pressure on the forest with the vast majority of the population still below the threshold for the turning point of the EKC. There is therefore no evidence in support of the PEH, and only a partial support for the EKC. Instead, collections were decreasing significantly owing to a decline in livestock owned by households, reflecting a shift towards modern occupations. An additional contributing factor was the decline in household sizes, which reduced firewood collected by the household owing to fewer people available to collect wood as well as reduced need for cooking energy and heat.

Second, there is no statistically significant relation between firewood collections and the existence of a Forest User Group (FUG) in the village. However, there is some tendency for collection times to fall with the creation of a FUG in the village. Since the emergence of a FUG and membership within the village are likely to be endogenously affected by prior pressures of deforestation as well as various unobserved political and economic factors, it is hard to attribute any causal significance to these results. If these concerns for possible endogeneity problems are ignored, the data suggests that the creation of FUGs allowed collection times to fall via regeneration of the forest or rationing and coordination of collection of members, rather than inducing any significant changes in the level of collections. However, even this conclusion must be tempered by the possibility that the creation of FUGs merely transferred contiguous forests from state ownership to the user groups, while more distant forests remained under state ownership and control. It is possible that households constituting the user groups redistributed their collections to the adjoining forests transferred to them, without any change in average forest conditions. Hence the data does not permit any inference regarding the role of the FUGs in forest conservation or regeneration.

How do we then explain the large drop in collection times, if not by the creation of FUGs? We find that an important part of the observed changes in collection time are

associated with the incidence of the civil war in Nepal during this period, arising from a Maoist-led peasant insurgency. Villages that witnessed greater mortality in this war experienced significantly greater reductions in collection times. Do and Iyer (2010) have documented how the Nepal civil war was concentrated in geographic locations favoring insurgents such as mountains and forests, and in areas of greater poverty owing to the need of the insurgents to recruit soldiers (see also Bohara et al, 2006 and Hatlebakk, 2009). Hence villagers may have reacted by shifting their collections from distant denser forests to nearby forests, in order to avoid encountering insurgents and thereby getting recruited or caught in cross-fire. If so, the observed reductions in collection time may have been temporary, lasting only as long as the civil war lasted, and may have contributed to deforestation of forests in the proximity of the villages.

In sum, therefore, the evidence indicates that the observed reductions in collection levels as well as collection times in Nepal in the late 1990s owed neither to rising living standards as postulated by PEH or EKC, nor to the widespread transfer of state forests to community forest groups. Falling collections owed to a shift away from traditional livestock rearing occupations, as well as to declining household sizes. The fall in collection times resulted from the civil war and was therefore temporary in nature, rather than reflecting a decline in deforestation.

Our findings differ partly from those obtained by Foster and Rosenzweig (2003) who used a panel data set of 250 villages in India, over a period of 29 years, by combining satellite imagery and census data. They found that the increased demand for firewood that accompanied the rise in living standards led to reforestation overall India and an increasing role for the market for firewood. The hilly and mountainous regions of Nepal do differ from India in a number of important characteristics: (1) the forests are abundant relative to the population, (2) the forests are still of an essentially open (though possibly regulated by the FUG) access nature, which involves that households collect according to their needs, and, most importantly, (3) the demand for heating energy in the winter constitutes an important and relatively inelastic component of the demand for firewood, for which few substitutes are available.[6] Relatedly, Chaudhury and Pfaff (2003), on the basis of the Pakistan World Bank LSMS, found some evidence of an EKC

[6] Related to this, Nepal et al (2010) show that the introduction of improved stoves does not seem to affect firewood collections in Nepal, which supports the idea of an inelastic demand for firewood.

in indoor air pollution. While richer households tend to consume more energy, they switch to cleaner and more efficient fuels (kerosene) which reduces the amount of indoor pollution.[7] Combined with our own evidence here, this suggests that, in the absence of available alternatives (LPG or kerosene), the rise in living standards in Nepal will increase the pressure on the accessible forests. This is also in line with numerous cross-section studies on Nepal and rural India which suggest that firewood is a normal good (see in particular Heltberg et al, 2000; Arnold et al, 2003; Andikhari et al, 2004, and Gundemida and Kohlin, 2008).

Our results on FUGs tend to support the findings of Somanathan et al (2009) and, to a lower extent, of Baland et al (2010b), who showed that the impact of community forestry in India on the state of the forest was quite limited. They however differ from those obtained by Edmonds (2002) who found that the creation of FUGs in Nepal tends to reduce fuelwood extraction from forests (see also the recent surveys by Kanel, 2008, and Shyamsundar and Ghate, 2011).[8] The methodology used in those studies deals explicitly with the possibility of a selection bias in the creation of the FUGs, a problem that we could not satisfactorily address with the present data set.

A final objective of this paper is to examine the consistency of the panel data estimates with those obtained previously using cross-sectional data in our earlier work in the context of Nepal (Baland et al (2010a)) and India (Baland et al (2007)). This will help assess the biases arising from cross-sectional analysis traditionally used in this literature. Our panel estimates are essentially consistent with those highlighted there: (1) we find evidence of a strong association between income and firewood consumption, and (2) we also find that occupational pattern, as measured by livestock ownership, plays an important role. By contrast, in the panel data used in this paper, the increase in education or in non-farm assets do not reduce firewood collections, which suggests that the cross-

[7] The switch of higher incomes households to higher quality but more expensive substitutes (gas or kerosene) is known as the 'energy-ladder' hypothesis, and is often viewed as an important mechanism behind the EKC (see Arnold et al, 2003). Recent evidence from China suggests that firewood is an inferior good in China, with coal being used as a superior alternative (Demurger and Fournier, 2011). Our own research in the Indian Himalayas finds a strong sensitivity of the demand for firewood to the price of kerosene (Baland et al, 2007).

