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By

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# **Wealth Accumulation and Activity Choice Evolution Among Amazonian Forest Peasant Households**

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## **Abstract**

This paper examines investment and livelihood decisions among forest peasant households in the Amazonian floodplain. A dynamic household model of multiple asset accumulation and activity choice under risk and credit constraints is developed by incorporating natural resource use and human capital evolution. Asset portfolios and sectoral incomes are estimated and then simulated to investigate the endowment and lifecycle dependency as well as the convergence/divergence of asset accumulation and corresponding activity choices. Physical asset endowment (especially land) and different human capital evolutions across activities help to explain forest peasants' livelihood choices, distinctive asset portfolios, and divergent income outcomes over the lifecycle.

JEL classification: Q12; O13; O16; O54; J24

Keywords: Asset accumulation; Livelihood choice; Resource extraction; Amazon

## **1. Introduction**

Economic activities of peasant households living in tropical rainforests (“forest peasant households”) include agriculture, fishing, aquatic extraction, hunting, timber and non-timber forest product gathering. The specific mix of such activities pursued by forest peasants tends to be quite heterogeneous across communities, within communities, and within households over time (Anderson and Ioris, 1992; Coomes, 1996; Godoy et al., 1995; Gunatilake et al., 1993; Padoch et al., 1999). Developing a basic understanding of this heterogeneity in forest peasant livelihood strategies is essential in the on-going effort to designing effective integrated conservation-development initiatives in valued rainforests around the world. In the absence of such understanding, policies and programs tend to be rather general in both focus and approach (i.e., “one-size fits all”), and lack firm grounding in the basic logic of household decision-making (Coomes and Barham, 1997). Using a unique data set gathered in 1996/97, this paper explores wealth accumulation and activity choice evolution among forest peasant households in Peru’s Pacaya-Samiria National Reserve (PSNR), one of the world’s richest zones of biodiversity and largest protected areas in the Amazonian floodplain.

Our major hypothesis is that wealth holdings strongly shape livelihood choices among forest peasant households and explain livelihood heterogeneity in rain forest environments. “Wealth” in our framework includes physical assets (i.e., land, productive and non-productive capital), non-physical assets (i.e., human and social capital), and natural capital (e.g., natural resource stock). In biodiverse tropical rain forests, natural capital undoubtedly contributes to observed activity variations across communities, but significant inter-household variations in activity mix appear to exist even among

households facing similar natural endowments (Coomes, 1996). Using the same PSNR data, we have shown elsewhere that differences in extant physical wealth holdings do help to explain livelihood heterogeneity among forest peasant households (Barham et al., 1999; Takasaki et al., 2001).

This *asset-dependency of activity choice* is an informative but rather obvious finding, especially to economists. A more critical question is how household asset portfolios evolve given differences in initial endowments, and whether there is evidence of *endowment-dependency of asset accumulation*. If so, households starting with relatively poor endowments may be constrained in their ability to select a mix of activities and to accumulate assets in a way that will allow convergence with richer households. Indeed, recent work by Zimmerman and Carter (1999) and Dercon (1998) find strong evidence of such constraints at work among African peasant households, respectively, in Burkina Faso, where only relatively asset-rich households accumulate high-risk, high-return land, and in Tanzania, where credit constraints restrict the ability of poorer households to make the lumpy investment into the high-risk, high-return activity of cattle raising. Should endowment dependency also be evident among Amazonian forest peasant households – where rich biodiversity gives rise to multiple activity options – then additional and perhaps more compelling evidence would be available to suggest the broad applicability of the concept of endowment dependency across a wide range of natural environments.

Because forest peasant households face a broad set of choices in terms of resource use activity and asset accumulation, the paper extends standard agricultural household models by adding extractive capital and resource extraction options into the

dynamic choice problems. Along the Amazon floodplain, the recent adoption of modern fishing equipment has enabled rural households to engage in more commercially oriented fishing (Goulding et al., 1996; McGrath et al., 1993), and fishing capital has become an alternative asset to land (Takasaki et al., 2001). Moreover, traditional skills and practices developed by indigenous forest peoples to extract highly valued resources are also important non-physical - or human capital - assets in Amazonia (e.g., Denevan and Padoch, 1987; Nepstad and Schwartzman, 1992; Redford and Padoch, 1992). This paper considers the role of such extractive skills by evaluating heterogeneous human capital evolution as shaped both by training and/or family experience in traditional resource extraction and by changes that occur over the lifecycle with shifts in the physical capabilities of household members.

Lifecycle effects are incorporated not only in the analysis of human capital evolution and the pursuit of extractive activities, but also with the other economic activities pursued by forest peasant households. Specifically, we treat Chayanovian concerns about how peasant households needs and capabilities may shift over time and thus affect their resource allocation decisions in agriculture and fishing. As such, the paper also attempts to address the extent to which activity choice and asset accumulation are also *lifecycle-dependent*, and whether this dependence affects the observed patterns of convergence or divergence in the evolution of asset portfolios and activity choices. Both endowment-dependency and lifecycle-dependency may help to explain differential reliance among households on certain types of critical natural resources.

The organization of this paper is as follows. Section 2 introduces the relationship between wealth and activity choice among Amazonian peasant households by comparing

current and initial asset holdings and relating them to current activity choice variations. Section 3 develops a stochastic dynamic programming model that formally captures the dynamics of multiple asset accumulation and activity choice. Section 4 presents the econometric models used to estimate the system of asset accumulation and sectoral income relationships whose results in turn allow us to examine asset, endowment, and lifecycle dependencies. Section 5 discusses the estimation results. Section 6 simulates asset and income evolution paths of initially “poor” and “rich” households to explore tendencies toward convergence or divergence over the lifecycle. Section 7 concludes.

## **2. Descriptive results of asset accumulation and activity choice**

The PSNR – situated in northeastern Peru – is a vast lowland region (more than two million hectares) dominated by inundated (swamp) forest with significant areas of seasonally flooded forest (Bayley et al., 1991; Rodríguez et al., 1995). Residents are primarily mestizo peasants (locally known as *ribereños*) who rely on floodplain agriculture, fishing, and aquatic and terrestrial extraction for their livelihood (Coomes et al., 1996; Takasaki et al., 2001). Forest peasants adapt to flood cycles by seasonally shifting resource use activities: generally, floodplain agriculture and fishing are productive during low water, whereas hunting and gathering become more productive during the high-water period when extractive access improves and agricultural options are limited. The primary source of information used in this paper is socio-economic survey data gathered from 300 forest peasant households in eight villages in the PSNR area in 1996/97.<sup>1</sup>

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<sup>1</sup> The eight villages were selected so as to capture the region’s diversity in economic activity and location. The sample was stratified to include most of the wealthy households, who were chosen on the basis of an initial Rapid Rural Appraisal that identified and ranked the wealth holdings of all households in the villages (Takasaki et al., 2000). Respondent attrition during the extended study period and incomplete responses to



As shown in Table 1, the mean household annual income for the sample is 4,223 Peruvian soles (about US\$1,624 in 1996/97). Agriculture and fishing are the two major activities, each with nearly 40% income share. The balance is accounted for by skilled and unskilled extractive activities.<sup>2</sup> Both subsistence crops (mainly manioc and plantain) and cash crops (rice, and to a lesser degree maize and cowpea) are cultivated. Fishing involves a wide variety of equipment, from very rudimentary nets and canoes to larger boats, engines, and various types of synthetic fishing nets. Skilled extraction entails the capture or gathering of aquatic and terrestrial resources using special skills, knowledge, and traditional equipment. Examples include *paiche* fishing<sup>3</sup>, aquarium fish gathering, and hunting (Coomes et al., 2001). Unskilled extraction involves aquatic and terrestrial resources, collected with relatively limited skills, knowledge, and equipment, such as shrimp, turtle and turtle eggs, palm hearts and fruit, and other non-timber forest products. Wage labor opportunities (included in Table 1 under unskilled extraction) are very limited, and mostly arise in the weeding and harvesting stages of agricultural production (especially in rice cropping). Almost all households in the study region practice agriculture and fishing for subsistence and/or cash earnings; fewer households engage in extractive activities, primarily for cash earnings. Unskilled extraction is considered to entail less risk than the agriculture, fishing or skilled extraction.

