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ANALYSIS

Poverty and resource dependence in rural India

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A B S T R A C T

Previous studies of rural households in developing countries have tended to find that the dependence of these households on common-pool resources declines with income. Our study of households in Jhabua, India, finds a more complex relationship. Using the share of resource income in total long-run or “permanent” income as our dependence measure—which we argue is more appropriate than the short-run income-based measure commonly used in the literature—we find that for households that collect any resources at all, dependence exhibits a U-shaped relationship with income. That is, the poorest and richest households depend more on resources than households with intermediate incomes. The poorest and richest households are also found to be least likely to collect, however, indicating that resource use at the income extremes is bimodal—either zero or above average. Moreover, the observed trends for resources as a whole are not mirrored in those for individual resources. Dependence on fuelwood and dung declines with income, for example, while dependence on fodder and construction wood increases. These findings suggest that common-pool resources are a productive source of income not just for the poor but also for the rich, and that improvements in the stocks of these resources can potentially form the basis of poverty reduction efforts in these economies.

1. Introduction

It is by now widely recognized that poor rural households in developing countries depend to a significant degree on income from local common-pool resources such as forests and grazing lands for their daily livelihoods. With this recognition has come a growing empirical literature (recently reviewed by Beck and Nesmith, 2001; Vedeld et al., 2004; Kuik, 2005) attempting to quantify this dependence. There is as yet, however, no consensus in this literature on two fundamental—and closely related—issues, namely (i) how dependence should be measured, and (ii) how dependence measures should be interpreted, i.e., what policy message they convey.

With respect to the first issue, it is interesting to note that the seminal study in the literature, Jodha (1986), uses as many as nine different measures of dependence. Some of these are income-based—such as the ratio of income from common-pool resources to total income from all other sources—while others are based on time-allocation decisions made by the household—such as time spent in collecting resources as a share of total work time. Others still are based on the rate of participation by households in natural-resource collection activities. Subsequent studies have suggested yet other measures, but the most commonly used in the more recent literature is the share of natural resource income in a household's *total* income (see, e.g., Hecht et al., 1988; Gunatilake and

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Senaratne Abeygunawardena, 1993; Hegde et al., 1996; Singh et al., 1996; Bahuguna, 2000; Beck and Ghosh, 2000; Cavendish, 2000; Fisher, 2004; Adhikari, 2005).

With respect to the second issue, how dependence measures should be interpreted, in a very general sense they of course simply capture the "importance" of common-pool resources in the lives of the rural poor, giving policymakers some sense of how much attention they should pay to the health and proper governance of these resources. Along these lines, Hecht et al. (1988) and Beck and Ghosh (2000) interpret their preferred measure, namely the share of resource income in total income, as a measure of the degree to which reduced access to, or destruction of, natural resources destabilizes rural livelihoods. Similarly, Singh et al. (1996), citing Jodha (1995), interpret the ratio of resource to non-resource income as the percentage by which the latter income will have to increase if common-property resources degrade or disappear.

In contrast, McSweeney (2002) prefers to measure dependence by the ratio of resource income to total *market* income, defined as the sum of cash income and the imputed value of barter transactions. This measure, McSweeney argues, conveys to policymakers how likely households are to respond to market-based incentives to conserve land and other natural resources.

Several other studies focus not on the resource income share per se, but on how this share varies with households' total income, and what this implies for measures of income inequality. Jodha (1986), Cavendish (1999b), Reddy and Chakravarty (1999), and Fisher (2004), for example, compare Gini coefficients with and without taking resource income into account, and find that inclusion of resource income reduces estimated income inequality.

Lastly, and most importantly for this paper, Fisher (2004), citing Angelsen and Wunder (2003), argues that the manner in which the resource income share varies with total income is an indicator of how successful a policy of natural-resource led development is likely to be. The argument is that an observed *decline* in resource dependence with income is evidence that resource collection is a low-return activity, a form of "employment of last resort" that richer households—whose assets and education provide a broader set of employment options—can avoid. Resource conservation or enhancement can still help "alleviate" poverty, but because low returns to collection leave no surplus to acquire assets with, such a policy is unlikely to "reduce" poverty. Conversely, an observed *increase* in resource dependence with income indicates that resource collection is a relatively high-return activity, and that natural-resource led development *is* potentially feasible.

Fisher's own study, based on data from three villages in Malawi, provides mixed evidence on how resource dependence in fact varies with income. Dividing sources of income from the forest into low-and high-return activities, she finds—consistent with her hypothesis—that the share of income from low-return activities declines, but that from high-return activities increases with total income. Much more common in the literature is a finding that resource dependence unambiguously declines with income. Jodha (1986) finds, for example, based on data from 21 villages across India, that poor households derive on average between 9% and 26% of their annual income from the commons, while (relatively) rich households derive only between 1% and 4%. Reddy and Chakravarty (1999) similarly find, based on data from 12 Himalayan villages, that dependence on resources decreases, from 23% for the poor to just 4% for the rich. Cavendish (2000) finds, based on data from 29 villages in Zimbabwe, much higher rates of dependency, with poor households deriving as much as 40%, and the rich about 30% of their incomes from natural resources.

The sheer volume of studies with similar findings suggests that the tendency of resource dependence to decline with income is quite robust.[1] Other than Fisher (2004), however, very few studies have examined this tendency in any detail, or offered more than conjectures—supported at best by anecdotal evidence—in explaining it. Most studies merely tabulate resource dependence against income categories, without subjecting observed trends to any further analysis. It is often unclear, for example (i) whether the observed trend applies to all sources of resource income individually, or only in aggregate for resource income overall; (ii) what part of the trend obtains because rich households stop relying on the commons altogether; or (iii) how much of the observed trend can be explained by variation in household and village characteristics across income categories.

This paper attempts to address these questions, and more generally contribute to the literature in four ways. First, we propose yet another measure of resource dependence, namely the share of resource income in what we call the household's total "permanent" income, defined as the flow of income that the household can expect to derive over the long-run. In contrast, most existing studies calculate the share relative to total "current" income for the survey period. The typically high variability of short-run household incomes makes this a noisy measure, which in particular fails to fully capture differences between households that are poor in private assets and households that are not. All else equal, asset-rich households have a wider array of options at their disposal to cope with negative income shocks, and they are in that sense less dependent on common-pool assets as a buffer against such shocks.[2] Our permanent income measure accounts for this fact by including in total income not just observed short-run income, but also the long-run expected return to a household's private assets.

Second, we present a study, using purpose-collected data from the district of Jhabua in the Indian state of Madhya Pradesh, in which we too find that resource dependency tends to decline with household income.

Third, however, we follow Fisher (2004) in examining this trend more closely for evidence of how promising a policy of resource-led development might be. Doing so, we find a considerable degree of complexity that the simple tabulations common in the literature fail to convey.

Fourth, because our data includes measures of private-asset holdings and other household and village characteristics,

[1] An important exception is Adhikari (2005), who, based on data from eight "forest user groups" in Nepal, finds that dependence increases with income, from 14% for the poor to 22% for the rich.

[2] Jodha (1986) makes a similar observation by noting that "...the [common-property resources'] role as a cushion during the crisis situation, non-crop season, or drought period, is greater for the poor households, as unlike the rich, they do not have many other adjustment mechanisms." He does not account for this difference between poor and rich in his measures of dependence, however.

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we are able to explore whether the observed trend can be explained in terms of the underlying distributions of these variables.

The remainder of the paper is organized as follows. Section 2 describes our data and discusses why the resource income share in total current income is an inappropriate measure of dependence. Section 3 describes the methodology used to derive permanent income. Section 4 presents our analysis of the relationship between our preferred measure of resource dependence and total permanent income, using both simple tabulations and regression analysis. We examine this relationship in aggregate, i.e., for all resources and households combined, as well as disaggregated by resource products and by household participation in collecting them. Section 5 presents our findings on the relationship between resource dependence and various household- and village-level characteristics. Section 6 discusses a striking feature of our data, namely a bimodality of resource dependence at both extremes of the income distribution. Section 7 concludes with a discussion of the policy implications of our findings.

