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ABSTRACT

Firewood Collections and Economic Growth in Rural Nepal 1995-2010: Evidence from a Household Panel*

A household panel data set is used to investigate the effects of economic growth on firewood collection in Nepal between 1995 and 2010. Results from preceding cross-sectional analyses are found to be robust: (a) rising consumptions for all but the top decile were associated with increased firewood collections, contrary to the Poverty-Environment hypothesis; (b) sources of growth matter: increased livestock was associated with increased collections, and falling household size, increased education, non-farm business assets and road connectivity with reduced collections. Nepal households collected 25% less firewood over this period, mostly explained by falling livestock, and rising education, connectivity and out-migration.

JEL Classification: D12, O1 and Q2
Keywords: deforestation, environmental Kuznets curve, growth and Nepal

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Introduction

Deforestation in South Asia and Sub-Saharan Africa 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] A key question frequently debated by scholars[6], media[7] and policy-making community[8] concerns the likely effect of economic growth on environmental degradation in these countries. For instance, the World Bank 2000 report on deforestation in India stated:

> "urbanization, industrialization and income growth are putting a tremendous demand pressure on forests for products and services. The shrinking common property resource base, the rapidly increasing human and livestock population, and poverty are all responsible for the tremendous degradation pressure on the existing forest cover." (World Bank (2000, Summary section, page xx)

Views commonly expressed on this issue differ widely. Some (expressed by the World Bank above as well as the 2006 World Economic Forum Summit) believe income growth will increase the demand for household energy, thereby putting additional pressure on forests (the principal source of household fuel). Others argue poverty forces households to rely on forest firewood rather than modern fuels; hence declining poverty made possible by economic growth will reduce the pressure on forests, in what is commonly referred to as the Poverty-Environment hypothesis (PEH).[9] Intermediate between these is the Environmental Kuznets Curve (EKC) hypothesis, which states that environmental degradation will intensify with growth in living standards until a threshold, beyond which it will fall.[10] These differences stem from alternative assumptions regarding the nature of wealth effects (i.e., whether firewood is a normal or

[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).
[6] Arrow *et al* (1995), Dasgupta *et al* (2000).
[7] *Economist,* July 8 2004, *Economist,* September 23 2010.
[8] World Economic Forum 2006 Summit Report, World Bank (2000).
[9] Barbier (1997a, 1998, 1999), Duraiappah (1998), Jalal (1994), Lele (1991), Lopez (1998), Maler (1998).
[10] Barbier (1997b), Grossman and Krueger (1995), Yandle, Vijayaraghavan and Bhattarai (2002).

inferior good) and their strength relative to substitution effects associated with changes in collection times, the shadow value of household time and cost of alternative fuels. More nuanced viewpoints argue that effect of growth on deforestation depends on whether it is accompanied by changes in property rights, government regulations and their enforcement[11], demographics, occupational structure, education and availability of modern fuels.[12]

Despite the importance of the issue, existing evidence available from disaggregated household surveys is subject to numerous concerns over their reliability. The most important of these is that nearly all studies are based on cross-sectional data, i.e., on comparisons of firewood collection behavior between different households with varying incomes at a single point of time. The possibility of unobserved heterogeneity between households and local communities limits the reliability of predictions based on these comparisons on how a given household's collection behavior will be modified as its income and assets change over time. Unobserved attributes of households may be correlated with both its living standards and its firewood collections, which could generate spurious correlations. For instance, a household whose members are more hardworking and upwardly mobile will exert more effort and achieve higher incomes and consumption; it will also collect more firewood. The same household may not, however, collect more firewood as its income increases over time. A cross-sectional analysis will then generate an upwardly biased estimate of growth in collections of a household with given attributes. Similar problems arise through the effects of unobserved community norms in resource use: villages with stronger social capital may be able to attain higher living standards owing to successful collective action in irrigation or water use. They would also have more effective regulations of firewood collection from community forests. But this does not imply that any given village would collect less firewood as its living standards rose. The comparison of firewood collections across villages would then be biased downward, if used to predict the effects of growth in living standards. Moreover, cross-sectional comparisons may pertain to the effects of long-standing differences in incomes between households, which could be a poor guide to predicting

[11] Agrawal and Yadama (1987), Baland and Platteau (1996), Baland, Das and Mookherjee (2010b), Jodha (2001), Somanathan (1991), Somanathan, Prabhakar and Mehta (2009), Varughese and Ostrom (2000).
[12] Amacher et al (1996), Baland et al (2006, 2010a), Bluffstone (1995).

effects of income changes in the short or intermediate run (owing to differential responses to permanent and transitory shocks). These sources of bias can be avoided only in longitudinal studies in which the effects of changes in incomes and assets over time of a given set of households and communities are studied. Unfortunately, such datasets in the context of use of environmental resources in developing countries are conspicuous by their absence.

In the context of firewood collection in Nepal, such a longitudinal household survey has recently become available from the World Bank Living Standards Measurement Survey (LSMS). A relatively small (but representative) sample of households residing in the mountainous regions of Nepal (i.e., excluding the low-lying *Terai* regions) were surveyed in three successive rounds of the Nepal LSMS corresponding to 1995, 2003 and 2010, while other sub-samples were surveyed in two of these waves, allowing us to utilize an unbalanced household panel.[13] Nepal is an appropriate context to study since it has been subject to serious deforestation, with forest cover declining at an annual rate of 1.9% over the 1980s and the 1990s (UNDP, 2011). At the same time, it experienced substantial growth in per capita incomes, consumption, and household assets as well as changes in household demographics, occupations, literacy and community forest management rights between 1995 and 2010. During this period, the LSMS data shows firewood collections per household fell 25%, while living standards rose 70% and time to collect firewood fell by nearly 20%. These changes were uneven across different parts of Nepal and also across different households within any given village, allowing us to compare changes over time in firewood collected by each household in the panel with corresponding changes in their economic and demographic circumstances. This provides a rare opportunity to directly study changes over time in use of environmental resources of poor households, and assess the extent of bias in estimates based on cross-sectional comparisons.

Our main finding is that the results of preceding cross-sectional analyses are robust, with a few exceptions. In particular, the inferences drawn in Baland *et al* (2010a) based

[13] The alpine regions of Nepal are particularly interesting for our purpose since firewood is extensively used as the main source of energy by the households and most forests are located there.

on cross-sectional analysis of the 1995 LSMS continue to be broadly valid in the panel analysis over the subsequent fifteen years, with a few exceptions. The main results are summarized as follows:

(i) Growth in household per capita consumption was associated with rising firewood collections for all but the richest 5% of the population. There is no evidence in favor of the PEH, while there is some evidence in favor of the EKC with a turning point located somewhere in the top consumption decile. Hence rising consumption levels *per se* for most of the rural population in the non-*terai* region were associated with rising pressure on the forests. This result is robust to functional form, as well as controls for household dummies, a large range of time-varying household (e.g., assets, demographics, occupation, education) attributes and time-varying village dummies.