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retrospective questions by some respondents reduced the sample size to 211 households for which complete data are available.

<sup>2</sup> Takasaki et al. (2000) offer more detailed descriptive analyses on households' asset holdings and activity choice. Total income values are not fully comprehensive, because cash-earnings from livestock sales, shop sales, trading, informal market-credit contract, and capital rental, and some subsistence forest product gathering (e.g., firewood, medicinal plants) are not included in income calculations. That said, these additional income shares are likely to be much smaller than those of the productive activities covered here. Incomes of large productive capital owners may be overestimate because they do not include the transportation costs of product sales and extractive trips, and the provision and maintenance cost of fishing and hunting. Also, household incomes in one upland village may be somewhat underestimated because our survey scheme failed to include production levels from some fruit crops on upland agroforestry holdings.

Land and capital equipment – the main productive factors for agriculture and fishing, respectively – are expected to be key determinants of variations in activity choices across households (Takasaki et al., 2001). Land is held in usufruct (with no title), privately used, and transferred principally along kin lines. Land markets are absent; new land is obtained by clearing forests in this land-abundant environment.<sup>4</sup> Non-land assets consist of high-return, high-risk productive capital (mainly fishing capital), as well as low-return, low-risk non-productive capital, such as consumer durables, other houses, and livestock. These assets are privately owned and are typically purchased outside of the village.

Holdings of land and non-land assets can change significantly over the lifecycle of households, from initial endowments through to the current portfolio. Indeed, in this paper, we are particularly interested in how initial endowments shape households' investment decisions and wealth portfolios over time. Initial evidence of asset portfolio evolution is found in Table 1 which compares the 'average household' between two subsamples, one called the "initial land-poor—capital poor", and the other the "initial land-rich—capital rich". Initial holdings are defined as those held by the household after its first year in the current village.<sup>5</sup> A household's class assignment is based on whether its holdings are below or above the median for that wealth type. Examining asset accumulation only in the current village avoids any confusion caused by the impacts of

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<sup>3</sup> *Paiche* (*Arapaima gigas*) is a premium species caught using traditional fishing techniques as well as modern large-mesh fishing nets.

<sup>4</sup> This paper does not consider different land types and agricultural strategies but rather aggregated land holdings and agricultural activity in order to focus on broader asset portfolio issues (such as land versus non-land assets) and activity choice (agriculture versus fishing versus extraction).

<sup>5</sup> Initial asset holdings are constructed based on lifecycle history data. The current median value of each non-land asset item is used to construct monetary measures of initial non-land asset holdings. With no data on relative price of non-land asset items over time, we do not adjust values in different years.

changes in the endowments of local environments. Mean tests assess whether the subsample characteristics are similar to those of remaining observations in the sample.

The results in Table 1 should be viewed with two cautions in mind. First, Table 1 provides an *aggregated* picture of households from all eight villages where natural endowments differ markedly and household distributions across wealth classes are unbalanced. Second, households in the poor (rich) class are significantly younger (older) than the remaining households. Thus, different asset holding patterns may be explained by village factors and/or lifecycle effects, which we control for later in the econometric analysis.

As shown in Table 1, significant differences between wealth classes in current asset holdings coincide closely with differences in households' initial holdings, though the degree of inequality declines over the lifecycle, especially in non-land asset holdings. Initial endowments not only influence the level of current holdings and incomes but also appear to shape the composition of current asset portfolios. Note that the "poor" currently hold proportionally more productive capital among their non-land assets than do the "rich", and that the current asset portfolio of the "poor" is more productive-capital-oriented, whereas the portfolio of the "rich" is more land-oriented (Table 1). Such differences in asset composition are associated with differences in livelihood activity: the "poor" rely more on fishing and less on agriculture; the "rich" rely more on agriculture and less on fishing. Poorer households' greater reliance on productive capital and fishing may be a response to constraints they face in accumulating land; ready access to rich fishing areas may also offset their demand for land. Lastly, limited differences in labor

endowments between ‘rich’ and ‘poor’ households suggest that major activity variations are unlikely to be significantly explained by differential labor supply.

### **3. A model of asset accumulation and activity choice**

Following Dercon (1998), this section develops a dynamic model of asset accumulation and activity choice under risk and credit constraints. Households allocate labor to different activities and invest in a variety of assets. The model shows that under credit constraints, initial asset holdings determine subsequent asset accumulation, labor allocation, and income generation.

One distinctive feature of this model is our incorporation of multiple natural resource use options that are available to rain forest peasant households. Most natural resources in the PSNR are open access.<sup>6</sup> Production technologies of land clearing, fishing, and extraction involve extractive effort and resource stock as key production factors. Under an open access regime, no feedback of resource use decisions on stocks is considered by individual households (i.e., there is stock externality).

With a highly abundant resource stock, households naturally assume that the potential flow of services from resource stock is stationary over time; in a stochastic environment, households anticipate the expected flow of services based on information available at the current period. These conditions appear to predominate in the stochastic, biodiverse riverine environment of the PSNR. First, large-scale deforestation is not occurring, nor is it foreseen in this protected area with moderate population growth (i.e., land is still abundant regionally, and only about 1% of the PSNR is cleared for

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<sup>6</sup> Where communal labor is used for land clearing, as discussed below, forest land destined for agriculture should be considered as a common property resource. In our modeling, however, we treat forest land as an open access resource, because the communal labor group size in the community tends to be large enough

agricultural purposes). Second, in the Amazonian floodplain, fish are also abundant except for certain premium species (Bayley and Petrere, 1989). Third, stocks of fish, other aquatic species, and wildlife stocks are strongly affected by the stochastic flood regimes. Therefore, households are modeled as treating the potential flow of services from resource stocks as exogenous and stationary.

There are five activities to which labor can be allocated in each year  $t$ . The gross return of activity  $i$  is defined as  $p^i Y_t^i$  where  $p^i$  is exogenous output price and  $Y_t^i$  is a well-behaved production technology. The profit function of activity  $i$  is defined as  $F_t^i$ . Natural resource stocks do not appear in production functions for brevity. The model considers only yield risk, which can be incorporated in each risky production technology (i.e., agriculture, fishing, skilled extraction). Rental, insurance, credit, and land markets are absent though the model assumes the existence of a labor market for agriculture.