2. Data

Data used in this study was collected from 536 households in 60 villages in the Jhabua district of the Indian state of Madhya Pradesh, covering the period from June 2000 to May 2001. Whenever possible, information about the household's income and asset holdings was obtained directly from the household's head, defined as the member in charge of the household's economic and financial dealings. In all but 39 households, the head was male. Information about common-property resource collection, however, was obtained from members in charge of this activity, which were most often female.[3]

2.1. *Study site*

Jhabua is a semi-arid hilly region lying in the southwest corner of the state of Madhya Pradesh. Compared to other Indian districts, Jhabua is sparsely populated, with 1.3 million people living on 6793 km^2. The district's population is largely rural, with only 9% living in urban areas, and largely tribal or indigenous, with only 14% of the population being classified as non-tribal. Jhabua is also a poor district, with 47% of the population living below the poverty line and a literacy rate of only 37% (MPG, 2007).

The large majority of rural households in Jhabua practice rainfed agriculture, supplemented with livestock rearing and collection of resource products from common forest lands. The main resource products collected are fuelwood, dung (which is used for both fuel and manure), fodder, construction wood, *mahua* flowers and seeds (which are processed into liquor and cooking oil, respectively), and *tendu* leaves (which are processed into cigarettes).

As is true in much of the country, forest lands in Jhabua are owned by the state and have traditionally been managed by the Madhya Pradesh state forest department to maximize timber revenue. At the same time, villagers have been given rights, called *nistar*, that permit them to collect forest products from these lands for non-commercial household use (PRNRM, 2002). However, given the difficulties in monitoring such use and the lack of incentive on the part of households to self-regulate, state forest lands have in effect become open-access resources. This, combined with the management practices of the state forest department, has over the years resulted in widespread forest degradation, not only in Jhabua but throughout India.

Recognizing this problem, the Indian government's National Forest Policy of 1988 called for the development of a new forest management system that would involve local people and would also be geared towards meeting their needs. This new management system has come to be known as Joint Forest Management (JFM). Though some details vary from state to state, under JFM the state forest department agrees to share forest produce from state-owned forest lands with local villagers in return for their participation in the management of these lands. Villagers are allowed to collect dry and fallen branches for fuelwood, are given access to wood removed during thinning operations, are permitted to gather fodder and minor forest products, and are given a share of the final timber harvest. In return, villagers participate in the development of forest working plans, agree to protect the forests against encroachment and timber smuggling, and agree to restrict their use of certain forest products (Khare et al., 2000).

The Madhya Pradesh government passed its first JFM order in 1991 and the program was formally initiated in Jhabua the following year. JFM had been implemented in 22 of our 60 sample villages at the time of our survey.

2.2. *Sampling procedure*

The survey sample of households was generated through a two-stage sampling design. In the first stage, a stratified random sample of 64 villages was selected to maximize variability in the forest stock. Unfortunately, political unrest in Jhabua at the time of the survey made it impossible to complete the survey in 4 of the selected villages, leaving 60 villages in all.

In the second stage, household sample frames were constructed for each of the sample villages from village land ownership records and from the Madhya Pradesh state government's village-level list of households living below the poverty line (BPL). This list contains households whose monthly per-capita expenditure is less than or equal to Rs. 255 (Rs. 41≈$1) and who do not possess any luxury goods (e.g., televisions, bicycles). Since it is possible for some landed households—those with very little land—to fall under this category, care was taken to exclude households already listed in the village land ownership records from the BPL list. A random sample of 550 households was then selected from three strata: landless, land-poor (owning less than 3 ha of land) and land-rich (owning more than 3 ha of land). Landless and land-rich households were oversampled, so as to improve the variability in household wealth across our sample and thereby the reliability of regression estimates at the wealth

[3] Of household members identified as primarily responsible for collection of a resource (sometimes several members per household for a particular resource) 78% were female. If water collection is excluded, the percentage drops to 65%.

Table 1 – Variable definitions, means, and standard deviations

Label	Definition	Units	All (n=536) Mean	All (n=536) S.D.	Landed (n=500) Mean	Landed (n=500) S.D.	Landless (n=36) Mean	Landless (n=36) S.D.
TOT.INC	Total permanent income	Rs/aeu	7,502	(8,570)	7,558	(8,677)	6,661	(6,491)
RES.INC	Income from collecting all resources	Rs/aeu	543	(1,537)	523	(1,501)	839	(2,004)
WFU.INC	Income from collecting fuelwood	Rs/aeu	212	(837)	207	(846)	278	(663)
DFU.INC	Income from collecting dung for fuel	Rs/aeu	61	(207)	54	(176)	170	(466)
DMA.INC	Income from collecting dung for manure	Rs/aeu	8.0	(33.7)	8.6	(34.6)	0.0	(0.0)
FOD.INC	Income from collecting fodder	Rs/aeu	205	(1,110)	207	(1,130)	164	(710)
WCO.INC	Income from collecting construction wood	Rs/aeu	42	(436)	29	(281)	226	(1,398)
ORS.INC	Income from collecting other resources	Rs/aeu	15.6	(131.6)	16.7	(135.5)	0.3	(2.1)
LAND	Land owned by the household	ha/aeu	0.29	(0.53)	0.31	(0.54)	0.00	(0.00)
LVSTK	Livestock owned by the household	#/aeu	0.76	(0.85)	0.80	(0.86)	0.20	(0.50)
HD.EDU	Education of household head	years	2.8	(4.3)	2.7	(4.1)	5.1	(5.9)
HD.AGE	Age of household head	years	43.8	(12.4)	43.8	(12.3)	44.1	(14.5)
HD.FEM	Gender of household head (1= Female)	Dummy	0.07	(0.26)	0.07	(0.25)	0.18	(0.40)
HH.AEU	Household size	Aeu	5.9	(2.6)	6.0	(2.6)	3.9	(1.9)
CS.SC	Scheduled caste	Dummy	0.06	(0.23)	0.05	(0.21)	0.16	(0.38)
CS.ST	Scheduled tribe	Dummy	0.74	(0.44)	0.77	(0.42)	0.26	(0.45)
CS.OBC	Other backward class	Dummy	0.17	(0.37)	0.15	(0.35)	0.45	(0.52)
CS.GEN	General class	Dummy	0.04	(0.20)	0.04	(0.19)	0.14	(0.36)
BIO	Timber and fodder biomass availability	t/aeu	704	(1,258)	659	(1,248)	1,375	(1,204)
WAGE	Wage index for in-village casual labor	Rs/day	21.1	(4.6)	21.1	(4.6)	20.9	(4.3)
MKTDIS	Average distance to agricultural markets	km	10.2	(8.7)	10.5	(8.8)	5.9	(4.9)
JFM	Presence of JFM project in village	Dummy	0.28	(0.45)	0.27	(0.44)	0.39	(0.51)

extremes.[4] Because of data problems, 14 households were ultimately dropped from the sample, leaving a final sample of 536 households.

Summary statistics for the variables used in this paper are presented in Table 1.[5]

2.3. Biomass

Household- and village-level survey data were supplemented with village-level data on forest and grassland biomass availability obtained from remote-sensing images. Ground-level measurements of tree and grass biomass were taken in the fall of 2002 from a total of 42 sample plots, each about 0.1 ha in size, covering different landscape types found in Jhabua. Also, two satellite images taken in the fall of 2002 by the Indian Remote Sensing Satellite (IRS LISS-III) were used to construct the Normalized Difference Vegetation Index (NDVI)[6] for the sample plots. The tree and grass biomass data were then regressed on the NDVI data, separately for three major land classifications—grass and young tree plantation, mature but leafless trees, and mature trees with leaves. Finally, these regression estimates were combined with NDVI data from satellite images taken in 2000 to estimate biomass measures for that year. The total biomass available to each household was estimated by summing up the volume of biomass that fell within a 5-km radius from the center of the village and dividing by the number of households in the village.[7]

2.4. Current household income

The survey data were first used to calculate each household's "current" income, defined as the income it obtained during the survey year from seven major sources, namely (i) agriculture, (ii) livestock rearing, (iii) common-pool resource collection,

[4] Unfortunately, this proved less effective than hoped for, as village land ownership records turned out to be quite unreliable: the correlation between officially recorded and subsequently observed land ownership for sample households turned out to be only 34%. While this makes our estimates less precise than they otherwise might have been, it has no other implications, as we use only observed land ownership in our statistical analysis and correct all estimates for the effects of our sampling scheme (see next footnote).

[5] In this table, and all tables reported hereafter, reported estimates (including means, standard deviations, quartiles, coefficient estimates, standard errors, and test statistics) are corrected for the effects of our sampling scheme. In particular, to correct for our oversampling of forest-rich villages and of landless and land-rich households within each village, observations were weighted by the inverse of their probability of inclusion in the sample. To correct for our two-stage selection process (stratified selection of villages and then of households within those villages), standard errors were adjusted for possible correlation of unobserved factors within the same village. See Deaton (1997) for a detailed discussion of these procedures. Note also that, whenever appropriate, quantities were made comparable across households by dividing the household-level value by the number of adult-equivalent units in the household. See Cavendish (1999a) for a discussion of this particular procedure.