(ii) Changes in household demographics, asset composition and occupations affect firewood collections in ways similar to those observed in cross-sectional comparisons: firewood collected by a household falls if it has fewer adult members, or if there is a fall in livestock owned. In contrast to the cross-sectional pattern, the effects of higher average years of schooling and non-farm business assets have unstable signs and are statistically insignificant.

(iii) The preceding results imply that the nature of the growth process matters: whether living standards rise as a result of increases in transfers or remittances, or increase in productive assets. In contrast to the former which generate pure wealth effects, the latter generate a combination of wealth and cost of collection effects (owing to induced effects on occupational patterns). Growth in livestock unambiguously increases firewood collected, both owing to positive wealth effects and complementarity of grazing with firewood collection. Effects of growth in education or non-farm business assets are ambiguous, owing to conflicting directions of induced wealth and cost of collection effects.

(iv) In predicting the implications of growth in assets, we extend previous analyses by incorporating spillover effects across households arising from community norms and congestion effects. Peer-group effects and congestion generate distinct predictions for how collections of any given household would respond

to changes in their neighbors' behavior. We find evidence for both conformity and congestion effects, while the former tended to dominate. Hence the effects of changes in household assets were magnified at the community level. The effects of increases in village average education and non-farm business assets are negative and statistically significant, consistent with the cross-sectional pattern at the household level.

(v) The implied effects of changes in household assets observed during the 1995-2010 period was a reduction in firewood collected by the average household (9.2% over 1995-2003 against an observed drop of 12%, and 18.5% over 2003-2010 compared with an actual drop of 15%), with the bulk of these effects generated by spillover effects. This indicates the role of occupational structure on firewood collections: Nepalese households in the *Hills* and the *Mountains* were moving away from livestock-based occupations. In contrast, the growth effects implied by the Engel curves predict rising firewood collections, by 5% over 1995-2003 and 29% over 2003-2010. Hence growth projections are sensitive to whether changes in consumption or in productive assets are used to measure growth.

The preceding results were robust to tests for measurement error (based on Griliches and Hausman (1986) applied to a balanced sub-sample of the overall panel). They are also robust to a variety of time-varying village controls, such as proximity to roads, village population, the presence of community forest user groups (FUGs), or casualties incurred in relation to the Maoist civil conflict.[14] We find no statistically significant association between changes in household firewood collections and formation of community forest user groups (FUGs), nor with casualties incurred in relation to the Maoist civil conflict. However, it is difficult to infer anything from these about possible causal effects of formation of FUGs or civil war on firewood collections, owing to the

[14] See Edmonds (2002), Baland et al (2010b), Somanathan et al (2009) and Shyamsunder and Ghate (2011) on the effects of FUGs in Nepal and India, and Bohara et al (2006), Do and Iyer (2010), Hattlebakk (2009) and Nepal et al. (2011) regarding the civil war in Nepal.

possibility of unobserved village attributes and endogeneity of FUGs or location of the conflict.[15]

The paper is organized as follows. Section 2 presents descriptive statistics concerning changes in living standards, household demographics, assets and firewood collections over the 1995-2010 period. Section 3 presents estimates of Engel curves relating firewood collections to household consumption, while Section 4 focuses on the reduced form relationship between collections and productive assets. Section 5 presents and compares the estimated growth effects across the two approaches. Section 6 presents robustness checks with respect to measurement error and a restricted sub-sample where FUGs were already present prior to 1995. Section 7 describes relation of our analysis to existing literature and concludes the paper.

2. Data and Descriptive Statistics

The World Bank Living Standards Measurement Survey (LSMS) for Nepal interviewed 3388 households concerning their production and consumption activities for the year 1995–96, 3912 households for the year 2002-3 and 5988 in 2010-11.[16] A random subset of these households was selected to constitute a moving panel representative of Nepal. We focus on the hills and mountain areas of Nepal, which share a similar agro-ecological system and a comparable reliance on forest resources. Our final panel data covers 634 different households in 60 villages, out of which 195 households were interviewed in the three waves, 240 households were interviewed in 1995-6 and in 2002-3, and 199 were interviewed in 2002-3 and in 2010-11. The corresponding numbers of villages in the panel are 22, 19 and 19. The attrition rate at the household level is around 15%.[17] Table 1 below provides a summary description of the main variables used in our analysis.

[15] For instance, it is possible that FUGs were more likely to form in (or civil war more likely to occur near) villages more subject to deforestation, and their formation or occurrence subsequently tended to arrest the process, resulting in absence of any correlation between FUG formation or civil conflict and changes in collection.

[16] Note that the 2002-3 LSMS was effectively administered in 2003 and part of 2004. To avoid confusion, we refer to the year of that particular survey as 2003, and to the two others as 1995 and 2010.

[17] We could not find any biases in the attrition process using household characteristics in 1995. In 2003, four villages originally included in the panel could not be re-surveyed because of the Maoist guerilla war.

INSERT TABLE 1 HERE

In this region, almost all households collect and consume firewood, which is the primary source of cooking fuel. More than 90% of households collected firewood in all three waves. The quantities of firewood exchanged on the market were negligible. The amount of firewood collected per household per year dropped 7% between 1995 and 2003, and 23% from 2003 till 2010. The time taken to collect firewood also fell substantially by 20% and 7% respectively in these two time periods.

Household living standards (measured by value of annual consumption at 2010 prices) increased 10% in the 1995-2003 period, and 60% in the subsequent seven years. The acceleration in the second period was related to sharp rises in remittances received from migrants, in turn associated with a rise in the mean number of migrants per household from 0.28 in 1995 to 0.42 in 2003, and 1.62 in 2010. By 2010 more than half the households had at least one member who had migrated out. Remittances formed one-third of household income by 2010.

There were also significant changes in household assets between 1995 and 2010. Mean holding of livestock fell 14%, years of schooling per household member rose from 1.8 to 3 years, and non-farm business assets rose 72%. Household size fell 11% and the proportion of children fell 15%. The average number of households per village rose, while the median number of households fell. Distance to paved roads fell from 14 to 7 hours.

The period under study witnessed the development of the Forest User Group program, after being launched in 1993. The programme's objective has been to transfer the management of accessible forests to local communities, via Forest User Groups (FUGs). These groups are empowered to control access to the forests, taxing forest products, hiring forest guards and launching plantation programme. Income generated by forest-related activities can be used to finance local projects such as roads, schools and temple.[18] Approximately half the villages had a FUG in 1995. This proportion rose to 80% in 2003 and 92% in 2010. The proportion of households collecting primarily from the community forest increased from 9.2% in 1995 to 31.7% in 2003 and 37.1% in 2010. The two other major alternative sources of firewood were state forests and own land.

[18] 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.