The first activity specified is agriculture. At the beginning of the agricultural season (i.e., the low-water period), households have two options; the first is to cultivate the same field as in the previous year, and the second is to clear open-access forest to add a field. Land clearing is done by communal work, which is assumed to be perfectly mutual in the same year; the household works for others just as much as the help they receive. Household labor allocation to land clearing,  $L_t^c$ , is thus equivalent to the total labor input for land clearing. The quantity and quality of land change over time under stochastic flood regimes. Land evolution is given by:

$$A_{t+1} = \phi_t(A_t + G_t(L_t^c)) \quad (1)$$

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for us to ignore strategic interaction among households. Put differently, the model treats forest land as an unregulated common property resource (Baland and Platteau, 1996).

where  $A_t$  is land available at the beginning of time  $t$ ,  $G_t(L_t^c)$  is a well-behaved forest clearing technology before cultivation in time  $t$ ,<sup>7</sup> and  $\varphi_t$  is a stochastic factor with mean 1 and constant variance during the high-water period after cultivation in time  $t$ . Fallow decisions are not modeled here for simplicity. Agricultural production technology is assumed to involve labor and land as the production factors. No purchased inputs, farming equipment, or animal plowing are used. In addition to own labor,  $L_t^a$ , labor can be hired in at fixed wage  $w$  per unit of labor, but hired labor,  $L_t^h$ , requires supervision time,  $M(L_t^h)$ , with  $M(0)=0$  and  $M'(L_t^h)>0$ . The agricultural profit function can thus be written as:

$$F_t^a = p^a Y_t^a(L_t^a + L_t^h, A_t + G_t(L_t^c)) - wL_t^h \quad (2)$$

The second risky activity is fishing. Fishing capital,  $K_t$ , accumulates by investments,  $I_t$ , at the end of time  $t$  which are purchased outside of the village. Investments are assumed to be perfectly sunk because of the prohibitively high transaction costs for resale in this remote environment: i.e.,

$$I_t \geq 0 \quad (3)$$

With depreciation at the rate of  $\delta^k$  ( $0 < \delta^k < 1$ ), the evolution of fishing capital follows:

$$K_{t+1} = (1 - \delta^k)K_t + I_t \quad (4)$$

Labor,  $L_t^f$ , and fishing capital,  $K_t$ , are assumed to be the production factors. A cost function,  $Q(K_t)$  with  $Q(0)=0$  and  $Q'(K_t)>0$  is assumed. Rather than modeling share or team fishing, we assume self-sufficiency of owned labor. We also abstract from capital rental, although such an extension is straightforward as suggested by Dercon (1998, p19, f27). Consequently, the net return for fishing is:

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<sup>7</sup> Barrett (1999) offers a model using a similar land clearing technology.

$$F_t^f = p^f Y_t^f(L_t^f, K_t) - Q(K_t) \quad (5)$$

Skilled extraction is the last risky activity. Specific extractive skills,  $H_t$ , are an important input in the skilled extraction technology in addition to labor,  $L_t^s$ . Skills available at the beginning of time  $t$  equals the sum of depreciated accumulated skills from the beginning of the previous period and any newly acquired skills during the previous period. Skill level depreciates at the rate of  $\delta^h$  ( $0 < \delta^h < 1$ ), if the household is not active in skilled extraction because of ever-changing environmental conditions. The household can acquire new skills or mitigate skill depreciation by learning-by-doing through participation in the activity.<sup>8</sup> Again, we assume a well-behaved skill acquisition function,  $D_t(L_t^s)$ , with  $D(0)=0$ ,  $D_t'(L_t^s) > 0$  and  $D_t''(L_t^s) < 0$ . Consequently, the evolution of extractive skill follows:

$$H_{t+1} = (1 - \delta^h)H_t + D_t(L_t^s) \quad (6)$$

and the profit function for skilled extraction is defined as:

$$F_t^s = p^s Y_t^s(L_t^s, H_t) \quad (7)$$

The fourth and fifth activities are unskilled extraction and agricultural wage labor, which are considered risk free, with low returns. Using labor,  $L_t^u$  and  $L_t^w$ , respectively, as the only production factor, the profit function of these two activities are given by:

$$F_t^u = p^u Y_t^u(L_t^u) \quad (8)$$

$$F_t^w = wL_t^w \quad (9)$$

Given fixed total available labor endowments,  $L$ , the labor time constraint and the usual non-negativity constraints on labor allocation are given by:

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<sup>8</sup> Another factor that shapes skill evolution is age of household members or household head, because the depreciation of skill holdings and the productivity of skill acquisition can vary over the lifecycle. Such lifecycle factors are not explicitly modeled here, but are explored in the econometric analysis. See

$$L \geq L_t^a + L_t^f + L_t^s + L_t^u + L_t^w + M(L_t^h) + L_t^c \quad (10)$$

$$L_t^i \geq 0 \quad (i = a, f, s, u, w, h, c) \quad (11a-g)$$

In addition to land and fishing capital, households own a variety of non-productive capital,  $Z_t$ , which we assume is to be held in non-negative amounts, yielding a low but constant return of  $r$ . This capital is assumed to be perfectly liquid, and thus serve both as a buffer against consumption shocks and as a temporary store of wealth for future investment. Non-productive capital can be accumulated (depleted) by saving (withdraw),  $R_t$ , at the end of time  $t$ . A credit constraint is thus given by:

$$R_t \geq -(1+r)Z_t \quad (12)$$

and non-productive capital evolution follows:

$$Z_{t+1} = (1+r)Z_t + R_t \quad (13)$$

Using (2), (5), (7), (8), (9) and defining  $C_t$  as consumption at time  $t$  and  $p_k$  and  $p_z$  as time-constant fishing equipment and saving unit prices, respectively, with consumer prices as the numeraire, the intertemporal budget constraint can be written as:

$$\begin{aligned} p^a Y_t^a (L_t^a + L_t^h A_t + G_t(L_t^c)) - w L_t^h + p^f Y_t^f (L_t^f, K_t) - Q(K_t) \\ + p^s Y_t^s (L_t^s, H_t) + p^u Y_t^u (L_t^u) + w L_t^w \geq C_t + p^k I_t + p^z R_t \end{aligned} \quad (14)$$

The household is assumed to solve the following stochastic dynamic programming problem subject to four state equations (1), (4), (6) and (13) and the intertemporal budget constraint (14), by choosing ten control variables, consumption, saving, capital investment, labor allocations to land clearings, agriculture, fishing, skilled extraction, unskilled extraction and wage labor, and hired labor:

$$\text{Max } u(C_t) + \beta \cdot V(A_{t+1}, K_{t+1}, H_{t+1}, Z_{t+1}) + \mu p^z (R_t + (1+r)Z_t) + \rho p^k I_t$$

---

Pattanayak and Sills (1999) for a similar conceptual argument on the learning-by-doing nature of human



$$\begin{aligned}
& + \eta_t(L - L_t^a - L_t^f - L_t^s - L_t^u - L_t^w - M(L_t^h) - L_t^c) \\
& + \phi_t^a L_t^a + \phi_t^f L_t^f + \phi_t^s L_t^s + \phi_t^u L_t^u + \phi_t^w L_t^w + \phi_t^h L_t^h + \phi_t^c L_t^c
\end{aligned} \tag{15}$$

where  $\beta$  is a discount factor;  $u(\cdot)$  is a well-behaved instantaneous utility function;  $V(\cdot)$  is a value function; and  $\mu_t$ ,  $\rho_t$ ,  $\eta_t$ , and  $\phi_t^i$ , where  $i = a, f, s, u, w, h, c$ , are Lagrangean multipliers for constraints, (12), (3), (10), and (11a-g), respectively. Labor has to be allocated before the earnings for the current year can be known, and actual consumption, saving, and productive capital investment will be determined after the uncertainty is resolved. It is further assumed that  $u'(C_t)$  becomes infinite if  $C_t$  approaches minimum consumption (Zeldes, 1989). Given an initial asset portfolio in the first year, a solution can be found by solving a standard stochastic dynamic program.<sup>9</sup>