[6] The NDVI is equal to the difference in near infrared (NIR) and red (R) light reflectance divided by the sum of these reflectances, that is, $NDVI = (NIR - R)/(NIR + R)$. The measure is commonly used to assess or predict vegetation biomass from remote-sensing data.

[7] By law, villages within 5 km of any given tract of forest have legal rights to its forest products; villages outside this radius do not have the same rights.

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(iv) household enterprise, (v) wage employment, (vi) transfers, and (vii) financial transactions. Income from each of these sources was calculated as the difference between total revenue obtained and total input costs incurred, where these totals included both market transactions and imputed values for non-market transactions. For households that stall-fed their cattle on fodder collected from the commons, for example, live-stock income was calculated net of the fodder's imputed value, but that imputed value was in turn included in the households' resource income.[8] For income sources (i)–(iv), no cost was imputed for a households' own labor inputs, however; this follows standard practice in the literature.

2.5. *Inappropriateness of current-income-based dependence measure*

The top panel of Table 2 shows the composition of per-capita current income by current-income quartiles. Notable is the large disparity between the mean current per-capita income of households in the bottom three quartiles and that of households in the top quartile. The average household in the lowest quartile lost Rs. 2002 over the course of the survey year, while the average household in the top quartile earned Rs. 10,370.

Also shown in the table is resource dependence by income quartile, measured by the share of overall current income derived from resource collection. For the second through fourth income quartiles, this measure declines monotonically, consistent with previous findings in the literature discussed above. For households in the first income quartile, however, the dependence measure is ill-defined, because most (104 out of 128) such households have negative total incomes. Moreover, if the measure is calculated for only those households in the bottom quartile that have positive total incomes, it comes out extremely high—351% on average. The reason is that for 9 of these households, resource income greatly exceeds total income.

Viewing households in the bottom quartile as highly dependent on resources seems inappropriate, however, because these households are by no means asset-poor. The bottom panel of Table 2 shows that they cultivate more land per-capita than households in the top three income quartiles, and own more farm capital and livestock as well. A likely explanation for this finding is that the survey year was the fifth consecutive drought year in Jhabua, resulting in low, and sometimes negative incomes for households with large land and livestock holdings.[9]

As argued above, private assets serve as a buffer to negative income shocks making asset-rich households less dependent on natural resources to cope with such income shortfalls. In fact, there is evidence of such buffering occurring in the survey year: the bottom row of Table 2 shows that households in the bottom income quartile disinvested over the course of the survey year (largely by taking on new debt and by selling jewelry) to make up for income losses.

Table 2 – Current per-capita household incomes, resource dependence, and asset holdings, by current-income quartile

	Current-income quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
Incomes:				
Agriculture	−1306	124	511	2095
Livestock rearing	−374	−89	0	24
Resource collection	320	368	485	994
Fuelwood	72	143	153	475
Dung for fuel	35	56	61	92
Dung for manure	13	4	6	9
Fodder	159	143	259	257
Constr. wood	2	14	3	147
Other resources	38	7	3	14
Household enterprise	45	108	172	1314
Wage employment	590	1151	2007	5038
In-village labor	106	158	259	431
Off-village labor	451	921	1405	1471
Pri. and pub. jobs	33	72	343	3136
Transfers	156	119	202	1472
Relatives	11	36	55	244
Friends	1	1	2	313
NGOs	0	2	0	27
State	144	80	145	887
Fin. transactions	−1,434	−610	−496	−566
Total income	−2,002	1172	2881	10,370
Resource dependence (%)	n/a	40	16	14
Assets:				
Land cultivated (ha.)	0.36	0.20	0.24	0.35
Value of land owned	29,825	14,073	18,170	36,714
Value of farm capital	7262	1945	2714	4306
Value of livestock	3134	2534	2571	2639
Financial assets	−3869	−1463	−1281	−1504
Total asset value	36,353	17,089	22,173	42,156
Net investment	−384	165	71	1466

3. Permanent household income

To make allowance for the buffering capability that private-asset holdings provide—and the implied reduced dependence on any particular income source—we propose a different measure of resource dependence, namely the resource income share in the household's long-run or "permanent" income. Ideally, this long-run income would be estimated by surveying households repeatedly over many years, and then averaging over their income realizations. In practice, we have to resort to the closest feasible alternative given our data limitations. We thereby make use of economic theory, which suggests that, given sufficiently well-functioning asset and labor markets, farm-household income should on average and over a sufficiently long-run provide a "normal" return to land and other assets, after taking into account the opportunity cost of own labor applied to the farm. Although observed returns in any given year—such as the survey year—may be nowhere close to normal, households can

[8] Prices for all resource products were readily obtained as active markets exist for these products.

[9] As pointed out to us by a reviewer, the low income-to-asset ratio of these households may also reflect a lack of access to other, complementary assets such as technical know-how, or may reflect variation in asset quality not captured by the asset price.

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reasonably expect to receive this normal return on average in future years. Based on this reasoning, we estimate long-run incomes derived from agriculture, livestock rearing, and financial transactions by calculating the annualized equivalent of an income stream that consists of observed income in the current year, followed by a normal return to the households' end-of-year holdings of private assets (land, livestock, farm capital, financial wealth) in future years.[10] The resulting correlation between current and permanent income turns out to not be very high (the correlation coefficient is 0.76). For example, although 62% of households that fall into the top permanent income quartile also fall into the top current-income quartile, 15%, 6% and 17% of these households fall into the third, second, and bottom current-income quartiles, respectively. This confirms that income in one particular year may not give an accurate picture of the household's expected long-run income, reinforcing our argument that resource dependence should be calculated in terms of the latter.[11]

4. Resource dependence based on permanent income

As shown in Table 3, permanent income from most individual sources increases monotonically from the first to the fourth quartile of total permanent income,[12] and productive-asset holdings now increase monotonically as well. That income derived from common-pool resource collection—the main focus of this study—increases with total income is consistent with similar findings by Cavendish (2000) and Adhikari et al. (2004).

Table 4 shows, however, that in contrast to the findings of Jodha (1986), Reddy and Chakravarty (1999), Cavendish (2000), and many others, dependence on common-pool resources does not decline monotonically with income. Instead, there is evidence of a U-shaped relationship, with dependence declining at first but then increasing. This relationship holds both in the survey sample as a whole and in the subsample of households that engage in resource collection. Among collecting households (400 households in all, dispersed across all 60 villages in the sample) the poorest derive 11.6% of their total income from resources. This share decreases to 8.9% for households in the second income quartile, but then increases again to 10.9% for the third income quartile and to 13.0% for households in the fourth quartile.

Table 3 – Permanent per-capita household incomes, asset holdings, and household characteristics by permanent income quartile

	Permanent-income quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
Incomes:				
Agriculture	1557	2468	3726	7987
Livestock rearing	126	186	214	180
Resource collection	189	326	549	1103
Fuelwood	103	149	223	370
Dung for fuel	46	58	79	61
Dung for manure	7	8	5	11
Fodder	23	71	196	526
Construction wood	2	1	41	122
Other resources	7	38	5	13
Household enterprise	51	145	229	1217
Wage employment	598	1482	2096	4618
In-village labor	127	271	217	340
Off-village labor	419	1044	1479	1308
Pri. and pub. jobs	52	167	400	2970
Transfers	133	153	189	1475
Relatives	31	33	36	248
Friends	0	3	0	313
NGOs	2	0	0	27
State	100	117	153	887
Fin. transactions	−235	−206	−304	−302
Total income	2419	4553	6699	16,279
Assets:				
Land cultivated (ha.)	0.13	0.20	0.26	0.55
Value of land owned	7754	12,795	18,900	59,193
Value of farm capital	1087	2535	3724	8842
Value of livestock	1862	2700	2937	3369
Financial assets	−1989	−1599	−2474	−2049
Total asset value	8715	16,430	23,087	69,356
Household characteristics:				
Head schooling (yrs)	2.0	1.9	2.2	5.2
Head gender (1 = fem.)	0.1	0.1	0.1	0.1
Scheduled caste	0.1	0.1	0.0	0.0
Scheduled tribe	0.7	0.8	0.8	0.6
Oth. backw. class	0.1	0.1	0.2	0.2
General class	0.1	0.0	0.0	0.1
No. of hh. members	6.0	6.3	6.0	5.3
No. of adults	3.7	4.5	4.3	4.0

For both the whole sample and the subsample of collecting households, the U-shaped relationship between dependence and income is explained by generally declining dependence on fuelwood, dung for fuel, and dung for manure, but increasing dependence on fodder and construction wood.