Table 2 shows that the percentage of households collecting primarily from their own land increased slightly from 26% to 29%. At the same time the proportion of villagers collecting from state forests decreased significantly from 54% to 21%. We therefore observe a significant switch in collections from state to community forests. This partly reflects the conversion of state forests into FUGs.[19]

INSERT TABLE 2 HERE

Since Forest User Groups are created voluntarily by villages, it is difficult to estimate their impact on firewood collections. Their creation and the time at which they were created are likely to be affected by prior pressures of deforestation as well as various unobserved political and economic factors. At the household level, membership in a FUG is also voluntary. Hence the right to collect from a community forest is not exogenous, even when one controls for village characteristics. Given our data, we therefore refrain from drawing any inferences regarding the role of the FUGs in forest conservation or regeneration. In the estimations presented below, we simply control for the existence of a FUG in the village.[20] [21]

Another important event during the study period was the Nepalese Civil War between government forces and Maoist rebels, 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 in 2003 belonged to a district where severe combats (involving more than a hundred casualties) occurred in 2003.[22] Over all

[19] However, not all the observed changes in collections and collection times could be accounted by the transfer of state to community forests. The average collection time from state forests was substantially higher than community forests in 1995, while collection times from both types of forests fell thereafter. If observed changes in collection times owed entirely to designation of some state forests as community forests, the state forests transferred must have involved collection times higher than the average for state forests in 1995. This would have raised the average collection time from community forests.

[20] From the information available in the LSMS, we do not know with certainty whether a particular household belongs to a FUG, but only whether he collected 'primarily' from a community forest. The measure at our disposal is therefore very noisy. Moreover, since we use a panel data set, our identification would rely on those households who changed their main source of collection towards community forests, thereby biasing the true impact of membership. Given these problems, we chose to control for the existence of a FUG in the village, but all our results are insensitive to the inclusion of the 'primary collection' variable in the regressions.

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

[22] 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

villages, the average number of casualties in 2003 was equal to 0.17 deaths per thousand inhabitants in the district and the average number of abductions and disappearances was equal to 0.20 per thousand. The conflict data at our disposal are imprecise as they correspond to the average casualties in the district to which the village belongs. Moreover, according to Do and Iyer (2010), 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). As a result, we are not able to draw reliable estimates of the effects of the civil war on firewood collections; we shall instead focus on effects of growth of consumption and assets on collections after controlling for the location and intensity of the conflict.

3. Firewood Collection and Living Standards

In this section we focus on the relationship between household consumption and firewood collections, in order to test commonly held views such as PEH or EKC concerning the effect of growth in living standards on firewood collections. Conceptually this corresponds to estimating the nature of wealth effect in the demand for firewood. This requires us to control for household assets and other attributes that could affect costs of collecting firewood. Econometric problems arise from the possibility that consumption and firewood collections are jointly determined by unobserved household and community attributes. Controlling for village dummies and focusing on intra-village variations in a cross-sectional analysis helps control for the bias resulting from unobserved village heterogeneity. Using a panel enables us to additionally gauge the bias resulting from unobserved household heterogeneity that is fixed over time, besides changes in observable household attributes. Additional problems arise from the possibility of incorrect functional form of the Engel relationship, and measurement error in consumption and firewood collections; we shall review robustness of our results with respect to these problems.

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over the different districts (60 villages over 41 districts in the panel). Only 2 districts had more than two villages in our sample.

Table 3 presents estimated Engel relationships using alternative parametric specifications and with varying sets of controls. Consumption is measured by annual household recurrent expenditures valued at 2010 prices. The first two columns show estimated relationships from the cross-sectional data (which pools all three waves) and the longitudinal data respectively using a quadratic specification and no controls apart from village and year dummies in the cross-sectional estimates (column 1) and village-year dummies in the panel estimates (column 2). [23] Columns 3 and 4 present the corresponding cross-sectional and panel estimates upon adding in controls for household attributes. Column 5 extends the panel regression further by including a control for the village median self-reported collection time per bhari[24]. All regressions include seasonal dummies, and standard errors are clustered at the village level.

All columns show a significant inverted-U relationship between firewood collections and consumption. The panel estimates show the turning point to be between consumptions of Rs 100,000 and 200,000, corresponding to consumptions above the 95th percentile. The turning point in the cross-sectional pattern is substantially higher (approximately Rs 358,000 in either column 1 or 3). Hence all the estimates show a significant upward sloping relationship between consumption and collections for all but the most affluent households. The evidence thus firmly rejects the PEH and is consistent with the EKC.

INSERT TABLE 3 HERE

The effects of variations in household assets are consistent across the cross-sectional and panel estimates, with respect to livestock, household size and composition: livestock ownership and household size have positive effects, while the proportion of children has a negative effect. The effects of schooling and non-farm assets are negative and significant in the cross-sectional estimates, but are insignificant and have unstable signs in the panel estimates. These results are consistent with what one might expect on *a priori* grounds. Increased livestock would be expected to generate positive wealth effects,

[23] Higher order polynomials were also tested, with little impact on the estimates. We report on a semi-parametric specification below. While not reported here, all the results discussed are robust to using income instead of consumption expenditures as the measure of income.
[24] The use of individual self-reported collection time per bhari does not affect our conclusions.

as well as lower the cost of collecting firewood owing to the complementarity of grazing and firewood collection activities. Increased size of the household in adult equivalent units would be expected to generate greater demand for household energy, while lowering the shadow costs of collecting firewood owing to the greater availability of family labor. In contrast, higher schooling or nonfarm assets would generate conflicting wealth and cost of collection effects owing to substitutability between time in modern occupations and firewood collection.

The coefficient of the number of migrants is insignificant in both cross-sectional and panel regressions. Again, this is expected as the effect of migrants on consumption via remittances is already incorporated, besides their effect on household size.

The last column shows that increases in the median collection time in the village over time has an insignificant effect on collections. This suggests that firewood collections are insensitive to collection costs, possibly reflecting the lack of alternative sources of fuel or the presence of peer effects (see also Heltberg et al, 2000). However, changes in collection times over time could reflect changes in unobserved determinants of firewood collections: villages with faster growing collections could be subject to greater deforestation, resulting in an increase in collection time. Hence this coefficient is subject to omitted variable bias. In the next section we explicitly allow collection times to be endogenously determined. The purpose of including column 5 in Table 3 is to show that the results concerning the relation of collections to consumption and household assets are robust with respect to controls for collection time replacing village-year dummies.

INSERT FIGURE 1 HERE

We next explore the robustness of the results with respect to functional form of the relationship between collections and consumption. Figure 1 provides two non-parametric estimations of the Engel curve, relating 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 in a semi-parametric panel regression.[25] The first estimate on the left hand side of the figure includes household and year fixed effects, while the right hand side also controls for individual assets and village variables (such as conflict intensity or the presence of a FUG). Again, we find an inverted-U relationship with a turning point lying somewhere between Rs 100,00 and 200,000. At the higher end the relationship is less clear with fewer and more scattered observations.

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

In a rural setting where households collect their own firewood and spend large amounts of time doing so, it is hard to dispute the possibility that household consumption, labor allocation and firewood collections are jointly determined by underlying household and community attributes. Observable household attributes include household demographics, occupational patterns and assets owned, while unobservable attributes include tastes and abilities. A panel analysis can control for household level unobservables that are fixed over time, but not those that vary over time. Hence the possibility of endogeneity bias remains in predicting effects of rising living standards on firewood collections on the basis of a panel study. This motivates a reduced form analysis in which collections are related to underlying household assets rather than consumptions. An added argument for such an approach is that household consumptions are more prone to measurement error than household assets.