The first order conditions define the optimal consumption-saving choice, portfolio choice between productive and non-productive capital, and labor allocations. These are not discussed here, as most of them are similar to those derived by Dercon (1998). One distinctive implication from this model is that a complete optimal asset portfolio choice is given by combining the optimal portfolio choice and labor allocation conditions. This arises because the marginal returns to land clearing and skilled extraction labor consist of not only the direct returns in the current year but also their contributions in the future years through land and skill accumulations. The model suggests that: (1) the household's asset holdings at the beginning of time  $t$ ,  $W_t = (A_t, K_t, Z_t, H_t)$ , are determined by initial asset holdings at time 0,  $W_0$ , labor endowments,  $L$ , duration of accumulation,  $t$ , and shock

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capital for extractive activities in the Amazon rain forest.

<sup>9</sup> With the continuity of the objective function, a closed and bounded feasible set is sufficient to guarantee the existence of a solution to the problem.

history,  $\{\varphi_t\}$ ; and (2) household resource allocations at time  $t$  are determined by the asset holdings at time  $t$ ,  $W_t$ , and labor endowments,  $L$ .

#### 4. An econometric model of asset portfolio and sectoral income estimation

By estimating regressions that predict current asset portfolios,  $W_t$ , and sectoral income outcomes,  $F_t=(F_t^a, F_t^f, F_t^s, F_t^u, F_t^w)$ , the following sections explore two empirical implications of the model – *endowment-dependency and lifecycle-dependency of asset accumulation* – while confirming a third – *asset-dependency of activity choice*. Given limited data on labor allocation, we cannot directly estimate labor allocation decisions, and redefine: (1) the asset set as  $W_t=(A_t, K_t, Z_t)$ , where extractive skills,  $H_t$ , are used only as exogenous explanatory variables, and (2) the income set as  $F_t=(F_t^a, F_t^f, F_t^s, F_t^u)$ , where  $F_t^u$  includes both unskilled extraction and wage labor income as in Table 1.

The theoretical model presented in Section 3 suggests an econometric model, with the following three sets of equations:

$$F_t^* = W_t \Gamma_t + X_t \beta_t + u_t \quad (16)$$

$$W_t = W_0 \Gamma_{t0} + X_{t0} \beta_{t0} + u_{t0} \quad (17)$$

$$W_0 = X_0 \beta_0 + u_0 \quad (18)$$

where  $F_t^*=(F_t^a, F_t^f, F_t^s, F_t^u)$  are  $N \times 4$  matrices, where  $F_t^i = F_t^i$  if  $F_t^i > 0$ ,  $= 0$  otherwise, where  $i = s, u$ , and  $N$  is the number of observations;  $W_t=(A_t, K_t, Z_t)$  and  $W_0=(A_0, K_0, Z_0)$  are  $N \times 3$  matrices of endogenous variables;  $X_t, X_{t0}$ , and  $X_0$ , respectively, are  $N \times J_t, N \times J_{t0}$ , and  $N \times J_0$  matrices of exogenous variables, where  $J_\tau$  is the number of exogenous variables for  $\tau = t, t0, 0$ ;  $\Gamma_t, \Gamma_{t0}, \beta_t, \beta_{t0}$ , and  $\beta_0$ , respectively, are  $3 \times 4, 3 \times 3, J_t \times 4, J_{t0} \times 3$ , and  $J_0 \times 3$  matrices of estimated coefficients;  $u_t, u_{t0}$ , and  $u_0$ , respectively, are  $N \times 4, N \times 3$ , and  $N \times 3$  matrices of estimated coefficients.

matrices of error terms; and notations of each asset and income variable follow the theoretical model above.

A censored regression specification is necessary for the skilled and unskilled extraction income regressions, because many households do not participate in these activities. Assuming the normal distribution of the 3rd and 4th columns of matrix  $u_t$ , we employ a standard Tobit model. The normality test for Tobit proposed by Pagan and Vella (P-V) (1989) is conducted to examine the validity of the distributional assumption.<sup>10</sup> Normality is crucial for the Tobit model, because if the underlying error structure is not normally distributed, the usual Tobit estimator is not consistent.

The first set of equations (16) estimates sectoral income at time  $t$  using asset holdings at the beginning of time  $t$  as an endogenous variable, which are estimated in the second set of equations (17), using asset holdings at time  $0$  as endogenous variables. The third set of equations (18) estimates asset holdings at time  $0$ . The endogenous variables and error terms in equation (16) and (17) may be correlated, because income generation and asset accumulation outcomes can both depend on the same unobservable cross-sectional factors, such as farming skills, ability, and location (field)-specific micro conditions. If either (or both) of these endogeneities exist, single-equation Least Squares (LS) and Tobit estimates of (16) and single-equation LS estimates of (17) will not be consistent; consequently, we must estimate simultaneous linear and Tobit equations, (16) and (17), simultaneous linear equations, (17) and (18), or simultaneous equations of (16)-(18). Smith and Blundell (S-B) (1986) provide an asymptotically efficient test for

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<sup>10</sup> The P-V normality test tests the null-hypothesis that the third and fourth moments of error terms are 0 and  $3\sigma^2$ , where  $\sigma^2$  is a variance of error terms.

exogeneity for this type of Tobit simultaneous equations, and an exogeneity test for the simultaneous linear equations is provided by Wu (1973).

A third specification issue in the regressions is that of heteroskedasticity. We conduct two Lagrange multiplier tests to examine heteroskedasticity assuming multiplicative forms: a standard Breusch-Pagan (B-P) test and its Tobit-version (Greene, 1993, pp698-700). Heteroskedasticity in the Tobit model is especially problematic because, if present, the standard Tobit estimator is not consistent.

The choice of exogenous variables follows the theoretical model closely. In all regressions, eight village dummy variables are included as intercept shifters to capture across-village variations. For the asset portfolio regressions, the exogenous variables include initial extractive skills, current labor supply, duration of accumulation, and shock factors. Initial extractive skills are captured using one proxy variable defined as the average of original and current extractive skills (discussed below in notes 12 and 14). Current labor supply includes the number of male and female adults in the household. Kinship group size is also included to capture the potential for communal labor access for land clearing (Coomes and Burt, 1997). Duration of accumulation is the number of years that the household has resided in the current village, and is essentially a lifecycle measure. Flood shock factors are captured by two dummies for prior experience with river bank slumping and high floods. A dummy variable for former credit receipts (mainly through Agrarian Bank which was liquidated in 1992) is included. The square of the lifecycle age and its linear interaction terms with each initial asset are also included.