Surprisingly, the fraction of households that engage in any resource collection at all does not vary with income in the same manner as dependence. As shown in the last row of Table 4, this fraction in fact shows an inversely U-shaped relationship to income, increasing from 77.5% in the bottom income quartile to 81.5% in the second, but thereafter declining to just 61.4% in the top quartile.

Some indication of the statistical significance of these observed trends is given in the last column of the table, which reports the *F*-statistic from an ANOVA trend analysis for each

[10] Details of the calculation are provided in the Appendix.

[11] It should be emphasized, however, that our adjustment to the standard resource dependence measure is only partial, because for incomes derived from natural resources, wages, household enterprise, and transfers, we still simply use current-year income. To the extent then that households adjusted these other activities in the survey year in response to income shocks—perhaps collecting more resources, for example, to compensate for income losses from a failed crop—our dependence measure will still differ from the ideal, long-run measure. This unavoidable shortcoming limits the extent to which our findings can be generalized to other settings, particularly again because our survey year was the fifth consecutive drought year in Jhabua.

[12] For brevity, we hereafter take the qualifier "permanent" as understood.

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Table 4 – Dependence on resources (%) by permanent income quartile

	Permanent-income quartiles				
	Lowest 25%	25–50%	50–75%	Top 25%	F
Collecting households:					
Fuelwood	9.6	6.5	7.0	7.0	0.79
Dung for fuel	4.5	2.7	2.4	1.2	5.30^{**}
Manure	3.0	1.3	0.9	0.7	1.53
Fodder	11.5	14.9	16.3	19.7	0.79
Construction wood	2.2	1.0	5.5	11.8	2.80^{*}
Other resources	4.6	5.4	0.9	1.6	2.12
All resources	11.6	8.9	10.9	13.0	0.39
All households:					
Fuelwood	4.6	3.3	3.1	2.7	2.35
Dung for fuel	2.7	1.3	1.3	0.5	6.56^{**}
Manure	0.4	0.2	0.1	0.1	1.27
Fodder	0.9	1.6	2.8	3.6	4.87^{**}
Constr. wood	0.1	0.0	0.6	1.0	3.92^{*}
Oth. resources	0.3	0.8	0.1	0.1	2.00
All resources	9.0	7.2	7.9	8.0	0.11
% of Hh that collect	77.5	81.5	72.8	61.4	7.15^{***}

*, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

row. Note, however, that this test is equivalent to regressing dependence on income as a categorical variable (coded as $n \in \{1, 2, 3, 4\}$ if the household falls in n-th income quartile) and then testing the significance of the slope coefficient. The test therefore discards important information about the income distribution within each category. To take advantage of the fact that our survey incorporates this information, we next turn to a regression analysis of dependence on income as a continuous variable.

4.1. *Regression analysis*

Since not all households in the sample collect common-pool resources, the main data issue we need to confront is that the dependence measure is censored at zero. For any given resource, households in our sample in effect make two decisions: whether or not to participate in the collection of the resource and, conditional on participation, how much of the resource to collect.

In Table 5, the top panel shows our regression estimates of the participation equations, both for all resources combined (RES, in the first column) and for individual resources—fuelwood (WFU), dung for fuel (DFU), dung for manure (DMA), fodder (FOD), construction wood (WCO), and others (ORS). The bottom panel shows our estimates of the corresponding outcome equations.[13] The right-hand side variables in each case are the log of total permanent per-capita income (L.TOTINC) and higher powers thereof.[14]

For each of the resources, a Heckman selection model was first estimated, by incorporating a Mills ratio term in the outcome equation. Only in the cases of fuelwood and construction wood was evidence of a potential selection problem found. Unfortunately, very high collinearity between the Mills ratio term and the explanatory variables—a problem frequently encountered in econometric practice—was found to make coefficient estimates for the outcome equation of the Heckman model imprecise and unstable. Following advice by Leung and Yu (1996) and Puhani (2000), we there-fore report the results of the two-part model—the participation and outcome equations estimated separately—for all regressions other than those for fuelwood and construction wood.[15]

4.1.1. *All resources combined*

The first column of the table shows that the probability of collecting any resources at all (P.RES) exhibits an inverse U-shaped relationship with income, initially increasing, but then declining. In contrast, conditional on collection, dependence on all resources combined (D.RES) exhibits a U-shaped relationship, initially declining, but then increasing.

Both predicted relationships are plotted in the top two panels of Fig. 1.[16] The top panel shows that the turning point for the probability of collection occurs at a per-capita income level of Rs. 2200, which is about the average income of households in the first quartile (see Table 3). The very poorest

[13] In all regressions reported in this paper, superscripts *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Standard errors are shown in parentheses.

[14] We log-transform income in order to correct for the large positive skew in the income distribution of our sample. The (weighted) mean income is Rs. 7502, but incomes in the upper tail of the distribution range up to Rs. 102,672. This is problematic because, as Belsey et al. (1980) show, in a simple linear regression of y on X, the influence or "leverage" of an observation i on the coefficient estimate increases in the squared distance of X_i from the mean X. Were we to use untransformed income, our regression estimates would therefore largely be driven by the behavior of the richest households in our sample, even though the behavior of the poorest households is at least as interesting from a policy perspective. As shown in Fig. 1 (which we discuss in more detail below), log-transforming income largely removes the skew in the distribution, thereby implicitly giving roughly equal weight in the regressions to the behavior of households at both income extremes.

[15] Leung and Yu (1996) and Puhani (2000) suggest that the two-part model is likely to outperform the Heckman model whenever collinearity as measured by Belsey et al.'s (1980) condition number is "high"—Leung and Yu suggest a cutoff of 20. In all our Heckman estimates, the condition number was well above this hurdle, often by an order of magnitude or more. This, despite our inclusion in the participation equation of variables capturing the presence or fraction of children or elderly in the household—variables that can arguably be excluded from the outcome equation, and therefore help identify it.

[16] The horizontal axis of each panel shows total income (in Rs. 1000) on a log scale, with vertical gridlines at the sample minimum income (Rs. 270), the 25th, 50th, and 75th percentiles (Rs. 3600, Rs. 5400, and Rs. 8300), and the sample maximum (Rs. 102,700). Also shown are the underlying datapoints, with marker sizes scaled in proportion to each point's weight in the regression (recall Footnote 5). In the top panel, the datapoints are also jittered vertically, to give some visual sense of their distribution along the 0 and 1 lines.

Table 5 – Resource dependence as a function of permanent income

Estimation method	PROBIT	HECKMN	PROBIT	PROBIT	PROBIT	HECKMN	PROBIT
Dependent variable	P.RES	P.WFU	P.DFU	P.DMA	P.FOD	P.WCO	P.ORS
L.TOT.INC	2.503*** (0.886)	3.067*** (1.060)	−0.275*** (0.083)	1.972 (1.213)	3.440** (1.608)	7.126** (2.610)	11.453*** (3.274)
L.TOT.INC^2	−0.162*** (0.051)	−0.185*** (0.062)		−0.117* (0.069)	−0.177* (0.091)	−0.376** (0.146)	−0.662*** (0.188)
Constant	−8.796** (3.886)	−12.821*** (4.497)	2.377*** (0.724)	−9.363* (5.344)	−17.544** (7.127)	−34.970*** (11.649)	−50.652*** (14.215)
No. of obs.	536	536	536	536	536	536	536
F	10.82***		11.00***	1.54	5.27***	0.88	6.06***
χ^2		13***					
Estimation method	OLS	HECKMN	OLS	OLS	OLS	HECKMN	OLS
Dependent variable	D.RES	D.WFU	D.DFU	D.DMA	D.FOD	D.WCO	D.ORS
L.TOT.INC	−0.655*** (0.188)	−0.049** (0.022)	−3.627*** (0.430)	−7.840*** (2.921)	0.456 (1.090)	0.038 (0.041)	−0.039 (0.025)
L.TOT.INC^2	0.039*** (0.011)		0.424*** (0.054)	0.884*** (0.331)	−0.024 (0.061)		
L.TOT.INC^3			−0.016*** (0.002)	−0.033** (0.012)			
Constant	2.868*** (0.778)	0.289 (0.176)	10.344*** (1.135)	23.129*** (8.565)	−2.020 (4.899)	−0.120 (0.373)	0.372* (0.222)
MILLSR		0.267*** (0.089)				−0.083* (0.063)	
No. of obs.	400	264	265	64	74	37	52
R^2	0.04***		0.34***	0.62*	0.02		0.04

households are therefore somewhat less likely to collect than middle-income households, but rich households are much less likely to collect than either. The turning point for conditional dependence, in the second panel, occurs at a per-capita income of Rs. 4800, about the average income in the second quartile. Conditional on collecting at all, the poorest and richest households therefore collect more than do middle-income households.