In this section we pursue such a reduced form approach, in which collections are related to household demographics and assets. The argument for using this approach is that the estimated relationships are subject to less bias, while a large fraction of changes in living standards are expected to be explained by changes in household assets. Table A1 in the Appendix shows results of a household panel regression of annual recurrent

[25] Baltagi and Li (2002) suggest eliminating the fixed-effects by first differencing over time the model, assuming that the non-parametric part of the regression has the same functional form in both periods. Combined with the use of sufficiently flexible splines, this assumption allows estimating consistent parameters which will be used to partial out the non-parametric part of the model from its parametric components. The partialled-out residuals will then be used to draw the non-parametric part of the regression. For more details, see Libois and Verardi (2013).

consumption expenditures on household assets and demographics. Living standards have a significant coefficient with respect to livestock, household size and education in all specifications, and a significant coefficient with respect to non-farm assets and number of migrants in some. These regressions have an R-squared varying between 40 and 60%. Changes in assets and demographics accounted for some but not most of the observed growth in consumptions. This implies that while the results of an asset-based reduced form approach is less prone to estimation bias, it would not be able to incorporate all the factors generating growth in living standards. Hence the reduced-form asset-based approach and the Engel curve approaches are complementary.

Increases in household assets could generate both direct effects on a household's own collection activities, as well as external effects of those of its neighbors. These externalities could be of two forms: (i) conformity or peer effects in which neighbors seek to imitate each other's behavior, carry them out jointly, or reflect shared community norms concerning common property access; (ii) congestion effects, wherein increased collections of others reduces access of any given household to a shared property. The latter includes possible dynamic effects of collections of any given community on future collection times. Below we develop a model which incorporates both kinds of interaction effects, and allows us to estimate direct and indirect spillover effects of changes in household assets.

4.1 The Reduced Form Model with Social Interactions

Let the amount of firewood collected by household *i* in village *j* at time *t* be denoted by C_{ijt}. This is 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, $\overline{C}_{jt}$ defined by $\overline{C_{jt}} = \sum_i C_{ijt} / N_{jt}$ where N_{jt} denotes the number of households in the village in year *t*. Average collections are included here to reflect the presence of peer effects in collections, for reasons explained above. We assume the following linear 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. The presence of peer effects imply a positive γ. Since individual collections get reflected in the village average collection which itself influences individual collections, individual collections are well-defined as long as $\gamma < 1$.

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}:

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

which can be rewritten as:

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

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 collections by others. To do this, we explicitly introduce the average collection at the village level in the determination of collection times. We thus have:

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

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

Average collection times are therefore given by:

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

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

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

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:

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

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 wealth 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 could directly use equations (1) and (3) to derive the semi-reduced form expression:

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

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 and congestion effects. However, this strategy is subject to Manski's reflection problem, since the average collection reflects exactly the same determinants as individual collections (Manski, 1993). We shall therefore rely on the reduced form expressions (5) and (6) which relate collection times and collections of any given household to its own assets, as well as those of the rest of the village.

4.2 Regression Results

Table 4 reports the results of regressions of household collections on its own assets as well as village averages of these, corresponding to (6). Column 1 presents the results of the cross-sectional relationship pooled across the three waves, while columns 2 and 4 present the panel estimates based on a linear and log-linear specification respectively. For purposes of comparison column 3 provides a panel regression based on the linear specification where the village level asset averages are replaced by village-year

dummies. The household level variables used include livestock, household size, the proportion of children, the average amount of education among the adults, the value of non-farm business assets owned and the number of migrating members in the household. At the village level, we use the village average level of all these assets, as well as the existence of a FUG, the distance to the nearest road, the number of households in the village and the intensity of the conflict in the district[26]. All regressions include year and seasonal dummies, while standard errors are clustered at the village level.

INSERT TABLE 4 HERE

The coefficients of the household attributes resemble the results of Table 3 which featured village-year dummies rather than the village interaction effects. With regard to the spillover effects in the panel regressions in columns 2 and 4, we see a significant positive coefficient with respect to average household size, and a significant negative coefficient with respect to village average levels of education and non-farm assets. This is consistent with peer effects dominating congestion effects, assuming the direct effect of higher education and nonfarm assets is to induce a household to collect less (which is valid and significant in the cross-sectional relationship, but is insignificant in the panel).

INSERT TABLE 5 HERE

Table 5 shows the regression for collection time corresponding to specification (5). As in Table 4, the first column shows the results of the pooled cross-sectional data, while the remaining three columns show panel estimates. The second and fourth columns include village averages of various assets, while the third column replaces these by village-year dummies. In all regressions, collection times are rising in household size (conceivably owing to collection times rising in the amount collected). The panel regressions in columns 2 and 4 show that they are also rising in village average household size, consistent with the existence of congestion effects. The log-linear relationship in column 4 shows collection times rising both in response to higher migrants out of the

[26] More specifically, for each household, this average is calculated for all the other households in the village.

household (which could owe to the effect of migrants on collections via their impact on remittances and consumption), as well as higher village average for migrants per household. This specification also shows collection times rising with the number of households in the village. Hence we see some evidence suggesting the presence of congestion effects. However, the evidence is not strong, as one would have expected higher average livestock ownership in the village to also raise collection times. The panel regression shows this effect to be positive but insignificant.

The coefficients of the FUG variable and the incidence of civil conflict violations on firewood collections as well as collection times turn out to be negative and insignificant in the panel regression. While it is difficult to impute any causal significance to these results, they are nevertheless of some interest insofar as they suggest that neither the community forestry initiative nor the civil war had a significant role to play in explaining the observed decline in collections and collection times. On the other hand, shrinking distance to paved roads may have reduced collections, as suggested by column 2 in Table 4.

5. Implied Growth Effects

Panel A in Table 6 calculates the predicted changes in firewood collections implied by the reduced form panel estimates in the linear specification (column 2) of Table 4, using the observed changes in regressors with a statistically significant coefficient. The direct household level effects associated with falling livestocks predicts a 0.8% reduction in collections between 1995-2003, while changes in household size and composition accounted for a net reduction of another 0.8%. The corresponding village level effects predict a substantially larger reduction of 7.4%, owing especially to the rise in education and proximity to roads. The total predicted effect is a 9.0% reduction in collections, compared to an observed drop of 12.2%. Similarly, the model predicts a drop of 19% in collections between 2003-10, the bulk of which (14.4%) is accounted for by the village interaction effects (which now includes a 5% drop owing to out-migration). The reduced form model therefore accounts for the decline in collections at the household

level by falling livestock, rising education and out-migration, and closer proximity to roads.