[8] Using cross-sectional LSMS data for the Arun Valley in1995/6, Edmonds estimated that the creation of new FUGs was associated with a small but statistically significant decline of firewood collection by about 12%.

sectional results obtained in our previous studies were possibly due to inter-household differences.[9]

The paper is organized as follows. In Section 2, we describe the major trends in the collection of firewood in Nepal between 1995-6 and 2003. We then present Engel curves in Section 3, and a more systematic reduced form approach in Section 4 which develops the model and then presents the main empirical findings. Section 5 summarizes and concludes the paper.

2. Major trends in forestry in Nepal

The World Bank Living Standards Measurement Survey (LSMS) for Nepal interviewed 3388 households concerning their production and consumption activities for the year 1995–96, and 3912 households for the year 2002-3.[10] The complete panel covers 1232 households. In the present paper, we focus our attention on the hills and mountain areas of Nepal, which share a similar agro-ecological system and a comparable reliance on forest resources. We therefore exclude the villages from the low level Terai region, as well as the 4 villages originally included in the panel and that could not be re-surveyed because of the Maoist guerilla. Our final panel covers 434 households in 41 villages. For these villages, the attrition rate across the two panels was 14.4 %.[11] Table 1 below provides a summary description of the main variables used in our analysis.

INSERT TABLE 1 HERE

In this region, almost all households collect and consume firewood, which is by far the primary source of cooking fuel. The percentage of households collecting firewood in 1995 was equal to 92%, and 95% in 2003. The quantities of firewood exchanged on the market were essentially negligible. Between the two surveys, the average amount of firewood collected per household dropped from 100 to 88 bharis (i.e., a headload), which

[9] It should also be noted that we have too few households switching to a non-farm occupation over the time period considered to obtain statistically significant outcomes.

[10] Note that the latter was effectively administered in 2003 and part of 2004, so that, to avoid confusion, we refer to the year of the second survey as 2003.

[11] Using household characteristics in 1995/6, we could not find any bias in the attrition process. One potential problem is that the panel villages might have been selected non-randomly due to their proximity to roads, market centers, distance to forests… We examined this question and could not find any systematic pattern in the choice of the villages in the panel.

represents a fall of about 12 %.[12] The time taken to collect firewood also fell substantially from 4.78 to 3.67 hours per bhari across the two surveys.

Three major changes characterize the environment over the period. First, the Nepalese Civil War opposed government forces and the Maoist rebels in Nepal, which started in 1996 and ended in 2006. The civil war culminated in 2003 and 2004, with the Maoist rebels controlling a large part of the countryside. 41% of the villages surveyed belonged to a district where severe combats (involving more than a hundred casualties) occurred in 2003.[13] Over all villages, the average number of casualties in 2003 was equal to 0.12 deaths per thousand inhabitants in the district. The cumulative number of casualties between 1995/6 and 2003 was on average equal to 0.47 deaths per thousand.

Second, living standards improved over the period. At the household level, the median consumption expenditures increased by 13.7% while median income increased by 24%. Most households were primarily engaged in self-employed agricultural activities and livestock rearing. The principal productive assets consisted of cultivated land, livestock, education and non-farm business assets. The value of non farm business assets increased on average by about 24%, while the amount of cultivated land and the number of big livestock animals fell by 15% and 5% respectively. Household size fell by 5% on average but gender composition remained unchanged. The average number of years of schooling of all adults in the household increased but remained low, with more than a third of the households having no education at all.

Third, the period under study also witnessed the full development of the Forest User Group program, which was launched in 1993. The programme's objective is to transfer the management of all accessible forests to local communities, via Forest User Groups (FUGs). This management implies controlling access to the forests, taxing forest products, hiring forest guards, launching plantation programmes, etc. Income generated by forest-related activities can be used to finance local projects (roads, schools, temples…).[14] This programme expanded rapidly and in January 2007, an estimated 38%

[12] The total amount of firewood collected in the villages has increased in net, since the average population growth in the districts studied was about 25% over the period.

[13] Unfortunately, the information available is not available at the village level, so that we will refer to the number of deaths in the district to which the village belongs. Note however that the villages are well spread over the different districts (41 villages over 37 districts). Only 3 districts had more than one village in our sample.

[14] Certain legal restrictions are set for the use of these funds. For example, 25% of revenue must be reinvested in projects aimed at developing the forest.

of the population were involved in an FUG. In 1995-6, 37 % of the villages surveyed had a forest user group. In 2003, this percentage increased to 66 % of the villages (27 out of 41), with 51% of the households in those villages collecting primarily from the community forest. The two other major alternative sources of firewood were state forests and own land. The percentage of households collecting primarily from their own land increased slightly, from 26% to 30%. More importantly, the percentage of villagers collecting from state forests decreased significantly, from 54% to 28 %. We therefore observe a large switch in collections out of state forests to community forests, which reflects the conversion of state forests into FUGs.

Table 2 below presents the reported collection time across the three main sources of firewood (the residual category appears as 'other land' in the survey, and concerned only 2 % of the households in 1995-6), as well as the number of collectors in each forest. As already discussed, collection times decreased for all categories of forest over the period. Collection times were, on average, largest on state forests and smallest on private land.

INSERT TABLE 2 HERE

3. Firewood Collection and Living Standards: the Engel curves

We first describe the relationship between living standards and firewood collection using simple Engel curves. Table 3 reports the estimates for the amounts collected at the household level. All the estimates are done with household fixed effects. This specification therefore effectively gives us an estimate of how much collections changed as living standards changed over time for the same household. The estimates also include time and seasonal dummies (which were used as household interviews were administered at different season of the year). Standard errors are clustered at the village level.