Also shown, in the bottom panel of the figure, is the predicted relationship between unconditional dependence on resources and income, i.e., dependence for the sample as a whole, including non-collectors.[17] The general trend of unconditional dependence is clearly declining in income, and our study therefore adds to the growing body of evidence that poor households depend relatively more on resource income than do the rich. Clearly, however, this broad-brush statement glosses over a considerable degree of complexity underlying the overall trend.

First, it is evident that the overall trend is not monotonically declining. After an initial, fairly sharp decline from about 20% dependence for the very poorest households to just 10% dependence at the 25th percentile, the trend is essentially flat to slightly increasing over the bulk of the sample before declining again for the very richest households.

[17] This relationship is simply the product of the predicted relationships in the top two panels: $E(\text{D.RES} \mid \text{L.TOT.INC}) = P(\text{D.RES}>0 \mid \text{L.TOT.INC}) \times E(\text{D.RES} \mid \text{D.RES}>0, \text{L.TOT.INC})$.

Second, the overall trend masks the interesting fact that emerges from the separate regressions of the participation and outcome equations, namely that at the income extremes, resource use appears to be bimodal: the poorest and richest households tend to collect either no resources at all *or* a lot of resources. The inclusion of rich non-collectors in effect "pulls down" the high conditional dependence of rich collectors, making the relationship between overall dependence and income negative. Similarly, the inclusion of poor non-collectors "pull downs" the high conditional dependence of poor collectors, making the initial decline of overall dependence less steep.

Lastly, as we show in the next subsection, the overall trends in dependence on all resources combined are in fact an amalgam of quite different trends in dependence on resources considered individually.

4.1.2. *Individual resources*

The second through last columns of Table 5 report our estimates of the participation and outcome equations for individual resources. For dung for fuel, shown in the third column, the predicted probability of collecting declines throughout in income. For all other resources, the predicted probability is inversely U-shaped in income, as was true of the predicted probability of collecting any resource at all. The estimated turning points vary considerably, however. For fuelwood and dung for manure, the turning points lie in the second income quartile, so that over much the sample the probability of collection declines. In contrast, for fodder and

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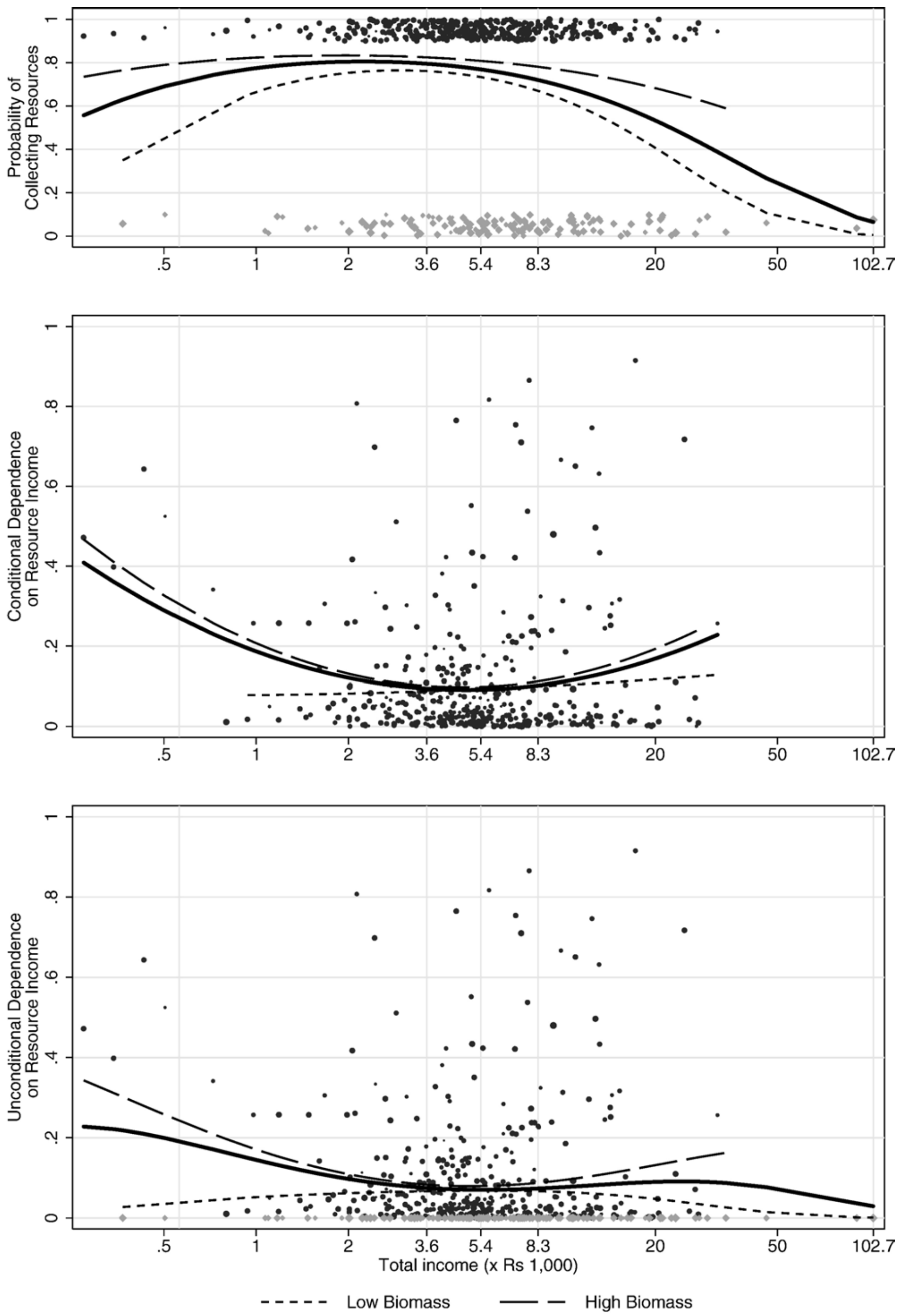

Fig. 1 – Resource dependence as a function of income.

construction wood, the turning points lie well into the fourth quartile, so that most of the sample the probability of collection increases. The turning point for other resources—mostly *mahua* flowers and seeds, and *tendu* leaves—lies around the median income level.

The trends for conditional dependence are consistent with those for participation. That is, the predicted relationships for fuelwood, dung for fuel, and dung for manure all decline over essentially the entire income range (because for dung the decline is by far the sharpest over the first income quartile, however, a cubic polynomial in income is required to adequately fit the data). In contrast, the predicted relationships for fodder and construction wood both increase. The estimated rates of increase are not large, however, and—possibly because of the relatively small subsamples of households that in fact collect these resources—not statistically significant. For other resources, finally, the predicted relationship is weakly declining.