INSERT TABLE 6 HERE

Panel B of Table 6 shows the changes in collections predicted by the observed changes in consumption implied by the estimated Engel relationship in column 4 of Table 3. The effects of rising consumption outweighs the direct effect of higher livestock and changing household demographics, generating a predicted increase in collections by 3.8% between 1995-2003 and by 25.4% over 2003-2010. Evidently the projections based on growth in living standards grossly over-predict increases in collections, even if they incorporate changes in assets that accounted for part of the observed increase in consumption. Failure to incorporate spillover effects of asset increases owing to social interactions cause the model underlying Table 3 to fail to predict some of the causes of declining collections.

6.Robustness Checks

Table 7 examines robustness of the estimated Engel curves with respect to the control for FUGs. Recall that about half the sample already had a FUG in 1995, so Table 7 reports results from re-estimation of the regressions in Table 3 for this sub-sample. We continue to obtain an inverted-U relationship, which is significant in the panel regression only in column 2 with village-year dummies. With a halving of the sample size, the loss in precision of estimates is not surprising. The effects of livestock, household size and composition continue to hold.

Table 8A tests for measurement error in the panel estimates of the reduced form using the Griliches-Hausman (1996) test comparing the first difference and within-estimators for the balanced sample of households that were surveyed in all three rounds. None of the direct effects of household-level attributes shows a significant difference between these estimators. We do see a significant difference for the village level effects for education, non-farm assets and number of households in the village. The estimates

obtained for these upon applying the Griliches-Hausman corrections are statistically significant and of larger magnitude. Hence corrections for measurement error do not affect the main qualitative conclusions, and would result in predicting larger declines in firewood collected compared with the results in Panel A of Table 6.

Table 8B shows the corresponding tests for bias owing to measurement error in the reduced form estimates of collection time in Table 5. We see significant differences between the within and first-difference estimators only for land, proportion of children and FUG presence. Upon applying the Griliches-Hausman correction, only the proportion of children has a coefficient significant at 5%, with the corrected estimate of substantially larger magnitude. Hence the results of Table 5 continue to be robust.

7. Relation to Existing Literature and Concluding Comments

The only longitudinal study on deforestation in South Asia that we are aware of is Foster and Rosenzweig (2003). They studied a panel of 250 villages all over India, over the last three decades of the 20th century, combining satellite imagery and census data. The satellite data showed evidence of reforestation, while the household data showed increased demand for wood and wood products accompanying the rise in their living standards. They argue that the increasing demand for wood products induced reforestation. We do not have any data on forest cover in Nepal, while our findings on household firewood collection patterns are consistent with their findings on household demands. Hence our results are broadly consistent with theirs, despite pertaining to a different country and period of analysis.

Chaudhury and Pfaff (2003) find evidence of an EKC in indoor air pollution, using a cross-sectional analysis of the Pakistan World Bank LSMS while controlling for village dummies. While richer households tend to consume more energy, they switch to cleaner and more efficient fuels (kerosene) which reduces the amount of indoor pollution. This is also in line with numerous cross-section studies on Nepal and rural India which suggest that firewood is a normal good for all but the wealthiest households (see in particular Heltberg et al, 2000; Arnold et al, 2003; Adhikari et al, 2004, Baland et al 2007

and Gundemida and Kohlin, 2008). The switch of high 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 becoming an inferior good in China, with coal being used as a superior alternative (Demurger and Fournier, 2011). Baland et al (2007) find the demand for firewood in Indian Himalayas to be sensitive to the price of kerosene. These earlier findings are consistent with our evidence in favor of an EKC, and provide a possible explanation for this pattern. However, the evidence concerning EKC in preceding literature has been based on cross-sectional analyses, without checks for robustness with respect to unobserved heterogeneity, functional form or measurement error.

On the other hand, the lack of data in the LSMS concerning cost and access to modern fuel substitutes prevented us from using the panel data to explore the nature of household substitution between firewood and modern fuels. Nevertheless, the results of this paper are consistent with the previous assessments of Baland et al (2007, 2010a) for the Indian Himalayas and rural Nepal respectively based on cross-sectional evidence: that growth of consumption per se is likely to increase the pressure on forests, which will be moderated by rising education, transition to modern occupations and access to modern fuel substitutes.[27]

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[27] See Bluffstone (1995) for similar cross-sectional evidence concerning the role of occupational structure in firewood collections.

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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	60435.0	68466.6	40545.3	6259.6	275603.5	0
		2003/4	67308.2	76440.4	45112.6	6984.4	305579.4	0
		2010/1	106194.1	116202.3	59337.1	10863.0	358484.3	0
Firewood collected	# Bharis per year	1995/6	84	100.74	71.10	0	360	35
		2003/4	78	89.30	54.03	0	300	30
		2010/1	60	75.53	61.66	0	600	36
Firewood collection time, for household reporting collection	# hours per bhari	1995/6	4	4.83	2.73	0.17	25.02	0
		2003/4	3.20	3.61	1.75	0.02	10	0
		2010/1	3	3.76	2.19	0.5	10	0
Livestock	# of big cattle heads	1995/6	3	3.84	2.84	0	15	40
		2003/4	4	3.74	2.57	0	16	70
		2010/1	3	3.36	2.41	0	12	50
Land	# hectares owned	1995/6	0.48	0.92	1.8	0	20.69	12
		2003/4	0.54	0.75	0.96	0	15.58	31
		2010/1	0.50	0.71	0.91	0	11.47	16
Household size	# individuals	1995/6	5	5.4	2.29	1	17	0
		2003/4	5	5.24	2.27	1	13	0
		2010/1	5	4.81	2.17	1	12	0
Proportion of children (0-15)	share of household size	1995/6	0.44	0.41	0.23	0	0.86	58
		2003/4	0.4	0.39	0.24	0	1	117
		2010/1	0.35	0.34	0.24	0	1	101
Average education of adults in the households	# of years of education	1995/6	1	1.82	2.40	0	15	197
		2003/4	1.67	2.30	2.60	0	12.5	238
		2010/1	2.67	2.99	2.91	0	13.5	121
Non-farm business assets	1000 Rs	1995/6	0	0.3218	0.8271	0	7	348
		2003/4	0	0.3722	1.0274	0	9	512
		2010/1	0	0.5508	1.3587	0	11	293
Number of migrants sending remittances	# of people	1995/5	0	0.28	0.54	0	3	330
		2003/4	0	0.44	0.70	0	5	412
		2010/1	1	1.62	0.94	1	8	0
Number of households in the village	# of households	1995/6	89	109.63	98.10	28	600	0
		2003/4	98	116.15	104.20	34	670	0
		2010/1	77	123.56	168.07	30	856	0
Village median distance to paved road	Walking time in hours	1995/6	10	14.46	14.99	0.08	70	0
		2003/4	8	11.20	12.78	0.08	70	0
		2010/1	4	7.10	9.10	0	43	1
Casualties and abductions in the 12 months before the survey	# Casualties and abductions per 1000 inh.	2003	0.25	0.35	0.26	0	1.16	1
Villages with community forest	%	1995/6	1	53.65	50.49	0	1	19
		2003/4	1	80.00	40.34	0	1	12
		2010/1	1	92.68	26.37	0	1	9