INSERT TABLE 3 HERE

The Engel curves reported in Table 3 all rely on a quadratic specification for living standards, measured by total recurrent consumption expenditures, which is less subject to short run fluctuations and measurement errors compared to incomes.[15] The first column provides a direct estimate, with no additional controls. In column (2) we introduce a village specific time trend. In column (3), we control for the village median collection time and, in column (4), we also control for individual assets and family composition, thereby taking into account the impact of occupational changes. In column (5) we introduce the extent of conflicts at the village level, the existence of a FUG and whether the household is a member of that FUG.[16] All variables are measured as described in Table 1.

Firewood collections vary with living standards. Both the linear and the quadratic coefficients are significant and consistent across the different approaches. The relationship therefore follows an inverted-U shape usually associated with the EKC. Across the three specifications, the turning point is located around the 95 percentile of the income distribution (under the first specification, it corresponds to a consumption of Rs. 112612), which implies that the slope is positive for a large majority of households. This finding is in line with our previous results using cross sectional data in similar areas of India and Nepal (Baland et al (2007, 2010a)). Also consistent is the finding that livestock and household size are related positively to collections. At the village level, conflict intensity is associated with a reduction in collections, while the presence of a FUG does not appear to matter. We will return to these issues in the following sections.

The coefficients attached to collection time (columns (3) to (5)) are not significant and changes sign. In Appendix 1, we provide further estimations of Engel curves along the specifications proposed in Baland et al (2010a). There also, collection time, whether by itself or interacted with the household productive assets, does not affect collections. This evidence suggests that the amount of firewood collected by the households are basically price-inelastic, reflecting the lack of alternative sources of fuel or the presence of peer effects (see also Heltberg et al, 2000). However, we cannot draw firm conclusions here as collection times are themselves endogenously determined at the household and at

[15] Higher order polynomials were also tested, with little impact on the estimates.
[16] While not reported here, all the results discussed are robust to using income instead of consumption expenditures as the measure of income. They are also robust to the inclusion of collection time, by itself and interacted with each household assets, as shown in Appendix 1.

the village level.[17] This is why, in the following, we favor a reduced form approach where the endogeneity of collection times is explicitly taken into account.

In Figure 1 below, we provide two non-parametric estimations of the Engel curve, relating the changes in household firewood collection to the changes in household consumption expenditures within the same household. To estimate these curves, we use the estimator proposed by Baltagi and Li (2002), which allows consistent estimates of β's in semi-parametric regression[18]. The first estimate on the left hand side of the figure includes a general time trend, while the right hand side also controls for individual assets, conflict and the presence of a FUG in the village. It follows specification [3] in table 3. Again, we find a relationship which is essentially increasing and concave. Above the 90th percentile of the distribution, the relationship is less clear but observations are scarcer and much more scattered.

INSERT FIGURE 1 HERE

4. Firewood Collection and Household Assets: A Reduced Form Approach

4.1 The Problem

At the household level, firewood collections depend not just on living standards but also on the costs of collecting firewood, equal to the time necessary to collect firewood multiplied by the opportunity cost of time or the shadow wage (see for instance Pattanayak, 2004). As we argued in Baland et al (2010a), household incomes and shadow wages are determined by occupational patterns, which themselves depend in a complex manner on the productive assets (land, education, livestock, household size, …) owned by the household. We proposed there a reduced form approach, wherein collections were expressed as a function of productive assets, both by themselves in order to capture their impact on household income, as well as interacted with collection time to capture collection costs. The time to collect firewood was measured by the village average and

[17] In all those estimates, we used the median collection time at the village level. The use of individual collection time provides similar results.

considered exogenous to each household. This assumption followed from the cross-sectional nature of the data used.

A major advantage of panel data is that they allow us to analyze changes in collection time over time. Collection times can now be viewed as endogenously determined, reflecting patterns of collection in the recent past and their impacts on the state of forest. Collection patterns being determined by household and village characteristics, we expect changes in collection times to depend on corresponding changes in household and village characteristics that affect collections. In particular, collection activities of other households in the village end up affecting the collection of any given household, via effects of the former on the collection time of the latter owing to a congestion effect. Besides this source of interdependence, there may also be a direct effect reflecting the presence of village norms regarding firewood collection and consumption, which we refer to as a peer effect.

The possible existence of these congestion and peer effects means that it is no longer legitimate to treat collection times as an exogenous determinant of collection levels. The use of average (or median) collection time at the village level clearly does not overcome this problem. In the following, we therefore propose a reduced form approach in which both collections and collection times are expressed as a function of productive assets at the household and at the village level.

4.2 The Model

We now develop the model underlying the reduced form approach, where the amounts collected and the collection times are expressed directly as a function of these assets. More specifically, let the amount of firewood collected by household *i* in village *j* at time *t*, C_{ijt}, be a function of various household assets, X_{ijt}, a household fixed characteristic, η_i, the time taken to collect one unit of firewood, T_{ijt},a time varying parameter, α_t, and average collections in the village, $\overline{C}_{jt}$. Average collections are included here to reflect the presence of *peer effects* in collections: households tend to observe each other, and collect similar quantities from the same forests. This may be due for instance to the existence of norms about what and where to collect, to some

conformity propensity, where individual households tend to behave as most others do, or to some collective mechanism whereby households collect together from the same places, in a semi-organized way. Average collections are defined by $\overline{C}_{jt} = \sum_i C_{ijt} / N_{jt}$ where N_{jt} is the number of households in the village in year *t*. We therefore assume the following specification:

$$(1) \quad C_{ijt} = \sum_j \beta_j X_{ijt} + \varphi T_{ijt} + \gamma \overline{C_{jt}} + \eta_i + \alpha_t .$$

Since T_{ijt} measures collection costs, we expect φ to be negative. In this equation, the presence of peer effects can in principle be tested as they imply a positive γ. Since individual collections get reflected in the village average collection which itself influences individual collections, we have to make sure that individual collections are well-defined by assuming $\gamma < 1$.