Table 6 – Probability of collection as a function of household and village characteristics

Estimation method	HECKMN	HECKMN	PROBIT	PROBIT	PROBIT	PROBIT	PROBIT
Dependent variable	P.RES	P.WFU	P.DFU	P.DMA	P.FOD	P.WCO	P.ORS
L.LAND	−0.081	−0.220***	−0.024	0.012	−0.233**	−0.318***	0.205
	(0.091)	(0.084)	(0.097)	(0.046)	(0.093)	(0.106)	(0.128)
L.LVSTK	−0.119	−0.192*	−0.218**	−0.163	−0.006	0.116	−0.025
	(0.107)	(0.103)	(0.100)	(0.135)	(0.124)	(0.115)	(0.165)
HD.EDU	−0.043**	−0.050***	−0.022	−0.017	−0.021	−0.063	−0.097***
	(0.018)	(0.018)	(0.019)	(0.020)	(0.026)	(0.040)	(0.036)
HD.AGE	−0.007	−0.005	−0.005	0.007	0.009	−0.005	−0.006
	(0.006)	(0.006)	(0.005)	(0.006)	(0.008)	(0.009)	(0.005)
HD.FEM	−0.025	0.096	0.090	0.051	−0.353	−0.356	−0.119
	(0.264)	(0.239)	(0.269)	(0.250)	(0.333)	(0.302)	(0.318)
L.HH.AEU	0.350*	0.341*	0.353*	−0.065	0.082	0.227	0.839***
	(0.186)	(0.174)	(0.179)	(0.242)	(0.174)	(0.201)	(0.229)
CS.SC	0.277	0.354	0.979***	0.093	−0.855*		
	(0.343)	(0.290)	(0.277)	(0.332)	(0.498)		
CS.OBC	−0.403**	−0.682***	0.200	−0.163	−0.522**	−0.390	−0.443
	(0.199)	(0.214)	(0.224)	(0.293)	(0.217)	(0.428)	(0.388)
CS.GEN	−0.460	−0.470	−0.070	0.132	−0.653		−0.038
	(0.323)	(0.358)	(0.350)	(0.372)	(0.595)		(0.590)
L.BIO	0.219***	0.307***	0.138*	−0.074	−0.021	0.109	0.295***
	(0.077)	(0.069)	(0.080)	(0.077)	(0.105)	(0.097)	(0.086)
Wage	0.827**	0.472	−0.273	1.072**	−0.448	−0.593	0.413
	(0.412)	(0.360)	(0.451)	(0.503)	(0.512)	(0.589)	(0.510)
MKTDIS	−0.002	0.031***	−0.024**	−0.003	0.019	0.029**	0.026***
	(0.009)	(0.009)	(0.009)	(0.013)	(0.012)	(0.011)	(0.009)
JFM	0.249	0.344**	−0.388**	−0.230	0.713**	0.257	0.519**
	(0.171)	(0.160)	(0.161)	(0.237)	(0.286)	(0.235)	(0.238)
L.TOT.INC	0.009	0.297***	−0.157	−0.023	0.646***	0.826***	0.186
	(0.102)	(0.102)	(0.106)	(0.158)	(0.164)	(0.255)	(0.164)
Constant	−34.739***	−20.422**	−15.170	−20.927*	1.794	−0.236	−8.396
	(10.867)	(9.748)	(11.585)	(12.217)	(16.013)	(15.138)	(11.896)
No. of obs.	536	536	536	536	536	536	536
F			3.74***	4.21***	2.86***	2.15**	5.76***
χ^2	180***	201***					

The overall picture that emerges is that the inverse U-shaped participation and U-shaped conditional dependence relationships observed for all resources combined are in fact averages over two sub-trends. Specifically, the high conditional dependence of poor households derives mainly from their collection of fuelwood, dung for fuel, and dung for manure, and these households are also more likely to collect these resources. On the other hand, the high conditional dependence of rich households derives mainly from their collection of fodder and construction wood, and these households are again also more likely to collect these resources.

5. Resource dependence as a function of private-asset holdings, other household characteristics, and village characteristics

In this section, we expand our regression analysis to explore how the simple relationships between resource dependence and household income identified in the previous section may be explained by underlying variation in households' private-asset ownership, as well as various other household and village characteristics. Tables 6 and 7 show the regression results for respectively the participation and conditional dependence equations. We again report results for the two-part model, except when Heckman estimates suggest the need to correct for possible selection bias.[18]

5.1. *Private-asset holdings*

As shown in Table 6, the probabilities that households collect fuelwood, fodder, or construction wood decline significantly with private land holdings. For households with large land holdings, the ability to substitute privately produced resources—wood collected from trees grown on their land and fodder either grown as a crop or derived from crop residue—reduces the incentive to collect these resources from the commons.

Table 7 shows that, in contrast, for those households with smaller land holdings that do collect fuelwood and fodder,

[18] Suppressed from both Tables are several additional independent variables, namely (i) village-level prices for each of the resources, (ii) price indices for crops and for non-labor inputs such as pesticides and fertilizers, (iii) dummy variables for landless households and households with no livestock, and (iv) variables capturing the presence or fraction of children or elderly in the household. The effects of these variables on resource dependence, while interesting in their own right, are not the main focus of this paper.

Table 7 – Resource dependence as a function of household and village characteristics

Estimation method	HECKMN	HECKMN	OLS	OLS	OLS	OLS	OLS
Dependent variable	D.RES	D.WFU	D.DFU	D.DMA	D.FOD	D.WCO	D.ORS
L.LAND	−0.050***	−0.034**	−0.000	0.006*	0.028	−0.089***	−0.004
	(0.013)	(0.014)	(0.007)	(0.004)	(0.029)	(0.014)	(0.015)
L.LVSTK	−0.013	−0.019	0.003	0.002	−0.056**	0.020	0.042**
	(0.016)	(0.015)	(0.004)	(0.004)	(0.023)	(0.029)	(0.019)
HD.EDU	0.008	0.007	0.000	0.001	−0.010*	−0.013***	−0.017*
	(0.006)	(0.006)	(0.001)	(0.002)	(0.005)	(0.004)	(0.009)
$HD.EDU^2$	−0.001***	−0.001**					
	(0.000)	(0.000)					
HD.AGE	−0.001	−0.002**	0.001	−0.000	0.002	0.004	−0.001
	(0.001)	(0.001)	(0.000)	(0.000)	(0.002)	(0.003)	(0.001)
HD.FEM	−0.014	0.023	−0.008	−0.002	−0.138*	0.073**	−0.008
	(0.035)	(0.029)	(0.015)	(0.008)	(0.076)	(0.032)	(0.023)
L.HH.AEU	0.029	0.013	−0.025**	−0.026*	0.003	0.029	0.025
	(0.029)	(0.026)	(0.009)	(0.013)	(0.061)	(0.046)	(0.029)
CS.SC	−0.015	0.027	−0.000	−0.015	−0.224**		
	(0.041)	(0.033)	(0.012)	(0.019)	(0.097)		
CS.OBC	−0.083**	−0.024	−0.002	0.002	−0.050	−0.333***	−0.076
	(0.041)	(0.043)	(0.011)	(0.018)	(0.059)	(0.047)	(0.119)
CS.GEN	−0.048	−0.061	−0.029**	−0.020	0.633***		−0.065**
	(0.063)	(0.055)	(0.013)	(0.029)	(0.078)		(0.030)
L.BIO	−0.157**	−0.199***	0.002	−0.010*	−0.001	−0.017	0.002
	(0.077)	(0.061)	(0.003)	(0.006)	(0.024)	(0.015)	(0.011)
$L.BIO^2$	0.011**	0.014***					
	(0.004)	(0.004)					
Wage	−0.010	−0.017	−0.003	0.021	0.016	−0.292***	0.033
	(0.061)	(0.048)	(0.019)	(0.023)	(0.127)	(0.078)	(0.045)
MKTDIS	0.002**	0.002**	−0.000	0.001	0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.000)	(0.001)	(0.002)	(0.001)	(0.001)
JFM	0.058**	0.023	0.001	0.007	0.068	−0.027	0.010
	(0.026)	(0.024)	(0.009)	(0.007)	(0.060)	(0.032)	(0.026)
L.TOT.INC	−0.730***	−0.573***	−0.035**	−0.040**	0.056	0.036	−0.075**
	(0.154)	(0.153)	(0.017)	(0.020)	(0.046)	(0.029)	(0.032)
$L.TOT.INC^2$	0.046***	0.035***					
	(0.009)	(0.009)					
Constant	2.864	2.410	0.098	0.868	2.825	2.985*	−3.012
	(2.076)	(1.469)	(0.429)	(1.077)	(2.351)	(1.531)	(2.516)
MILLSR	0.189*	0.134**					
	(0.105)	(0.064)					
No. of obs.	400	264	265	64	74	37	52
R^2			0.25***	0.45***	0.59	0.75	0.63

private production is evidently not important enough to significantly affect dependence on the commons for these resources. Conditional dependence declines with land only for households that collect fuelwood and construction wood. Nevertheless, because income from wood collection comprises an important share of total resource income for these households, conditional dependence on resources overall declines with land holdings as well. As for the weakly significant increase with land holdings in dependence on dung for manure, this is presumably demand-driven: households with larger land holdings obviously have more use for manure.

Households with larger livestock holdings—the other important private asset in Jhabua—are found to have a lower probability of collecting fuelwood or dung for fuel from the commons. Again, the ability of such households to substitute a privately produced resource—in this case dung for fuel collected from their own livestock—likely explains this trend. Again, however, for those households with smaller livestock holdings that do choose to collect these resources from the commons, private production does not induce lower levels of conditional dependence.