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

Primary source of firewood collection	Number of hh collecting in 1995	Number of hh collecting in 2003	Number of hh collecting in 2010	Mean collection time in 1995 (std. dev.)	Mean collection time in 2003 (std.dev.)	Mean collection time in 2010 (std.dev.)
Private land	114	176	116	3.9 (2.9)	2.6 (1.2)	2.7 (1.5)
Community forests	40	201	146	4.6 (2.8)	4.1 (1.9)	4.4 (2.0)
State forests	235	196	84	5.4 (2.5)	4.1 (1.6)	4.1 (2.2)
Other land (roadsides,…)	11	31	12	3.0 (1.8)	3.2 (1.2)	2.8 (1.2)
Total collectors	400	604	358	4.8 (2.7)	3.6 (1.7)	3.8 (1.9)
Non collectors	35	30	36	---	---	---

Table 3: Engel Curves

	Dependent Variable: Firewood collected (in bharis)				
	[1]	[2]	[3]	[4]	[5]
Consumption	0.000584***	0.000809***	0.000363***	0.000540***	0.000675***
	[5.31]	[6.49]	[4.13]	[3.52]	[4.53]
Square of consumption	-8.15e-10***	-2.24e-09***	-5.08e-10***	-1.69e-09***	-2.06e-09***
	[-4.24]	[-5.71]	[-3.63]	[-4.23]	[-4.81]
Livestock			2.868***	3.840***	2.969**
			[5.67]	[3.02]	[2.09]
Land			0.569	-1.167	-0.372
			[0.31]	[-0.46]	[-0.15]
Household size			5.267***	4.355***	4.966**
			[5.47]	[2.70]	[2.64]
Proportion of children (0-15)			-5.938	-21.85**	-32.78***
			[-0.69]	[-2.33]	[-2.72]
Education			-2.195***	-0.300	-1.411
			[-3.77]	[-0.23]	[-1.19]
Non-Farm Business Assets			-0.242***	2.319	-1.51
			[-5.11]	[1.53]	[-1.04]
Number of migrants remitting			0.0956	2.823	-1.699
			[0.07]	[1.12]	[-0.65]
Village median collection time					0.925
					[0.32]
Cross-section	YES		YES		
Village dummies	YES		YES		
HH. fixed-effects		YES		YES	YES
Village-year dummies		YES		YES	
# observations	5179	1463	5175	1459	1459
(Within) R-sq	0.199	0.324	0.211	0.351	0.152

Note: t statistics in brackets, * p<0.05, ** p<0.01, *** p<0.001. In all estimates, we include year and seasonal dummies. The standard errors are clustered at the village level.

Table 4: Reduced form for firewood collections

	Dependent Variable: Firewood collected			
	Linear Cross-Section	*Linear Panel*	*Village-time FE*	*Log(Wood)*
	[1]	[2]	[3]	[4]
Livestock	3.255***	4.037***	4.474***	0.0233*
	[6.32]	[3.22]	[3.59]	[1.84]
Land	2.965	0.0301	-1.293	0.00144
	[1.13]	[0.01]	[-0.51]	[0.07]
Household size	7.143***	7.499***	5.955***	0.0817***
	[6.73]	[4.75]	[4.53]	[6.67]
Proportion of children	-10.8	-34.98***	-23.50**	-0.156
	[-1.22]	[-2.80]	[-2.48]	[-1.53]
Education	-1.424***	-0.82	0.075	0.0106
	[-3.50]	[-0.74]	[0.06]	[0.91]
Non-Farm business assets	-0.188***	-0.626	2.265	0.0188
	[-4.88]	[-0.36]	[1.44]	[0.85]
Number of migrants	-1.991	-0.374	2.265	0.0092
	[-1.21]	[-0.13]	[0.77]	[0.35]
Village average Livestock	-1.972	-2.541		-0.0565
	[-1.00]	[-0.73]		[-1.66]
Village average Land	16.52**	13.52		0.107
	[2.28]	[1.36]		[1.04]
Village average Household size	-3.084	12.10*		0.121**
	[-0.89]	[1.96]		[2.21]
Average prop. of children in the village	-18.36	-115.9*		-0.945
	[-0.75]	[-1.74]		[-1.55]
Village average Education	-4.516***	-11.01**		-0.141**
	[-2.65]	[-2.10]		[-2.59]
Village average non-farm business Assets	0.138	-20.90***		-0.185***
	[0.93]	[-3.34]		[-2.89]
Village average number of migrants	-25.07***	-18.18		-0.166
	[-3.71]	[-1.67]		[-1.40]
FUG in the village	-9.309	-1.602		-0.0746
	[-1.05]	[-0.18]		[-0.79]
Median distance to road in the village	-0.0727	0.780*		0.004
	[-0.55]	[1.73]		[0.90]
Number of households in the village	-0.0158	-0.0474		-0.0000417
	[-0.51]	[-1.14]		[-0.09]
Number of conflict related casualties and abductions in the previous year	-12.58***	-9.751		-0.0434
	[-3.24]	[-1.52]		[-0.67]

Household fixed-effects		YES	YES	YES
Village-year dummies			YES	
(Within) R-square	0.0519	0.173	0.338	0.199
N	5037	1459	1459	1358

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

Table 5: Reduced form for firewood collection time

	Dependent Variable: Firewood collection time			
	Linear Cross-Section	*Linear Panel*	*Village-time FE*	*Log(Collection time)*
	[1]	[2]	[3]	[4]
Livestock	-0.0430***	0.0368	0.0325	0.0162
	[-3.37]	[0.82]	[0.80]	[1.58]
Land	-0.0272	0.000691	0.00586	-0.00587
	[-0.83]	[0.01]	[0.12]	[-0.47]
Household size	0.0753***	0.156***	0.0912*	0.0318***
	[5.04]	[2.72]	[1.68]	[2.86]
Proportion of children	-0.222	-0.582	-0.184	0.00432
	[-1.62]	[-1.13]	[-0.39]	[0.04]
Education	-0.0578***	-0.0655	-0.0524	-0.0103
	[-5.04]	[-1.18]	[-1.02]	[-0.95]
Non-Farm business assets	-0.00117*	0.0455	0.122	0.0213
	[-1.87]	[0.41]	[0.99]	[0.75]
Number of migrants	-0.0333	0.139	0.00651	0.0639**
	[-0.88]	[1.23]	[0.05]	[2.16]
Village average Livestock	-0.0914	0.0752		0.028
	[-1.50]	[0.41]		[0.78]
Village average Land	-0.0292	-0.144		-0.0261
	[-0.17]	[-0.59]		[-0.50]
Village average Household size	0.111	0.631***		0.155***
	[1.11]	[3.47]		[3.75]
Average prop. of children in the village	-0.532	-4.328***		-0.693*
	[-0.65]	[-2.85]		[-1.75]
Village average Education	-0.143***	-0.0377		0.00213
	[-2.98]	[-0.21]		[0.05]
Village average non-farm business Assets	-0.00953***	-0.341		-0.0625
	[-3.98]	[-1.36]		[-1.30]
Village average number of migrants	0.451**	1.218***		0.409***
	[2.49]	[3.49]		[5.14]
FUG in the village	0.334*	-0.253		-0.184**
	[1.96]	[-0.99]		[-2.52]
Median distance to road in the village	0.0353***	-0.00781		-0.00491
	[4.29]	[-0.34]		[-1.19]
Number of households in the village	-0.000112	0.00208		0.000775*
	[-0.20]	[1.13]		[1.94]
Number of conflict related casualties and abductions in the previous year	0.182	-0.252		-0.0817
	[0.53]	[-1.12]		[-1.21]