Exogenous variables for the initial asset estimation (18) are chosen treating time  $t$  as the current period and some previous (or original) time  $t_0$  as the initial period in the

theoretical model.<sup>11</sup> B-P heteroskedasticity tests are conducted by estimating the log of variances with initial holdings of the same asset, duration in the current village, and selected village dummy variable as explanatory variables.<sup>12</sup>

Exogenous variables for sectoral income estimation (16) consist of current extractive skills and current labor supply. The current extractive skills are captured by a dummy variable that represents whether skilled extraction has been a major activity of household head over his/her lifecycle.<sup>13</sup> Labor supply variables are the same as those in the asset portfolio regressions, with the addition of the current age of household head to capture broad lifecycle effects on income generation. The square of each of the three asset variables, labor supply variables, and lifecycle age variable are also included. Finally, village interaction terms with productive capital and its square are included for the fishing income regression to capture the distinctive fishing practices in one fishing-oriented village. Heteroskedasticity tests are conducted by estimating the log of variances with the main productive factors and selected village dummy variables as explanatory variables.

## **5. Asset portfolio and sectoral income estimation results**

The results of the Wu exogeneity test and B-P heteroskedasticity test of current asset portfolio regressions, or equations (17), are reported in Table 2. The exogeneity tests show no signs of endogeneity with respect to each of three initial assets for each of

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<sup>11</sup> Original extractive skills are captured using a dummy variable that represents whether skilled extraction was a major activity of the parents of the household head when he (or she) was living with them.

<sup>12</sup> We use the dummy for Village 2 for the productive capital regression. Use of large fishing nets based on work sharing is much more common in this village than in the other seven villages.

<sup>13</sup> Given limited data on historical activity, this variable considers only two major skilled extraction activities: paiche fishing and hunting. This variable takes the value of .5 and 1, respectively, if either paiche fishing or hunting and both paiche fishing and hunting have been a major activity of household head over his/her lifecycle. Original skills defined above also capture these two skilled extraction activities. It

the three regressions. B-P tests strongly reject the null-hypothesis of homoskedasticity for all three regressions. All estimated coefficients of explanatory variables for the heteroskedastic form have expected positive signs and are statistically significant. Generalized least square (GLS) specification assuming multiplicative heteroskedasticity and no endogeneity with initial assets is judged to be acceptable.

Table 2 shows the GLS estimation results. Initial land and non-productive capital holdings have a positive and statistically significant effect on the current holdings of the same assets, while initial productive capital holdings are positive but not significant. There exist very limited significant cross-asset relationships between initial and current holdings. Duration of the household in the current village has statistically significant concave relationships with all three current assets. That is, asset accumulation paths are consistent with the Chayanovian notion of lifecycle stages found in other studies of peasant land accumulation (e.g., Barham et al., 1995). These econometric results suggest that initial endowment and lifecycle factors shape the evolution of asset portfolios.

Table 3 reports the results of P-V normality test, Wu and S-B exogeneity tests, and heteroskedasticity tests of current sectoral income regressions, or equations (16). The P-V normality tests for skilled and unskilled extractions failed to reject the normality of the error terms. The results of exogeneity tests show no signs of endogeneity with respect to each of three current assets for each of four regressions. Heteroskedasticity tests reject the null-hypothesis of homoskedasticity for all four regressions. All estimated coefficients of explanatory variables for the heteroskedastic form have expected signs

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should be emphasized that the current extractive skills as well as the original skills are constructed based on lifecycle history data instead of current production data to avoid obvious endogeneity problems.

and most are statistically significant. Thus, GLS or Tobit specification assuming multiplicative heteroskedasticity and no endogeneity with current assets are employed.

Table 3 shows the GLS and Tobit estimation results. Current land holdings have a positive and statistically significant effect on agricultural income, and productive capital holdings have positive and statistically significant effects with decreasing marginal productivity on fishing and skilled extraction income. These results strongly confirm the expected asset-activity dependency relationship portrayed earlier in Table 1. Land has a convex relationship with respect to unskilled extraction income, with the minimum attained at about 8 ha. In general, as households accumulate land, they come to rely less on low-risk activities, but some larger land holders also pursue these activities.<sup>14</sup>

All skill coefficient estimates are positive and have relatively large magnitudes – the estimate for skilled extraction income is strongly significant. These estimates not only confirm that extractive skills are a key production factor in skilled extraction, but also that extractive skills may be correlated with skills for other activities which were not formally modeled. In other words, this skill variable may be a proxy for a larger base of productive local environmental knowledge and skills.

Lifecycle coefficient estimates are consistently concave with the estimate for skilled extraction income being significant. The three non-agricultural income sources peak early in the lifecycle (late 30s), whereas agricultural income is strictly increasing over the lifecycle. The early peaks of skilled and unskilled extraction income suggest that young households allocate more labor to extraction as a transitory strategy for income generation, and that older households are less likely to rely on these activities

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<sup>14</sup> Indeed, Coomes et al. (1999) reveal that a few larger, older, and wealthier households are among the leading extractors of certain (low-skill) non-timber forest products and discuss the underlying logic.

because of skill depreciation and/or improved opportunities in other activities. These findings may portray a stark contrast in the evolution of skill between agriculture and non-agricultural activities, and suggest that even young households that are fishing-oriented come to rely more on agriculture later in life.

## **6. Simulated evolution paths of asset portfolio and sectoral income**

This section uses the parameter estimates and the mean value of explanatory variables in Section 5 to simulate the asset accumulation and activity mix paths over the lifecycle for two hypothetical households, one “poor” and the other “rich” in initial endowments. Specifically, the evolution of predicted asset holdings of land, productive capital, and non-productive capital are generated first by using the regression parameters (Table 2) and the mean initial endowment holdings of land-poor—capital-poor and land-rich—capital rich households (Table 1). By then changing the duration variable and the corresponding household head’s age, using the mean duration in the current village and current household head’s age of the “poor” and “rich” (Table 1), we simulate the path of asset holdings over time. Incomes from agriculture, fishing, and both skilled and unskilled extractions are then generated using the predicted asset holdings in each period, the corresponding head of household’s age, and the regression parameters from Table 3.<sup>15</sup> These lifecycle paths provide further evidence on the extent of endowment and lifecycle dependence as well as a means for examining whether convergence or divergence is occurring in the mix and levels of assets and incomes across different households.

Figures 1 and 2 clearly demonstrate the distinctive role of initial endowments across assets over the lifecycle. Although initial holdings of productive capital are more



equal between the two groups than those of land and non-productive capital, relative inequality of productive capital significantly increases with the age of the household head whereas inequality of land and non-productive capital gradually decline. For example, initially (i.e., at age 31), the ratio of the holdings of productive capital by the “rich” versus the “poor” households is 1.1, but by age 55, this same ratio is 1.9. By contrast, similar ratios of land and non-productive capital holdings decline from 2.7 and 3.9, respectively, to 2.5 and 3.2. These findings are consistent with the different degree of endowment-dependency across assets mentioned above. Such findings also reflect differential risk-return calculations by households over investment decisions such that “rich” households are more likely to hold more risk-filled wealth portfolios.

For both types of households, the paths of agricultural income evolution are increasingly concave in form and correspond closely to the paths of land evolution, thus supporting the asset-dependency proposition. In contrast, the paths of fishing income evolution follow surprisingly similar trajectories (flat) despite the distinct productive capital accumulation paths. “Rich” households, it seems, tend to accumulate transportation capital (e.g., boats and engines to transport their agricultural produce) rather than that for fishing as they accumulate land and expand agricultural production (Takasaki et al., 2001). Skilled extraction incomes follow similar concave paths, with the maximum attained in the early 40s, followed by a dropping off to low levels (relative to other income sources) later in life. Finally, the paths of unskilled extraction income are almost flat over the entire lifecycle, suggesting the persistent role of this low-risk activity over the lifecycle. Overall, both “rich” and “poor” households take part more actively in

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<sup>15</sup> All other explanatory variables besides initial asset holdings, duration in the current village, and age of household head are assumed the same between the two groups, which allows us to focus exclusively on the

extractive activities when they are young. The predicted activity shift from extraction to agriculture appears to be caused by a transition from human to physical capital in the household asset portfolio corresponding to the lifecycle-dependency of asset accumulation.