The observed increase with livestock holdings in conditional dependence on other resources is harder to explain. We conjecture that households may use animals to haul larger quantities of some of these other resources. That is, for these resources, livestock may serve a complement to, rather than a substitute for, collection from the commons.

Lastly, counter to what one might expect, conditional dependence on fodder is found to decline with private livestock holdings. Recall, however, that this trend pertains to fodder that is collected from the commons by hand, and then stall-fed to livestock, rather than fodder collected "indirectly" by grazing livestock in the commons. As we show in Narain et al. (in press), a companion paper that focuses on households' optimal time-allocation decisions, households with larger livestock holdings prefer to spend time grazing their herds in the commons to stall-feeding them.

5.2. *Other household characteristics*

Households with more educated household heads are found to be less likely to collect resources, significantly so for fuelwood, other resources, and all resources combined. Conditional dependence on resources tends to be lower for such households as well.[19] This, too, can be explained from households' optimal time-allocation decisions. More educated household heads have access to more profitable activities than resource collection, such as private- and public-sector jobs and household enterprises.

Neither the age nor the gender of the household head appear to significantly affect resource dependence. Only conditional dependence on fuelwood declines with age, and although households with female heads (of which there are only 39 in our total sample) appear to collect somewhat less fodder and more construction wood, these findings are based on subsamples of just three and two households, respectively, and must therefore be treated with caution.

Larger households are found to be more likely to collect most resources, but to be less dependent on dung for fuel. The former finding may be explained by economies of scale in production—larger households can have members specialize in collection—and the latter by economies of scale in consumption—larger households can share in the use of fuel for cooking and heating.

The final household characteristic we consider is caste status. Under Indian law, three caste groups, referred to as scheduled castes (CS.SC), (formerly known as "untouchables"), scheduled tribes (CS.ST), and other backward classes (CS.OBC), are recognized as socially disadvantaged relative to "general" households (CS.GEN) and thereby eligible for certain forms of affirmative action. Unfortunately, because a large majority (74%) of households in our sample belong to scheduled tribes, the number of households belonging to the other three groups tends to be quite small in various subsamples of interest. This makes it difficult to obtain much resolution on the effect of social status on resource dependence. Nevertheless, it appears that scheduled caste households, which have lower social status than scheduled tribes (the excluded category in the regressions), are significantly more likely to collect dung for fuel. At the same time, general households, which have the highest social status, are significantly less dependent on this resource, conditional on collecting any at all. We conjecture that both findings may be due to a cultural bias that associates use of dung for fuel with backwardness.

Although general households seem to be significantly more dependent on fodder as well, this result is based on an outlier: only one general household in fact collects fodder, but it collects a large amount. More robust should be the finding that scheduled caste households are both significantly less likely to collect fodder and conditionally less dependent on it. A possible explanation is that fodder collection by hand is often restricted by village rules, and social status may correlate with the ability to bend such rules to one's advantage.[20]

5.3. *Village characteristics*

The productivity of time spent collecting resources can be expected to increase with the biomass density of the commons. Consistent with this, households in villages with higher per-capita levels of biomass are found to be significantly more likely to collect fuelwood, dung for fuel (from animals that graze on the commons) and other resources, as well as all resources combined. Conditional dependence increases in biomass as well.[21]

In villages that have higher wage levels and are closer to agricultural markets, dependence on resources might be expected to be lower, as the alternative of purchasing resources (or resource substitutes) should be relatively more attractive. Here, our evidence is somewhat mixed, however. Although conditional dependence on construction wood indeed declines with the village wage, the probability of collecting dung for manure and all resources combined is found to increase. Similarly, although the probability of collecting fuelwood, construction wood, and other resources is indeed found to increase with market distance, as does conditional dependence on fuelwood and all resources combined, the probability of collecting dung for fuel is found to decline.

In light of the attempts to improve forest management discussed in Section 2, a village-level characteristic of particular interest is whether a JFM project has been implemented. Table 6 shows that in villages with JFM projects, households are significantly less likely to collect dung from the commons, but more likely to collect fodder. Both findings may be explained by the fact that, in order to protect young plantations, villages with JFM projects often close off certain sections of village forest lands to grazing (thereby reducing the amount of dung available) and instead allocate families plots in other sections of the forest where they are permitted to collect fodder by hand. Other findings that suggest some success on the part of JFM projects in gearing forest management towards villagers' needs are that households in JFM villages are significantly more likely to collect fuelwood, as well as other, typically marketed resources such as *tendu* and *mahua*. The underlying mechanism is unclear, but it is possible that JFM villages have a more favorable mix of trees, with perhaps a larger fraction of fuelwood trees, as well as perhaps better opportunities for marketing non-timber forest products. Conditional dependence on all resources combined is found to be higher in JFM villages as well.

[19] The apparent initial increase with education in dependence on fuelwood and on all resources combined is an artifact of the quadratic specification. Non-parametric regressions indicate that dependence on both is essentially constant up to an education level of about 7 years, but declines sharply thereafter.

[20] See Beck and Nesmith (2001) for a review of evidence that "community"-based natural resource management often ends up benefiting rural elites rather than the poor.

[21] The apparent initial decrease in dependence on fuelwood and all resources combined is again an artifact of the quadratic specification. Non-parametric regressions indicate that dependence is essentially constant up to the mean biomass level of around 700 t/aeu, but increases thereafter.

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5.4. Income

Somewhat surprisingly, although private-asset holdings and household- and village-level characteristics explain a good deal of cross-household variation in incomes[22] income remains an important explanatory variable in many of the regressions. Most notable is the strong positive relationship between income and the probabilities of collecting fodder and construction wood. We conjecture that for construction wood, this relationship may simply reflect higher demand by rich households.[23] In addition, the income variable may proxy for the unmeasured asset of "political capital": as noted above, fodder collection by hand is often restricted by village rules, and richer households may be better able to bend such rules to their advantage.

6. Bimodality of resource dependence at the income extremes

We finally turn to a closer examination of the bimodality in resource use observed for households at the income extremes in our data. Why are both the poorest and richest households less likely to participate in collection from the commons than middle-income households, yet more dependent on resources if they collect at all?

Simple comparisons of means (not shown) between collecting and non-collecting households in the bottom income quartile show that, consistent with our regression results in the previous section, non-collecting households have significantly fewer members, significantly more educated household heads, and somewhat larger holdings of land and livestock. Also, none of these households belong to the scheduled caste. Furthermore, non-collecting households' higher education levels and asset holdings appear to give them a comparative advantage in deriving income from sources other than resource collection or casual labor: they derive more income from household enterprise and from public and private jobs, and significantly more income from agriculture.[24] This comparative advantage does not translate into higher overall incomes, however: non-collecting households are in fact slightly poorer than collecting ones, although the difference is not statistically significant.

Comparison of collecting and non-collecting households in the top income quartile reveals remarkably similar differences. Although household size is essentially identical for the two groups, rich non-collecting households, too, have more educated heads, considerably higher holdings of land and farm capital—more than twice as high as collecting households—and somewhat higher livestock holdings as well. This again appears to give these households a comparative advantage in deriving income from household enterprise, public and private jobs, and agriculture, as opposed to resource collection and casual labor. Moreover, for rich non-collecting households, in contrast to their poor counterparts, these comparative advantages do translate into higher overall income. Rich non-collecting households are among the "richest of the rich," with average incomes of about Rs. 20,400, compared to Rs. 13,700 for collecting households. To put these figures in perspective (as well as for later reference in the concluding section), the poverty line for Madhya Pradesh in 1999–2000, as estimated by Deaton (2003), was just Rs. 3467.

This still leaves the puzzle of why resource dependence is *not* as bimodal for middle-income households. As shown in the bottom rows of Table 3, households in the second income quartile are on average somewhat less educated than households at the income extremes, and also somewhat larger. In light of our regression results of Table 6, this goes some way towards explaining why the probability of collection for these households is higher. It does not, however, explain why their conditional dependence on resources would at the same time be *lower*.