By definition, average collection in the village, $\overline{C}_{jt}$, is the sum of all individual collections divided by the number of households, N_{jt}:

$$\overline{C}_{jt} = \frac{1}{N_{jt}} \sum_j \sum_i \beta_j X_{ijt} + \frac{1}{N_{jt}} \sum_i \varphi T_{ijt} + \gamma \frac{1}{N_{jt}} \sum_j \overline{C}_{jt} + \frac{1}{N_{jt}} \sum_i \eta_i + \alpha_t$$

which can be rewritten as:

$$(2) \qquad (1-\gamma)\overline{C}_{jt} = \sum_j \beta_j \overline{X}_{jt} + \varphi \overline{T}_{jt} + \eta_v + \alpha_t .$$

An analogous expression can be derived for the time taken to collect firewood. The latter depends on household assets and fixed characteristics, since some activities in the household, such as livestock grazing, are complementary to firewood collection, while others, such as non-farm business assets, are not. Moreover, we allow for a *congestion effect* at the village level whereby the time necessary to search and collect firewood in the common forests increases with village collections. To do this, we explicitly introduce the average collection at the village level in the determination of collection times. We thus have:

$$(3) \qquad T_{ijt} = \sum_j \lambda_j X_{ijt} + \delta \overline{C}_{jt} + \upsilon_i + \chi_t$$

where δ reflects the strength of the congestion effects, and is expected to be positive.

Average collection times are therefore given by:

(4) $$\overline{T}_{jt} = \frac{1}{N_t}\sum_i T_{ijt} = \sum_j \lambda_j \overline{X}_{jt} + \delta \overline{C}_{jt} + \rho_j + \chi_t$$

Combining equations (2), (3) and (4) together, one obtains after some simplifications:

(5) $$T_{ijt} = \sum_j \lambda_j X_{ijt} + \sum_j \delta \left(\frac{\beta_j + \varphi\lambda_j}{1-\gamma-\varphi\delta} \right) \overline{X}_{jt} + \phi_i + \iota_t ,$$

where ϕ_i, ι_t represent a time and an individual fixed effect in the individual collection time. Equation (5) can be directly estimated, with the coefficients attached to $\overline{X}_{jt}$ directly measuring the importance of the congestion effect. Using equations (2)-(5), we can also rewrite the collection equation as follows:

(6) $$C_{ijt} = \sum_j \left(\beta_j + \varphi\lambda_j\right) X_{ijt} + \sum_j \left(\gamma + \varphi\delta\right) \left(\frac{\beta_j + \varphi\lambda_j}{1-\gamma-\varphi\delta} \right) \overline{X}_{jt} + \kappa_i + \nu_t ,$$

where κ_i, ν_t represent a time and an individual fixed effect in individual collections. In equation (6), the coefficients attached to the individual assets combine the direct 'income' effect with the possible complementarity between a particular asset and collection times. The coefficients attached to the average productive assets combine the (negative) congestion and the (positive) peer effect, so that the net effect is therefore indeterminate *a priori*. If the congestion effect (resp. peer effect) dominates, we expect the coefficients attached to the average assets to have the opposite (resp. same) sign to those of the individual assets.

Alternatively, one can also directly use equations (1) and (3) to derive the semi-reduced form expression as follows:

(7) $$C_{ijt} = \sum_j \left(\beta_j + \varphi\lambda_j\right) X_{ijt} + \left(\gamma + \varphi\delta\right) \overline{C}_{jt} + \left(\eta_i + \varphi\upsilon_i\right) + \vartheta_t ,$$

which, jointly with equation (2), can also be directly estimated. In equation (7), the sign of the coefficient attached to $\overline{C}_{jt}$ directly reflects the relative strength of peer effects over congestion effects. We will use this second specification as a test of the robustness of our estimates. However, this strategy is subject to Manski's reflection problem, since the average collection reflects exactly the same determinants as the individual ones (Manski, 1993). It also means that there is no easy way out of this problem, since we cannot think of an instrument that would affect average collections but not individual behavior.

4.3 The Regression Results

Table 4 below reports the estimates for the amounts of firewood collected at the household level. All equations are estimated using household fixed effects, year and seasonal dummies, while standard errors are clustered at the village level. The first three columns use a linear specification: the first one directly follows from equation (6) above, with both village and individual asset levels, the second one uses individual assets and a village specific trend which summarizes all the changes at the village level, and the third one is based on equation (6) but with the amounts collected measured in logarithms. In the fourth column, we use a quadratic specification for individual and village assets. We report here the marginal effects estimated at the median, the estimated coefficients are reported in Appendix 2. The last column is proposed as a robustness check, and directly includes the village average collection level, following the specification proposed in equation (7) above.[19]

INSERT TABLE 4 HERE

In all the specifications, household assets, livestock, household size and the proportion of adult males all have a positive and significant impact on the amounts collected. This shows that occupational patterns are important determinants of collection. By contrast, land, education and non-farm business assets do not seem to matter (as in the Engel curve results in Table 3). The result on livestock is particularly interesting as it supports the idea emphasized in Baland et al (2010a) that livestock grazing is a complementary activity to firewood collection. The effect of increasing household size (and to some extent, the proportion of men in the household) is to reduce shadow wages and increase the demand for firewood.

At the village level, average livestock may perhaps reduce collections, in contrast to the positive effect of the household's own livestock, which could confirm the role of congestion effects. On the other hand, with the exception of land (which is barely significant), the village averages of most other assets do not exercise a significant effect,

[19] More specifically, we use the average collection level of all the other villagers, which partially addresses the reflection problem discussed above.

and their signs are the same as those of the corresponding household assets, indicating that congestion effects are weak or matched by peer effects. Moreover, the results obtained in column (5) indicate a strong positive and significant correlation between individual and village collections, which supports the idea that, if anything, the congestion effects are dominated by the peer effects. This is also consistent with the low and often positive elasticities of collection with respect to collection times.