In absolute terms, divergence is clearly evident in the physical wealth holdings of “poor” and “rich” households, with the land holding gap growing from about 2.5 to 3.7 hectares and the non-land asset gap increasing by a much greater proportion. Some evidence is found, however, of convergence in the mix of asset holdings as both households accumulate non-land assets more proportionally than they do land. Thus, early in the lifecycle, the asset portfolio of the “poor” household is relatively less land-oriented, but it becomes as much land-oriented as that of the “rich” household later in the lifecycle (for example, the ratio of the non-land holdings versus the land holdings at age 55 is 5.5 and 5.3, respectively, for the “poor” and “rich”). Together, these observations suggest the presence of natural constraints on land accumulation.

Absolute divergence in asset holdings is also reflected in a rising income gap over the household lifecycle. Initially, total incomes are relatively similar, with the “rich” earning about 16% more (at age 31). Overtime, the absolute incomes of both households rise, though by age 55, the “rich” earn about 25% more than the “poor” due to stronger growth among “rich” households in agricultural income. In terms of activity mix, divergence occurs initially, as “poor” households rely more on fishing. Over time, both types of households move toward an increased reliance on agriculture and a declining reliance on other activities. Activity choice shifts from fishing to mixed for the “poor”

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effects of endowments and lifecycle on wealth and activity choices.

and from mixed to agriculture for the “rich”, so that over the lifecycle there is no clear sign of convergence or divergence in activity mix between the two groups.

## **7. Conclusions**

In a wide variety of contexts, development economists have attempted to better understand the extent to which asset accumulation is endowment dependent. At the core of these explorations is an underlying concern whether poorer households can “catch-up” by moving toward a more optimal mix of activities and returns, and/or by closing the income and wealth gap with respect to richer households. This paper connects these development issues with natural resource use concerns, and examines them in a distinctive context – that of lowland Amazonia – where high environmental heterogeneity and rich biological diversity provide forest peasant households with a broad suite of livelihood activity options (i.e., agriculture, fishing, skilled and unskilled extractions) under highly stochastic biophysical conditions. A unique data set was employed on wealth accumulation and life history gathered from forest peasant households who reside in one of Latin America’s most important protected areas, the Pacaya-Samiria National Reserve in Peru.

The core findings of this paper are that: (1) agriculture, fishing, and skilled extraction are physical-asset dependent, and skilled extraction is also human-capital dependent; (2) land and non-productive capital accumulation are endowment-dependent though the accumulation of productive capital is not particularly endowment-dependent; (3) non-agricultural activities such as resource extraction (and probably related skills) peak earlier than agriculture and thus household activity choice shifts toward agriculture over the lifecycle; (4) in relative terms, convergence occurs during later years in the asset

portfolio of “poor” and “rich” households, but absolute divergence appears to arise in asset holdings and income; and, (5) the strong endowment-dependence of land accumulation and agricultural earnings probably underlie the tendencies toward divergence revealed by our analyses.

Basically, initially “poor” households cannot pursue the mix of activities that would be optimal because of constraints posed by their limited land endowments. Fishing and extraction offer reasonable alternatives in the earlier years of the family lifecycle, and allow them to achieve income levels that are fairly similar to “rich” households. Indeed, access to resource rich locales may limit their initial need for land. But over time, the gap in terms of both income and asset outcomes grows, because declining human capital for non-agricultural activities forces “poor” households to explore agricultural opportunities which are constrained by their limited land endowments and by relatively modest accumulation of land in the earlier years. This *endowment-dependency* of physical asset accumulation is consistent with the work of others (e.g., Dercon, 1998; Zimmerman and Carter, 1999), but it is more conclusively shown here by incorporating the *lifecycle-dependency* of human capital accumulation, based in part on retrospective data on initial conditions, and the modeling and econometric frameworks deployed. Given that the range of available resource-based economic options is considerably greater in this environment, endowment-dependency results such as those presented here are even more compelling in terms of their potential applicability in other locales.

Our paper also makes several methodological contributions that may assist researchers interested in modeling the accumulation of multiple assets and associated

activity choices in rural developing areas. First, our model incorporates a simple version of stochastic land evolution under flood regimes, which gives explicit treatment to the household decision to clear forest as a labor investment in land. This approach promises to contribute to improving extant models of traditional agricultural decisions. Second, a dynamic stochastic framework of multiple asset accumulation is developed, which then provides a bridge between peasant household theory and econometric modeling of resource use decisions, both in terms of variable choice and the system of equations that are estimated. Third, the econometric specification is formally tested with respect to endogeneity, heteroskedasticity, and normality. Such testing is important not only because it helps to ensure the consistency of the estimates derived here, but also because although researchers working on rural development are increasingly employing Tobit models for their empirical analysis, relatively few tend to undertake formal examination of the specifications. The recent development of a variety of specification tests for Tobit models make such omissions less excusable. Finally, the simulated asset and income evolution paths presented in this paper offer revealing portrayals of the factors underlying distinctive patterns of natural resource use behavior by forest peasant households. Further refinements of the stochastic dynamic programming framework along with additional econometric work to estimate key parameters should allow us to examine a wide range of conservation and development initiatives for their potential efficacy in shaping resource use decisions by peasant households in areas of rich biodiversity.

**Table 1**

Household asset holdings, labor supply, and sectoral incomes for the initial wealth endowments

	All		Initial land-poor Capital-poor		Initial land-rich Capital-rich	
	Mean	Std dev	Mean	t statistic	Mean	t statistic
<i>Initial asset holdings</i>						
Land (ha)	2.4 (2.8)		0.6	-10 ***	4.8	6.6 ***
Productive capital (S/.)	457 (1088)		47	-5.6 ***	823	2.8 ***
Non-productive capital (S/.)	436 (1531)		33	-3.9 ***	1139	2.8 ***
<i>Current asset holdings</i>						
Land (ha)	3.4 (3.9)		1.2	-7.5 ***	6.5	7.2 ***
Productive capital (S/.)	786 (1395)		510	-2.4 **	1110	2.4 **
Non-productive capital (S/.)	723 (1886)		241	-3.7 ***	1307	2.4 **
<i>Labor supply</i>						
No. male adults	1.9 (1.2)		1.8	-1.5	2.1	0.8
No. female adults	1.7 (1.2)		1.5	-1.7 *	1.7	0.4
Duration in the current village (year)	16 (13)		13	-2.7 ***	19	1.9 *
Age of household head (year)	44 (14)		39	-3.6 ***	50	4.3 ***
<i>Income (S/.)</i>						
Agriculture	1677 (1955)		949	-4.8 ***	3118	5.4 ***
Fishing	1642 (2203)		2071	1.6	1058	-3.1 ***
Skilled extraction	490 (1053)		416	-0.7	610	0.9
Unskilled extraction	415 (687)		382	-0.5	490	0.9
Total income	4223 (2847)		3817	-1.3	5277	3.4 ***
No. observations	211		62		59	

Note - Mean tests examine the null hypothesis that the mean of each sub-sample is the same as the remaining observations in the sample. US\$1=S/.2.6.