Household fixed-effects		YES	YES	YES
Village-year dummies			YES	
Within R-square	0.144	0.187	0.363	0.164
N	4695	1358	1358	1358

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

Table 6: Factors contributing to the observed changes in collections

PANEL A: PREDICTIONS BASED ON REDUCED FORM TABLE 4 ESTIMATES (COLUMN 2)

	1995-2003	2003-2010
Observed changed in the amount of firewood collected	-12.2	-14.9
Estimated change at the household level	**-1.6**	**-4.5**
Household Size	-2.0	-4.2
Proportion of Children	1.2	2.1
Livestock	-0.8	-2.4
Estimated change at the village level	**-7.4**	**-14.4**
Distance to Road	-2.8	-3.5
Average Education	-5.9	-7.8
Average hh size	-1.2	-5.3
Average Prop. Children	3.0	7.1
Average Out-migration	-0.5	-4.9

PANEL B: PREDICTIONS BASED ON ENGEL CURVE TABLE 3 ESTIMATES (COLUMN 4)

	1995-2003	2003-2010
Observed changed in the amount of firewood collected	-12.2	-14.9
Estimated change at the household level	**+3.78**	**+25.44**
Consumption	4.99	28.82
Livestock	-0.79	-2.27
Household size	-1.16	-2.42
Proportion of children	0.74	1.31

Table 7: Engel Curves in village with a FUG in 1995

	Dependent Variable: Firewood collected (in bharis)				
	[1]	[2]	[3]	[4]	[5]
Consumption	0.000659***	0.000626***	0.000249**	0.000209	0.000388*
	[5.06]	[4.10]	[2.16]	[1.15]	[1.75]
Square of consumption	-7.37E-10	-1.82e-09***	2.50E-10	-1.04E-09	-1.23E-09
	[-1.26]	[-2.85]	[1.11]	[-1.41]	[-1.62]
Livestock			2.328***	5.236**	4.372*
			[2.72]	[2.13]	[1.91]
Land			-0.508	-0.404	0.945
			[-0.94]	[-0.19]	[0.34]
Household size			5.573***	6.494***	5.565***
			[5.16]	[3.75]	[3.16]
Proportion of children (0-15)			-7.215	-20.18	-23.04*
			[-0.86]	[-1.40]	[-1.78]
Education			-0.478	0.409	0.315
			[-0.52]	[0.34]	[0.33]
Non-Farm Business Assets			-3.867***	0.631	-1.21
			[-6.04]	[0.24]	[-0.43]
Number of migrants remitting			1.055	9.269**	6.3
			[0.32]	[2.09]	[1.45]
Village median collection time					1.92
					[0.58]
Cross-section	YES		YES		
Village dummies	YES		YES		
HH. fixed-effects		YES		YES	YES
Village-year dummies		YES		YES	
# observations	886	558	886	556	556
(Within) R-sq	0.404	0.33	0.464	0.385	0.212

Note: t statistics in brackets, * p<0.05, ** p<0.01, *** p<0.001. In all estimates, we include year and seasonal dummies. The standard errors are clustered at the village level.

Table 8A: Reduced form for firewood collections – Griliches-Hausmann correction

	Dependent Variable: Firewood collected			
	Linear balanced panel [1]	*First difference, balanced panel* [2]	*χ^2-test of equality of coefficients, p-value* [3]	*G-H corrected coefficient and bootstrapped std. dev.* [4]
Livestock	0.563 [0.34]	-0.058 [-0.04]	(0.4482)	
Land	-2.115 [-0.35]	-1.276 [-0.31]	(0.6723)	
Household size	9.393*** [3.58]	8.915*** [3.88]	(0.5610)	
Proportion of children	-63.49*** [-3.40]	-59.86*** [-4.12]	(0.6886)	
Education	-3.019* [-1.89]	-3.005 [-1.67]	(0.9870)	
Non-Farm business assets	-3.617 [-1.18]	-3.981 [-1.29]	(0.7921)	
Number of migrants	5.076 [1.28]	5.961 [1.48]	(0.6523)	
Village average Livestock	13.59* [1.77]	13.45* [1.88]	(0.9468)	
Village average Land	-18.06 [-1.21]	-17.75 [-1.35]	(0.9437)	
Village average Household size	26.41*** [2.88]	24.29*** [2.98]	(0.5330)	
Average prop. of children in the village	-191.6** [-2.25]	-185.7** [-2.45]	(0.8349)	
Village average Education	-22.98*** [-2.87]	-17.54** [-2.20]	(0.0210)** [-4.87]	-26.44***
Village average non-farm business Assets	-35.49** [-2.27]	-23.98* [-1.88]	(0.0001)*** [-4.18]	-65.79***
Village average number of migrants	1.102 [0.11]	1.963 [0.18]	(0.9156)	
FUG in the village	2.121 [0.15]	7.384 [0.71]	(0.3559)	
Median distance to road in the village	0.786 [0.75]	0.49 [0.51]	(0.5159)	
Number of households in the village	-0.0484 [-0.91]	-0.00629 [-0.12]	(0.0960)* [-2.08]	-.0933**
Number of conflict related casualties and abductions in the previous year	-29.2 [-0.95]	-27.33 [-1.38]	(0.8539)	

Household fixed-effects	YES	YES		
N	585	390		

Note: t statistics in brackets, p-value in parentheses, * p<0.10, ** p<0.05, *** p<0.01. In all estimates, we include year and seasonal dummies. The standard errors are clustered at the level of the village. In column 4, t-statistics of the block bootstrap of the Griliches-Hausmann estimator are reported.