In table 5, we turn to the estimation of the determinants of the individual collection times, using the specification defined by equation (5) above.

INSERT TABLE 5

First, with the possible exception of non-farm business assets, household assets do not have any significant impact on collection times. Turning to village assets, average household size has a positive effect on collection time, which is consistent with a congestion effect: larger households collect more firewood, increasing the pressure on the forests. While the other assets in general have the expected sign, they are not significant, except for the average level of non-farm business assets at the village level (though not at the household level), which may reduce collection time. Taken together, these findings suggest that collection times do not react very strongly to congestion effects.

Two more results from Tables 4 and 5 are worth emphasizing. The first one is the impact of conflict on collection behavior. Conflict intensity, as measured by the number of deaths in the district between 1996 and 2003, has a large negative impact on the collection time, while its impact on collections is not systematically insignificant. We interpret this finding as follows. Conflicts induce villagers to collect firewood in safe areas, which are typically located closer to the village. In times of conflict, villagers do not venture in the forests as far as they used to. Conflicts may also reduce total amounts collected.

The other result concerns the effects of forming a Forest User Group in the village. In the absence of a reasonable identification strategy, it is difficult to properly evaluate the effects of FUGs.[20] One of the problems involved is that Forest User Groups

[20] For various attempts at identifying the impact of community forest management in Asia, we again refer to Edmonds (2002), Somanathan (2009) and Baland et al (2010b).

are created voluntarily by villages, so that the creation of an FUG and the time at which it is created are not exogenous. Moreover, membership in a FUG is also voluntary, and therefore the right to collect from a community forest is again not exogenous, even when one controls for village characteristics. Finally, the criterion to be used to evaluate the 'success' of a FUG is not entirely clear. For instance, improved management of the forest may imply a temporary reduction in collections, followed in the longer run by an increase in collections, given the proper regeneration of the resource. This may reduce in the long run the time necessary to collect firewood, but improved harvesting practices and restrictions have the opposite effect. We therefore adopt here an agnostic view, and focus on the correlations that the estimations above suggest, without drawing causal inferences.

Since we are using a panel with household fixed effects, the impact of FUG measured here is identified on those villages in which a FUG was created between the two surveys. The effect is therefore measured with respect to recently formed FUGs. Collection times are significantly lower in villages with a new FUG, by about half an hour, while collection levels are not significantly affected. This suggests that the creation of community forests results in a better management of the forest resources, which reduces average collection times even though collection levels remain unchanged.[21] However we cannot rule out the possibility that households merely shifted their collections to the community forests from the state forests. We also looked at the characteristics of the households which collected primarily from community forests, and found no systematic difference with other villagers in terms of wealth, incomes or asset levels (with the exception of livestock, where large livestock owners tend to collect from other types of forests, probably better suited for extensive grazing).

4.4 Discussion

We started our enquiry by reporting the important changes in collections that occurred in Nepal between 1995/6 and 2003. Over that period, the average amount of firewood collected by a household fell by 12%, from 100 to 88 bharis per year, while the time required to collect one unit of firewood fell by 30%, from 4.78 to 3.67 hours per

[21] It is worth noting that the effects of conflict and of FUGs are clearly distinct, as the two are negatively correlated across villages.

bhari. We can now use the results presented in Table 4 and 5 to estimate the relative importance of the different factors explaining those changes. To do this, we rely on the linear specification (column (1)), and focus only on the significant coefficients. The reported figures correspond to the average of the effects predicted at the household level. Table 6 reports the contribution of the main factors explaining the changes in the amounts collected and collection times.

INSERT TABLE 6 HERE

The fall in firewood collected is explained mostly by the changes in livestock and in household size at the household level, which together account for 20% of the observed changes in collections. At the village level, the changes in the average amount of land are important but, as we saw, this particular coefficient is imprecisely estimated. These estimates support the idea that occupational patterns are a major factor in the collection of firewood (see also Bluffstone (1995)).

The fall in collection times is essentially driven by the conflict, which explains 50% of the change, while the other factors have a much smaller impact. The presence of a FUG corresponds to a fall in collection time of about 10 minutes, which represents 15% of the observed change.

We end by briefly discussing the limitations of the reduced form approach followed above. First, the coefficients estimated represent the net effect of a change in a particular asset on the amounts collected. While this is certainly adequate to measure the implications of changes in occupational patterns, it does not provide readily interpretable coefficients. As can be seen in equation (6) above, these coefficients represent a mixture of income, substitution and complementarity effects that we are not able to disentangle. Second, a possible concern with the above estimates is that the productive assets used in the reduced form specifications are themselves endogenous. This may be particularly relevant for the amount of livestock, but in general for all the assets. (We have re-run all the estimates without livestock, with no changes in the main results.) Finally, the reduced form adopted here has been simplified to enable us to carry out the estimations. However, in a more developed model, one could have added interaction terms aimed at capturing the ‘cost of collection’ effect, which is the product of collection times and the household

shadow wage. The shadow wage itself can be expressed in terms of the productive assets, which implies that we should have in the estimation allowed for interaction terms between each productive asset and the village average. The estimations reported here ignore these higher order terms.

5. Conclusions

In this paper, we proposed an analysis of household firewood collection in Nepal, using the panel data set based on a sub-sample of the two waves of the Nepal LSMS. We found that both the amounts collected and the collection times fell substantially over the period.

We first found strong evidence in support of a rising Engel curve, which suggest that rises in incomes are on average associated with rises in the amounts collected. Collections are inelastic to collection time. We then argued that, contrary to a common practice in the literature, collection times could not be considered as exogenous, and could not therefore enter as such (or interacted with a measure of the shadow wage) in the collection equation. We therefore proposed a reduced form approach, where collection levels and collection times at the household level are determined by both the household and the village productive assets. Two mechanisms are at work in the impact of village assets: a congestion effect, whereby increased collections in the village increase collection time, which in turn reduces individual collections, and a peer effect, whereby households tend to collect the same amounts as the village average.