\*: significant at 10%; \*\*: significant at 5%; \*\*\*: significant at 1%.

Table 2

Current household asset portfolios

	E(x)	Land (ha) GLS		Productive capital (100S/.) GLS		Non-productive capital (100S/.) GLS
Initial land (ha)	2.4	0.60 (0.13)	***	0.50 (0.32)		0.15 (0.62)
Initial land * Duration in the current village	42	0.0075 (0.01)		0.0021 (0.03)		0.0196 (0.04)
Initial productive capital (100S/.)	4.6	0.03 (0.02)		0.20 (0.14)		-0.07 (0.17)
Initial productive capital * Duration in the current village	76	-0.0010 (0.00)		-0.0012 (0.01)		0.0038 (0.01)
Initial non-productive capital (100S/.)	4.4	0.03 (0.02)		-0.10 (0.08)		0.84 (0.36) **
Initial non-productive capital * Duration in the current village	72	0.00001 (0.002)		0.0121 (0.01)	**	0.0013 (0.02)
Initial extractive skills (0, .25, .5, .75, 1=high)	0.09	-0.47 (0.90)		0.39 (2.87)		0.23 (5.06)
No. male adults	1.9	0.23 (0.20)		1.23 (0.62)	**	0.91 (1.08)
No. female adults	1.7	-0.25 (0.19)		0.08 (0.60)		0.57 (1.04)
Kinship group size (household)	7.8	0.00 (0.04)		-0.01 (0.11)		-0.15 (0.21)
Credit receipt experience (0=no, 1=yes)	0.46	0.40 (0.44)		1.38 (1.45)		-1.28 (2.50)
River bank slump experience (0=no, 1=yes)	0.19	0.56 (0.56)		-0.63 (1.78)		-3.42 (3.10)
High flood experience (0=no, 1=yes)	0.55	0.97 (0.39)	**	-0.01 (1.29)		1.09 (2.20)
Duration in the current village (year)	16	0.12 (0.06)	**	0.44 (0.19)	**	0.66 (0.34) *
Duration in the current village <sup>2</sup>	433	-0.003 (0.001)	*	-0.010 (0.004)	**	-0.015 (0.01) **
Village dummy 1	0.09	-1.14 (0.70)		-2.79 (2.19)		-2.79 (3.92)
Village dummy 2	0.07	-1.19 (0.58)	**	7.50 (9.7)		-1.74 (3.52)
Village dummy 3	0.11	0.05 (0.66)		-1.96 (2.02)		-3.13 (3.65)
Village dummy 4	0.26	0.75 (0.62)		-2.80 (1.98)		-0.94 (3.54)
Village dummy 5	0.25	-1.10 (0.58)	*	1.57 (1.88)		-1.01 (3.45)
Village dummy 6	0.09	-0.07 (0.69)		-3.79 (2.25)	*	-5.43 (4.05)
Village dummy 7	0.05	-0.67 (0.77)		1.16 (2.61)		-0.59 (4.47)
Village dummy 8	0.09	0.79 (0.68)		-2.03 (2.05)		-3.16 (3.75)
<i>Wu exogeneity test</i> ( $F_{(2,186)}$ )						
Initial land (ha)		1.20		0.27		0.89
Initial productive capital (100S/.)		1.20		0.22		1.07
Initial non-productive capital (100S/.)		2.19		0.03		0.52
<i>B-P heteroskedasticity test</i> ( $\chi^2_{(2)}$ , $\chi^2_{(3)}$ , $\chi^2_{(2)}$ )		36 ***		532 ***		143 ***
<i>Heteroskedastic form</i>						
Constant		-0.67 (0.25)	***	1.28 (0.27)	***	1.53 (0.27) ***
Initial land (ha)		0.10 (0.05)	**			
Initial productive capital (100S/.)				0.04 (0.01)	**	
Initial non-productive capital (100S/.)						0.05 (0.01) ***
Duration in the current village (year)		0.05 (0.01)	***	0.05 (0.01)	***	0.04 (0.01) ***
Village dummy 2				3.72 (0.62)	***	

Note - Asymptotic standard errors are in parentheses. \*: significant at 10%; \*\*: significant at 5%; \*\*\*: significant at 1%.

**Table 3**

Current household sectoral incomes

	E(x)	Agriculture GLS		Fishing GLS		Skilled extraction Hetero. Tobit		Unskilled extraction Slope Hetero. Tobit		Slope
Land (ha)	3.4	253 (90.6)	***	0.005 (35.8)		167 (104)		43	-98 (34.8)	*** -70
Land <sup>2</sup> (ha <sup>2</sup> )	27	-8.4 (8.74)		0.62 (2.25)		-10 (7.10)		-2.6	6.0 (2.18)	*** 4.3
Productive capital (100S/.)	7.9	9.2 (13.3)		50 (18.1)	***	115 (49.0)	**	30	8.7 (7.34)	6.3
Productive capital <sup>2</sup> (10 <sup>4</sup> S/.)	256	-0.074 (0.09)		-1.3 (0.49)	***	-2.6 (1.52)	*	-0.68	-0.06 (0.05)	-0.05
Productive capital * Village dummy 2	1.5			69 (104)						
Productive capital <sup>2</sup> * Village dummy 2	139			0.80 (0.83)						
Non-productive capital (100S/.)	7.2	14 (19.1)		-1.6 (9.1)		-45 (24.8)	*	-11.6	12.36 (8.37)	8.9
Non-productive capital <sup>2</sup> (10 <sup>4</sup> S/.)	406	-0.17 (0.16)		0.00004 (0.07)		0.19 (0.18)		0.05	-0.082 (0.06)	-0.06
Current extractive skills (0,.5,1=high)	0.07	777 (424)	*	210 (270)		2468 (466)	***	639	384 (249)	277
No. male adults	1.9	254 (292)		131 (170)		444 (548)		115	-61 (163)	-44
No. male adults <sup>2</sup>	5.2	-64 (53.5)		-10.3 (30.4)		-139 (112)		-36	8.5 (31.0)	6.2
No. female adults	1.7	68 (181)		129 (138)		-358 (335)		-93	107 (110)	77
No. female adults <sup>2</sup>	4.3	14.4 (26.5)		-11 (21.9)		47.1 (50.9)		12.2	-19 (16.8)	-14
Kinship group size (household)	7.8	-51 (15.5)	***	8.3 (12.5)		-48.9 (29.4)	*	-12.6	6.1 (9.19)	4.4
Age of household head (year)	44	53 (38.0)		21 (25.6)		188 (77.1)	**	49	21 (22.5)	15
Age of household head <sup>2</sup>	2122	-0.40 (0.41)		-0.27 (0.27)		-2.4 (0.86)	***	-0.63	-0.28 (0.24)	-0.20
Village dummy 1	0.09	-408 (806)		-257 (575)		-4427 (1608)	***	-1146	941 (522)	* 679
Village dummy 2	0.07	-1229 (768)		3228 (1502)	**	-4052 (1617)	**	-1049	-430 (463)	-310
Village dummy 3	0.11	-51 (795)		-243 (566)		-4659 (1670)	***	-1206	71 (478)	51
Village dummy 4	0.26	-991 (793)		-91 (572)		-3989 (1571)	**	-1032	19 (479)	14
Village dummy 5	0.25	-615 (801)		2084 (633)	***	-4218 (1595)	***	-1092	-216 (483)	-156
Village dummy 6	0.09	-611 (832)		-473 (590)		-1784 (1633)		-462	-179 (495)	-129
Village dummy 7	0.05	-561 (803)		-276 (559)		-1801 (1589)		-466	-201 (468)	-145
Village dummy 8	0.09	246 (1038)		-444 (560)		-3505 (1629)	**	-907	-235 (484)	-169