The key underlying factor appears to be specialization, or rather, for middle-income households, the lack thereof. This becomes clear from tabulations that break out, just as Table 4 does for resource collection, the percentage of households participating in each income-generating activity listed in Table 3, as well as the conditional dependence for only those households that participate. These tabulations indicate that the pattern evident from Table 4, namely that middle-income households are more likely than poor households to collect resources, but are less conditionally dependent on resource income, in fact holds for almost all income-generating activities.[25]

In other words, whereas poor households tend to specialize in just one or two income-generating activities, middle-income households tend do diversify—they derive relatively small fractions of their income from a wide array of activities. As for rich households, these again tend to specialize, but in a more specific set of activities. Over 30% of rich households report having public or private sector jobs, for example, and those that do derive on average over half of their income from those jobs.

The observed bimodality in resource dependence at the income extremes therefore appears to be not unique to resource collection, but rather just one instance of a broader pattern. Of course, this begs the question of why the broader pattern exists: why do middle-income households tend to diversify their income sources, while households at the income extremes specialize?

The most straightforward explanation, consistent with elementary risk theory, is that the converse is in fact the case. Households at the income extremes are not less likely to

[22] An auxiliary regression (not shown) of income on all other variables in Tables 6 and 7 yields an R^2 of 0.36.

[23] If buying and selling resources is unrestricted, and involves no large fixed costs, demand-side income effects should not matter to collection: rather than collecting more, richer households would simply buy more or sell less. The fact that no household in our sample sells construction wood, however, suggests that markets for this resource are less than perfect, in which case demand may well affect collection.

[24] Auxiliary regressions confirm that the probabilities of deriving income from either public-and private-sector jobs or household enterprise significantly increase in education, as do the conditional levels of income from these sources. The same is not true of income derived from casual in-or off-village labor.

[25] The partial exception is off-village casual labor, which middle-income households are both more likely to engage in and conditionally more dependent on.

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diversify; rather, households that diversify, i.e., choose to generate their income from a broad portfolio of activities, reduce the riskiness of their total income and are therefore less likely to end up at the income extremes. Consistent with this is the observation made above that middle-income households tend to be larger, and in particular have more adults, which presumably gives such households more scope for undertaking a variety of activities.

6.1. *Relationship with biomass availability*

A final observation concerns the effect of biomass availability on resource dependence. In the three panels of Fig. 1, the lower dashed lines show the relationships between income and respectively the probability of collection, conditional dependence, and unconditional dependence for the subsample of households with below-median biomass availability. The upper dashed lines show the same relationships for households with above-median biomass availability. Consistent with the regression analysis of Tables 6 and 7, higher levels of biomass induce an upward shift in all three relationships. Surprisingly, however, the shift is substantially larger at the income extremes than at intermediate income levels.

The foregoing discussion provides an explanation for this feature. If households that specialize in resource collection are more likely to end up at the income extremes, then households at the income extremes should be expected to benefit to a greater extent from higher levels of biomass availability. Note moreover that the observed association is likely to be at least in part causal. That is, higher biomass availability in the commons may well *induce* households to specialize in resource collection. This raises the intriguing policy question whether measures that improve biomass availability might, by inducing such specialization, indirectly increase income riskiness and thereby also income inequality.

Any careful investigation of this potential biomass-inequality link would require panel data and is therefore beyond the scope of this paper. A cursory investigation using our cross-section data reveals no evidence consistent with the link, however. To the contrary, when we compare income Gini coefficients across households with below-and above-median biomass availability, we find that inequality is somewhat *lower* for the latter ($G=0.36$ versus 0.44). If anything, then, specialization in resource collection appears to reduce income variability, perhaps by drawing households away from other, more risky specialized activities.

7. Conclusions

Previous studies of rural households in developing countries have tended to find that dependence on common-pool resources declines with income. Our study of households in Jhabua, India, examines the same issue using a different measure of dependence. We find that the dependence measure most commonly used in the literature, namely the share of resource income in total short-run or "current" income, can be misleading: it may indicate high levels of dependence for households that happen to have low current incomes in a given year, yet also have large asset holdings and therefore a large capability to buffer income shocks. Moreover, for households with negative current incomes the measure is ill-defined. Using instead the share of resource income in total long-run or "permanent" income as our dependence measure, we, too, find that dependence on all resources combined tends to decline with income. When we examine this trend more closely, however, we find a considerable degree of complexity.

First, we find that for the subsample of households that collect any resources at all, dependence does not decline, but exhibits a U-shaped relationship with income. That is, conditional dependence is higher for the poorest and richest households than for households with intermediate incomes.

Second, we find that the poorest and the richest households are at the same time least likely to collect any resources at all, indicating that resource dependence at the income extremes is bimodal—either zero or above average.

Third, we find that the observed trends for resources as a whole are not mirrored in those for individual resources. Dependence on fuelwood and dung declines with income, for example, while dependence on fodder and construction wood increases.

Fourth, when we more closely examine the bimodality of resource dependence at the income extremes, we find that non-collecting households tend to own more productive assets, including human capital. In the bottom income quartile, these assets are insufficient to lift these households out of poverty. In the top income quartile, however, non-collecting households tend to be the "richest of the rich," with average incomes far above the subsistence level in Madhya Pradesh.

Lastly, we find that in villages with higher biomass availability, resource dependence tends to be higher, and that in villages with JFM projects, households are more likely to collect fodder, fuelwood, and other resources, while also being more conditionally dependent on all resources combined.

These findings have potentially important policy implications. On the one hand, our finding of significant resource dependence at both income extremes implies that when biomass availability declines—whether because of degradation or restrictions on access—a large share of the rural population suffers losses. Not just poor households, but also rich households that collect have to make up for a significant share of their income from other sources.

On the other hand, our finding that dependence on some resources increases rather than declines with income, and that higher biomass availability induces all households to increase their collection of resources, indicate that resource collection is not necessarily a low-return activity. Far from being a form of "employment of last resort" that asset-rich households avoid, resource collection appears to be a productive source of income. In fact, it is only when asset holdings (including human capital) reach the very highest levels observed in our sample, permitting incomes from agriculture, household enterprise, and public- and private-sector jobs that are far above subsistence levels, that resource dependence becomes insignificant.

This then suggests, particularly in combination with our positive findings on the impact of JFM projects, that natural-

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resource-led development policies (recently advocated, e.g., by Pearce, 2005; WRI, 2005) may well be feasible in practice. In terms of the distinction drawn by Angelsen and Wunder (2003), such policies may do more than merely "alleviate" poverty, by keeping household incomes from dropping below subsistence. Rather, they may be able to "reduce" poverty, by lifting incomes *above* subsistence and thus allowing households to accumulate assets of their own.

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Appendix A

Permanent income from financial assets is calculated as follows. Given an interest rate of r%—we use 10% throughout the paper, which is slightly above the value-weighted mean interest rate of 9.3% on bank deposits and other types of savings reported by all households in the sample—and given financial assets worth A_t at the beginning of year t, the long-run average return that the household can expect from these assets is equal to rA_t per year. Given this formulation, one could estimate the household's permanent financial income as r times the value of total financial assets owned by the household at the beginning of the survey year. This, however, would not make use of information we have from the survey year on the actual return from financial assets in that year. In order to use this information, we instead calculate permanent financial income as

$$r\left[\frac{I_t}{1+r}-\frac{\Delta A_t}{1+r}+\frac{rA_{t+1}}{(1+r)^2}+\frac{rA_{t+1}}{(1+r)^3}+\ldots\right]=\frac{r}{1+r}(I_t+A_t).$$

where I_t is the actual return on the assets during the survey year; $\Delta A_t \equiv A_{t+1}-A_t$ is the net change in asset holdings between t and $t+1$; A_{t+1} is the value of the assets at the end of the year (i.e., at the beginning of the following year); and rA_{t+1} is the long-run return that the household can expect to obtain from these assets.

To calculate permanent income from physical assets—land, farm capital, and livestock—we have to take into account that these assets mostly produce income only when combined with labor. Expected income from these assets over the long-run is therefore the sum of the expected return to the capital itself and that to the household's own labor. That is, given an economy-wide interest rate r, physical assets worth K_t, an economy-wide wage rate w, and L_t units of own labor applied to the assets, the long-run flow of income that the households can expect from these assets is equal to rK_t+wL_t. Again taking into account actual returns in the current year as well as net changes in asset holdings during the year, the permanent income from physical assets is calculated as

$$r\left[\frac{I_t}{1+r}-\frac{\Delta K_t}{1+r}+\frac{rK_{t+1}+wL_t}{(1+r)^2}+\frac{rK_{t+1}+wL_t}{(1+r)^3}+\ldots\right]$$
$$=\frac{r}{1+r}\left(I_t+K_t+\frac{wL_t}{r}\right).$$

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