Using this approach, we highlighted the importance of occupational patterns in the relationship between income growth and firewood collections. In particular, we found that falling livestock ownership and household size contribute significantly to a reduction in firewood collections. Collection times do not appear to vary with the individual assets of a particular household, but the estimates support the existence of some congestion effects on collection time at the village level. Moreover, there is little evidence of congestion effects on household collections, either because collections are not very sensitive to the cost of collection or because peer effects have strong enough counteracting effects. Our results also show that the development of community forestry is associated with a decrease in collection times, but does not affect collection levels.

Finally, we showed that collection times fell substantially in the areas most affected by the Nepalese civil war, which suggests that, in troubled areas, households chose to collect firewood closer to the village, presumably out of safety concerns.

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Table 1: Descriptive statistics of the main variables

Variable	Unit of measurement	year	median	mean	st. dev.	min	max	nb 0
Recurrent consumption expenditures	Rs per year	1995/6	24338.24	28229.9	16765.04	2294.78	108320.2	0
		2003/4	27685.07	31436.65	18545.78	3078.16	106800.3	0
Actual Income	Rs per year	1995/6	21113.42	26714.31	22939.26	1092.44	228986.1	0
		2003/4	26234.6	33890.46	26024.96	1624.12	172976	0
Firewood collected	# Bharis per year	1995/6	84	100.42	70.87	0	360	35
		2003/4	72	88.15	55.16	0	300	22
Firewood collection time	# hours per bhari	1995/6	4	4.78	2.55	0.17	12.8	35
		2003/4	3.5	3.67	1.82	0.17	10	22
Percentage of collectors	%	1995/6	100	91.94	27.26	0	100	35
		2003/4	100	94.93	21.96	0	100	22
Livestock	# of big cattle heads	1995/6	3	3.84	2.84	0	15	40
		2003/4	3	3.63	2.48	0	13	54
Land	# hectares owned	1995/6	0.48	0.92	1.8	0	20.69	12
		2003/4	0.55	0.78	1.04	0	15.58	21
Household size	# individuals	1995/6	5	5.4	2.29	1	17	0
		2003/4	5	5.14	2.26	1	13	0
Proportion of adult men (16-65)	share of household size	1995/6	0.2	0.22	0.16	0	1	69
		2003/4	0.2	0.22	0.16	0	0.67	93
Education	Average # of years of education in the household	1995/6	1	1.82	2.4	0	15	197
		2003/4	2	2.39	2.63	0	12.5	159
Non-farm business assets	Rs	1995/6	0	4435.75	29924.13	0	460869.6	372
		2003/4	0	5530.39	29549.74	0	290697.5	360
Percentage of community forest members	%	1995/6	0	10.83	31.11	0	100	387
		2003/4	0	32.95	47.06	0	100	291
Total number of casualties from 1996-2003	# casualties per 1000 inh.	2003	0.42	0.59	0.65	0.07	3.93	0
Villages with community forest	%	1995/6	0	36.59	48.77	0	1	26
		2003/4	1	65.85	48.01	0	1	14

Note: A bhari is a headload of firewood, and weights between 15 and 30 Kgs of wood.

Table 2: Collection times and number of collectors by main source of collection

Primary source of firewood collection	Number of hh collecting in 1995/6	Number of hh collecting in 2003/4	Mean collection time in 1995/6 (std. dev.)	Mean collection time in 2003/4 (std.dev.)
Private land	113	129	3.7 (2.13)	2.65 (1.3)
Community forests	40	138	4.64 (2.82)	4.26 (2.09)
State forests	235	121	5.41 (2.5)	4.16 (1.57)
Other land (roadsides,…)	11	24	3.05 (1.82)	3.24 (1.33)
Total collectors	399	412	4.78 (2.55)	3.67 (1.82)
Non collectors	35	22	---	---

Table 3: Engel Curves

	Dependent Variable: Firewood collected (in bharis)				
	[1]	[2]	[3]	[4]	[5]
Consumption	0.00250***	0.00210***	0.00247***	0.00171**	0.00189***
	(4.44)	(3.58)	(4.47)	(2.55)	(2.82)
Square of consumption	-2.22e-08***	1.93e-08***	-2.22e-08***	-1.69e-08**	-1.83e-08**
	(-3.37)	(-2.88)	(-3.36)	(-2.36)	(-2.55)
Village median collection time			1.577	0.929	-0.257
			(-0.36)	(0.23)	(-0.06)
Land				0.289	0.0525
				(-0.11)	(0.02)
Livestock				5.068**	4.981***
				(2.71)	(2.94)
Education				-1.211	-1.178
				(-0.62)	(-0.59)
Non-Farm Business Assets				0.0000414	0.0000532
				(0.46)	(0.59)
Household size				3.455	3.603*
				(1.68)	(1.71)
Proportion of men				28.35	27.6
				(1.34)	(1.33)
Casualties from 1996 to 2003					-11.10*
					(-1.88)
FUG in the village					-2.481
					(0.26)
Member of FUG					7.233
					(0.96)
Village trend		X			
Within R-sq	0.084	0.276	0.085	0.13	0.138
# observations	868	868	868	868	868

Note: t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001. In all estimates, we include an individual fixed effect, a year dummy and seasonal dummies. The standard errors are clustered at the level of the village.