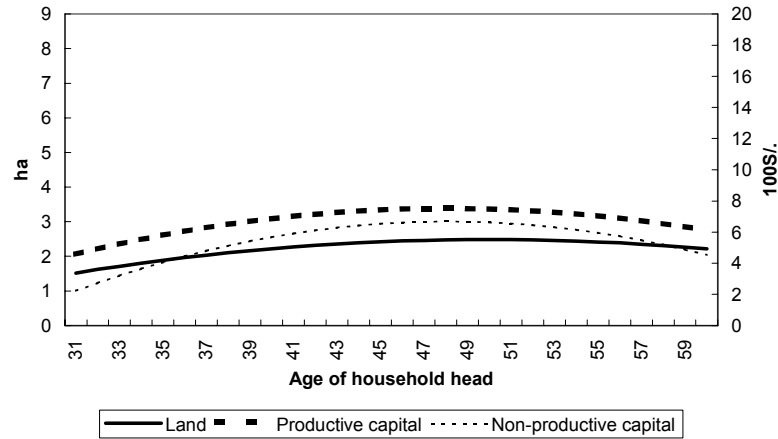
(continued)

<i>P-V normality test</i> ( $t_{(185)}$ )									
Skewness					0.10			0.63	
Kurtosis					0.07			0.49	
<i>Wu exogeneity test</i> ( $F_{(2,187)}$ )									
Land (ha)	0.09		0.22						
Productive capital (100S/.)	0.003		0.53						
Non-productive capital (100S/.)	1.20		0.03						
<i>S-B exogeneity test</i> ( $t_{(185)}$ )									
Land (ha)					0.45			0.10	
Productive capital (100S/.)					0.30			0.97	
Non-productive capital (100S/.)					0.42			-0.22	
<i>B-P heteroskedasticity test</i> ( $\chi^2_{(2)}$ , $\chi^2_{(3)}$ )	125 ***		247 ***						
<i>Tobit heteroskedasticity test</i> ( $\chi^2_{(2)}$ )					5.4 *			14.3 ***	
<i>Heteroskedastic form</i>									
Constant	11.87 (0.22) ***		11.38 (0.21) ***		14.61 (65.0) ***	3.78	12.39 (0.26) ***		8.94
Land (ha)	0.19 (0.04) ***								
Productive capital (100S/.)			0.001 (0.01)						
Current extractive skills (0,.5,1=high)					-2.36 (2.66) ***	-0.61			
No. male adults							0.15 (0.12)		0.109
Village dummy 1							1.21 (0.38) ***		0.873
Village dummy 2			3.93 (0.65) ***						
Village dummy 5			2.36 (0.38) ***						
Village dummy 6					0.30 (0.69)		0.078		
Village dummy 8	1.84 (0.59) ***								

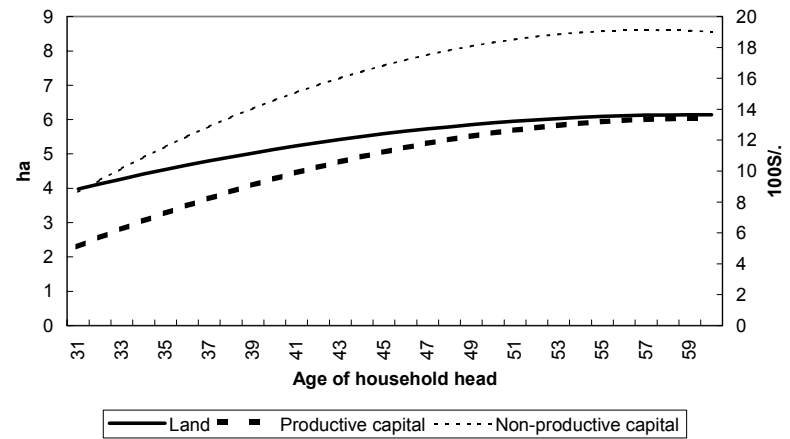
Note - Asymptotic standard errors are in parentheses. \*: significant at 10%; \*\*: significant at 5%; \*\*\*: significant at 1%.

Slopes (or marginal effects) are computed using mean value of all explanatory variables.

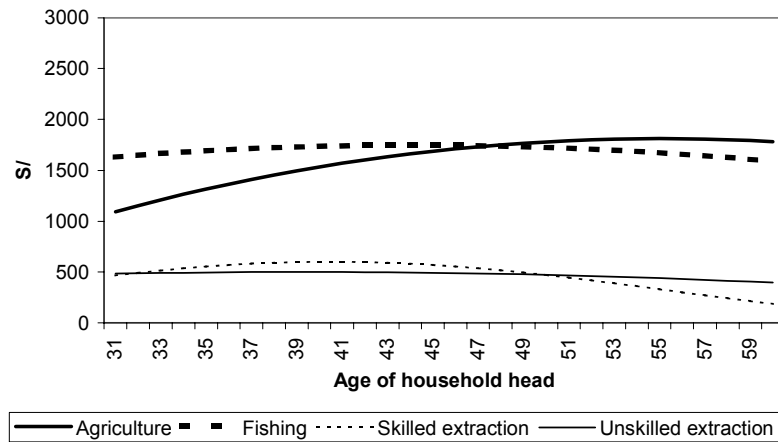
**Figure 1a. Asset evolution paths of  
Initial land-poor--capital-poor**



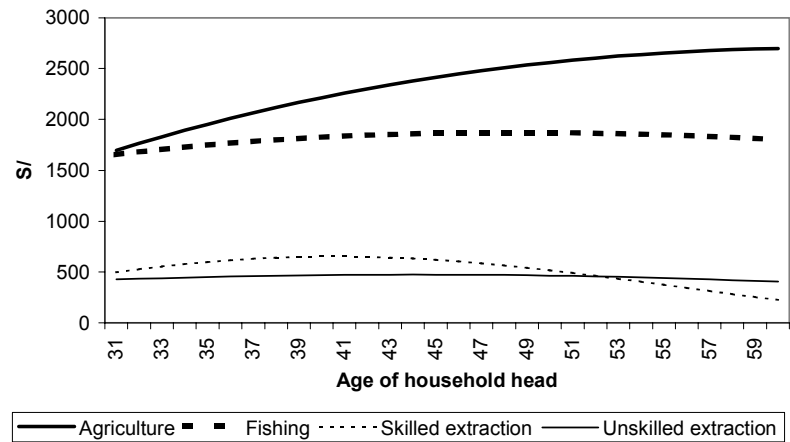
**Figure 2a. Asset evolution paths of  
Initial land-rich--capital-rich**



**Figure 1b. Income evolution paths of  
Initial land-poor--capital-poor**



**Figure 2b. Income evolution paths of  
Initial land-rich--capital-rich**



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