Table 8B: Reduced form for firewood collection time – Griliches – Hausmann correction

	Dependent Variable: Firewood collection time			
	Linear Cross-Section [1]	*Linear Panel* [2]	*Village-time FE* [3]	*Log(Collection time)* [4]
Livestock	0.0895	0.100		
	[1.39]	[1.57]	(0.6298)	
Land	0.0192	-0.0436		-8.6503
	[0.15]	[-0.34]	(0.0993)*	[-0.0239]
Household size	0.292***	0.273***		
	[3.62]	[3.42]	(0.6056)	
Proportion of children	-1.842***	-1.196*		
	[-2.78]	[-1.77]	(0.1742)	
Education	-0.135*	-0.0811		
	[-1.90]	[-1.12]	(0.2234)	
Non-Farm business assets	0.0985	0.0678		
	[0.62]	[0.39]	(0.6205)	
Number of migrants	0.0994	0.157		
	[0.58]	[0.93]	(0.3975)	
Village average Livestock	0.147	0.0376		
	[0.79]	[0.19]	(0.1283)	
Village average Land	0.309	-0.0283		-17.46
	[0.70]	[-0.07]	(0.0278)**	[-0.43]
Village average Household size	0.960***	1.132***		
	[3.39]	[3.74]	(0.1536)	
Average prop. of children in the village	-6.958***	-9.733***		-166.810**
	[-2.94]	[-3.82]	(0.0210)**	[-2.31]
Village average Education	-0.085	-0.0836		
	[-0.42]	[-0.40]	(0.9834)	
Village average non-farm business Assets	-0.612**	-0.717**		
	[-2.04]	[-2.33]	(0.4109)	
Village average number of migrants	1.538**	1.649***		
	[2.58]	[2.88]	(0.6693)	
FUG in the village	-0.233	0.198		-14.2501
	[-0.55]	[0.45]	(0.0524)*	[-1.00]
Median distance to road in the village	-0.0680**	-0.0557*		
	[-2.37]	[-1.94]	(0.2536)	
Number of households in the village	0.000557	-0.000391		
	[0.27]	[-0.16]	(0.1653)	
Number of conflict related casualties and abductions in the previous year	-1.173	-1.182		
	[-1.08]	[-1.34]	(0.9800)	

Household fixed-effects	YES	YES		
N	471	314		

Note: t statistics in brackets, * p<0.10, ** p<0.05, *** p<0.01. In all estimates, we include year and seasonal dummies. The standard errors are clustered at the level of the village. In column 4, t-statistics of the block bootstrap of the Griliches-Hausmann estimator are reported.

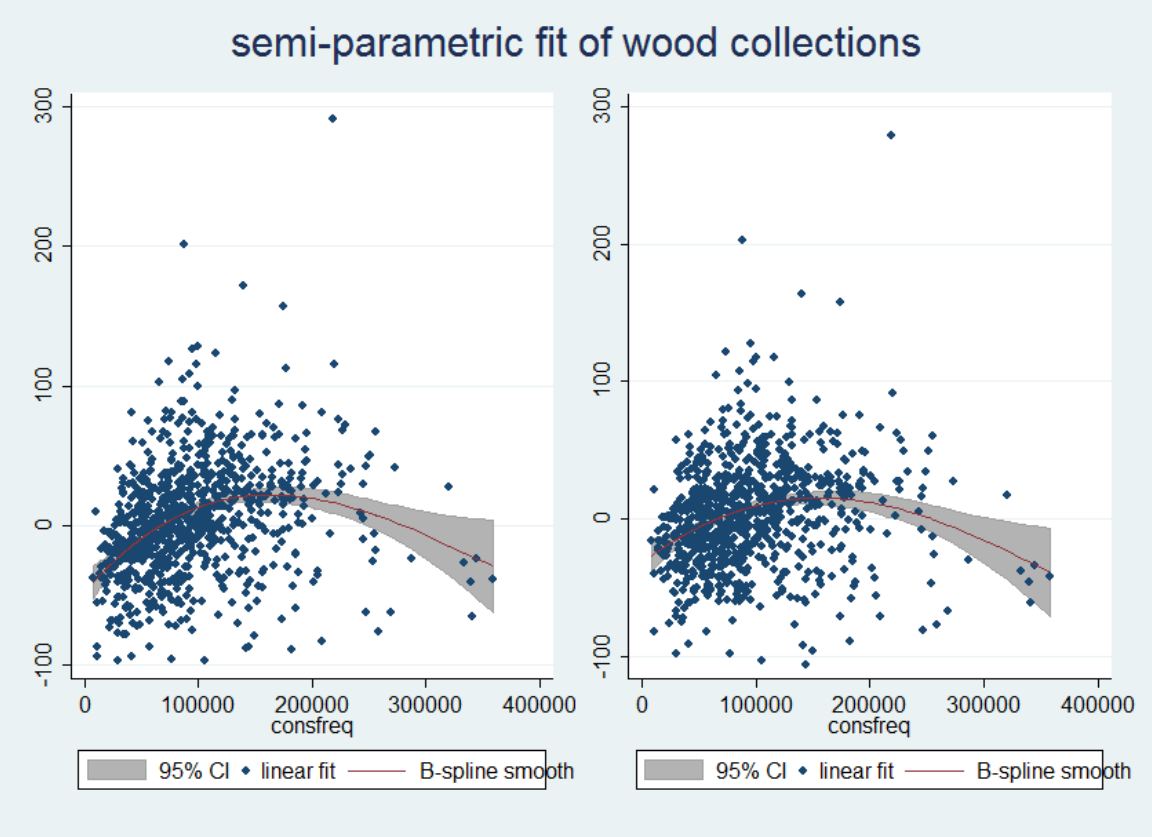
Appendix: Consumption regression

Table A1: Regression of Consumption on Household Assets

	Dependent Variable: Frequent consumption expenditures in Rs_{2010}			
	Linear [1]	*Village-time FE* [2]	*Village control* [3]	*Log(cons_freq), Village-time FE.* [4]
Livestock	2294.8***	2911.6***	2300.2***	0.0432***
	[4.02]	[4.42]	[3.88]	[7.86]
Land	-148	-335.3	38.72	-0.00981
	[-0.19]	[-0.44]	[0.05]	[-1.14]
Household size	8677.0***	8278.4***	8807.9***	0.111***
	[7.48]	[7.56]	[8.02]	[10.36]
Proportion of children	-14464.9*	-13413.7*	-12585.3	-0.0661
	[-1.83]	[-1.75]	[-1.59]	[-0.76]
Education	3714.3***	3090.6***	3612.5***	0.0332***
	[4.90]	[4.74]	[4.54]	[4.57]
Non-Farm business assets	1692.2	3996.6*	2111.6	0.0305*
	[0.77]	[1.87]	[0.96]	[1.73]
Number of migrants	6072.9**	5834.3**	5412.6**	0.0272
	[2.42]	[2.31]	[2.20]	[1.35]
FUG in the village			-5208	
			[-1.06]	
Median distance to road in the village			911.8**	
			[2.27]	
Number of households in the village			5.857	
			[0.19]	
Number of conflict related casualties and abductions in the previous year			9495.3*	
			[1.71]	
Village-year dummies		YES		YES
Within R-square	0.429	0.546	0.446	0.617
N	1459	1459	1459	1459

Note: t statistics in brackets, * p<0.10, ** p<0.05, *** p<0.01. In all estimates, we include household fixed-effects, year and seasonal dummies. The standard errors are clustered at the village level.

Figure 1: Semi-parametric regression of the Engel curves



Note: The left hand side figure is a semi-parametric fit of wood collections with respect to income where individual, time and seasonal fixed effect enter linearly as control variables. The right hand side figure also results from a semi-parametric estimation, with additional controls for individual assets and village level variables. The non-parametric fit has been estimated by a fourth order spline with an optimal number of knots.