Table 4: Reduced form for firewood collections

	Dependent Variable: Firewood collected				
	Linear [1]	*Village. trend* [2]	*Log(wood)* [3]	*Quadratic* [4]	*Village average collections* [6]
Livestock	6.307***	6.360***	0.0492***	3.596	5.509***
	(3.65)	(3.64)	(3.41)	(1.68)	(3.55)
Land	-1.643	-1.669	-0.00829	0.020	-0.653
	(-0.60)	(-0.60)	(-0.35)	(0.00)	(-0.25)
Household size	5.279***	5.497***	0.0706***	7.978***	5.272***
	(2.95)	(2.9)	(6.06)	(6.17)	(3.05)
Proportion of men	32.23*	35.59**	0.18	38.29**	34.27*
	(1.87)	(2.04)	(1.13)	(2.07)	(1.85)
Education	-0.936	-0.934	0.0108	0.227	-0.978
	(-0.49)	(-0.48)	(0.58)	(0.08)	(-0.52)
Non-Farm business assets	0.0000898	0.0000906	-0.000000311	-0.0002587	0.0000314
	(0.86)	(0.87)	(-0.16)	(-1.08)	(0.32)
Village average wood collection (-i)					0.594***
					(6.97)
Village average Livestock	-3.378		-0.0933	-16.13***	
	(-0.53)		(-1.65)	(-2.82)	
Village average Land	13.40*		0.0879	25.474	
	(1.73)		(1.34)	(1.39)	
Village average Household size	7.302		0.138*	14.83*	
	(0.87)		(1.9)	(1.91)	
Average prop. of men in the village	70.7		0.618	18.184	
	(0.42)		(0.4)	(0.11)	
Village average Education	-2.598		-0.0895	6.376	
	(-0.22)		(-0.92)	(0.58)	
Village av. non-farm bus. assets	-0.000763		-0.0000124**	-0.0004777	
	(-1.57)		(-2.57)	(-0.26)	
Casualties from 1996 to 2003	-9.600		-0.145*	29.318	-4.668*
	(-1.06)		(-1.72)	(1.3)	(-1.69)
FUG in the village	1.266		-0.0747	13.97*	0.987
	(0.12)		(-0.87)	(1.91)	(0.22)
Village trend		X			
Within R-square	0.141	0.325	0.197	0.222	0.192
N	868	868	811	868	868

Note: t statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01. In all estimates, we include an individual fixed effect and seasonal dummies. The standard errors are clustered at the level of the village.

Table 5: Reduced form for collection time

	Dependent Variable: Time taken to collect one unit of firewood			
	Linear [1]	*Village. trend* [2]	*Log(wood)* [3]	*Quadratic* [4]
Livestock	0.0456	0.0338	0.0114	0.044
	(0.8)	(0.61)	(0.82)	(0.8)
Land	-0.000377	0.00237	0.000132	-0.047
	(-0.01)	(0.04)	(0.01)	(-0.35)
Household size	0.0704	0.0882	0.0211	0.100
	(1.13)	(1.38)	(1.27)	(1.41)
Proportion of men	-0.198	-0.127	-0.0449	-0.245
	(-0.35)	(-0.22)	(-0.26)	(-0.41)
Education	-0.0372	-0.0353	-0.00534	0.036
	(-0.65)	(-0.59)	(-0.37)	(0.41)
Non-Farm business assets	-0.0000025	-0.00000296*	-0.00000140**	-0.0000131*
	(-1.10)	(-1.91)	(-2.08)	(-1.78)
Village average Livestock	0.00421		0.012	-0.232
	(0.02)		(0.25)	(-0.97)
Village average Land	-0.34		-0.0362	0.295
	(-1.25)		(-0.51)	(0.4)
Village average Household size	0.603**		0.158***	0.730**
	(2.63)		(3.02)	(2.5)
Average proportion of men in the village	-2.86		0.0502	-1.140
	(-0.66)		(0.05)	(-0.21)
Village average Education	0.0658		-0.0387	0.309
	(0.18)		(-0.67)	(0.72)
Village average Non-farm business assets	-0.0000126		-0.00000233	-0.0000146
	(-0.88)		(-0.39)	(-0.3)
Casualties from 1996 to 2003	-0.975**		-0.180***	-1.906
	(-2.66)		(-2.76)	(-1.62)
FUG in the village	-0.600*		-0.158*	-0.515
	(-1.93)		(-1.94)	(-1.32)
Village trend		X		
# of observations	811	811	811	811
Within R-square	0.246	0.405	0.177	0.277

Note: t statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01. In all estimates, we include an individual fixed effect and seasonal dummies. The standard errors are clustered at the level of the village.

Table 6: Tables contributing to the observed changes

Change in the average amounts of firewood collected: -12.28 bharis				
Main Factors	Household Size:	Household Livestock:	Prop. of Men in the Household:	Village Land:
	-1.37	-1.29	-0.19	-1.94
Change in the time required to collect one unit of firewood: -1.12 hours				
Main Factors	Conflict:	Presence of FUG	Average Village Household Size:	
	-0.57	-0.17	-0.16	

Table A1: Semi-reduced form for firewood collections

	Dependent Variable: Firewood collected (in bharis)				
	Engel curve [1]	*Engel curve* [2]	*Red. Form* [3]	*Red. Form, log(wood)* [4]	*Red. Form, vil. trend* [5]
Consumption	0.00270***	0.00198**			
	-3.79	-2.19			
Square of consumption	-2.27e-08***	-1.77e-08**			
	(-3.36)	(-2.29)			
Consumption* collection time	-0.0000455	-0.0000281			
	(-0.57)	(-0.24)			
Village median collection time	2.986	5.361	6.369	0.0472	
	(0.67)	(0.95)	(1.08)	(0.71)	
Land		-1.323	-0.756	-0.00546	1.645
		(-0.23)	(-0.14)	(-0.09)	(0.26)
Land * collection time		0.287	0.186	0.0033	-0.795
		(0.22)	(0.15)	(0.24)	(-0.64)
Livestock		0.319	0.878	-0.014	1.901
		(0.1)	(0.29)	(-0.47)	(0.51)
Livestock * collection time		0.978	0.938	0.00936*	0.951
		(1.64)	(1.63)	(1.78)	(1.35)
Education		-1.07	-0.597	0.000345	-2.827
		(-0.33)	(-0.21)	(0.01)	(-0.76)
Education * collection time		0.0681	0.0241	0.00195	0.493
		(0.09)	(0.04)	(0.31)	(0.58)
Non-Farm Business Assets		-0.000198	-0.000305	-0.0000110***	-0.000281
		(-0.77)	(-1.61)	(-3.85)	(-1.51)
Non-Farm Business Assets * col. Time		0.0000742	0.0000959*	0.00000245***	0.000115**
		(1.14)	(1.97)	(3.66)	(2.18)
Household size		8.409*	11.00***	0.107***	13.39***
		(1.83)	(3.19)	(2.79)	(3.73)
Household size * collection time		-1.119	-1.255*	-0.00731	-1.803**
		(-1.26)	(-1.88)	(-0.97)	(-2.21)
Proportion of men		76.91**	81.69**	0.816**	103.7***
		(2.09)	(2.28)	(2.56)	(2.83)
Proportion of men * collection time		-11.92	-11.32	-0.139*	-16.76**
		(-1.51)	(-1.40)	(-1.83)	(-2.22)
Casualties from 1996 to 2003		-10.28*	-7.245	-0.0802	
		(-1.83)	(-1.33)	(-1.43)	
FUG in the village		-1.499	0.542	-0.0275	

		(-0.16)	(0.06)	(-0.30)	
Member of FUG		7.334 (0.98)			
Village trend					X
Within R-square	0.085	0.151	0.128	0.163	0.345
# observations	868	868	868	811	868

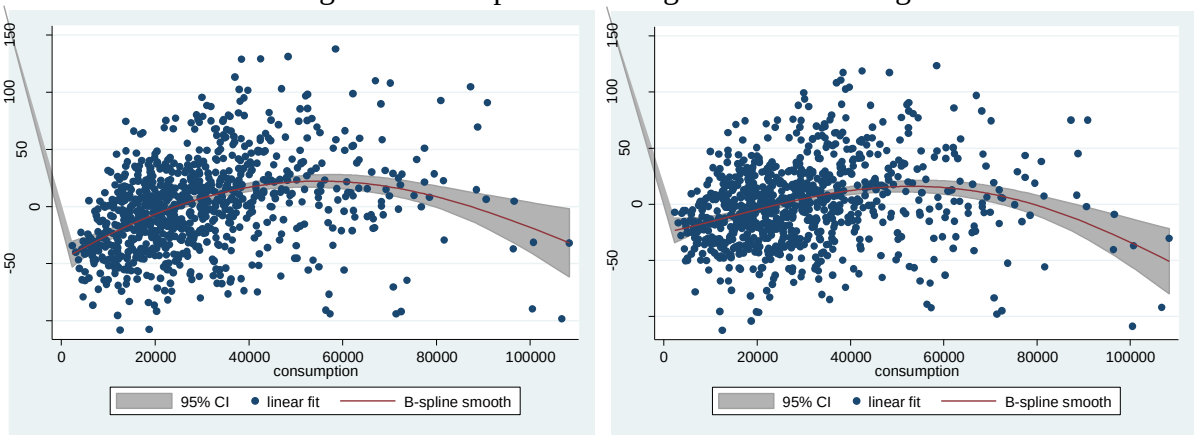
Note: t statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01. In all estimates, we include an individual fixed effect and seasonal dummies. The standard errors are clustered at the level of the village.

Table A2: Quadratic specification

	Wood collected [1]		*Collection time* [2]	
	Coefficient attached to the linear term	Coefficient attached to the quadratic term	Coefficient attached to the linear term	Coefficient attached to the quadratic term
Livestock	1.706 (0.49)	0.315 (1.05)	0.0878 (0.92)	-0.00552 (-0.62)
Land	0.123 (0.02)	-0.101 (-0.24)	-0.0517 (-0.36)	0.00421 (0.42)
Household size	17.02*** (4.57)	-0.904*** (-2.72)	0.252 (1.31)	-0.0152 (-1.00)
Proportion of men	38.29** (2.07)		-0.245 (-0.41)	
Education	0.905 (0.27)	-0.254 (-0.74)	0.0821 (0.68)	-0.0172 (-1.17)
Non-farm business assets	-0.00027 (-1.10)	1.12e-09* (2.02)	-0.0000136* (-1.78)	6.42E-11 (1.49)
Village average livestock	-83.37*** (-4.21)	9.168*** (4.21)	-1.298* (-1.75)	0.142 (1.68)
Village average land	27.03 (0.93)	-1.076 (-0.14)	0.811 (0.69)	-0.355 (-1.10)
Village average household size	118.3*** (3.11)	-9.820*** (-3.15)	1.28 (0.89)	-0.0522 (-0.42)
Village average proportion of men	18.18 (0.11)		-1.14 (-0.21)	
Village average education	12.71 (0.69)	-1.837 (-0.60)	0.293 (0.45)	0.00474 (0.05)
Village average non-farm business assets	-0.000458 (-0.25)	-1.95E-08 (-0.52)	-0.0000145 (-0.29)	-1.19E-10 (-0.11)
Casualties from 1996 to 2003	29.95 (1.31)	-9.639* (-1.73)	-1.945 (-1.60)	0.298 (1.05)
FUG in the village	13.97* (1.91)		-0.515 (-1.38)	
Within R-square	0.222		0.277	
# observations	868		811	

Note: t statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01. In all estimates, we include an individual fixed effect and seasonal dummies. The standard errors are clustered at the level of the village.

Figure 1: Semi-parametric regression of the Engel curves



Note: This first semi parametric regression controls for individual fixed effect, time fixed effect and seasonal dummies, and the other additionally controls for individual assets, fug presence and membership and conflict intensity. The non-parametric regression follows a Gaussian kernel of the third order with optimal bandwidth. The confidence interval is bootstrapped.