The economics of fire prevention for traditional households in the Tapajós National Forest in the state of Pará, Brazil

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October 6th, 2006

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****Woods Hole Research Center**

Additional funding provided by the Instituto de Pesquisa Ambiental da Amazônia

1. **Introduction:** Subsistence households and the economic approach to examining household decision-making
2. **Model**: How economic theory about household decision-making provides us with a theoretical model to analyze survey data
3. **Sample area:** Sample characteristics and an orientation to the FLONA Tapajós
4. **Results:** Regression estimation results of the decision to engage in fire prevention (aceiros) and the scale of burning and fire prevention activities
5. **What drives our models:** A look at the relative roles of economic variables *vs.* household characteristics in household decisions
6. **Conclusions**

Household decision-making with respect to fire.

- Fire is an important land management tool for small landowners
- When not properly managed, fire presents a significant risk to the ecosystem and to the smallholders themselves
- Small landowners do, however, take certain precautions….
- What are the driving factors for household behavior with respect to burning and fire prevention?

Economic tradeoffs for the traditional household.

- **Time/labor in fire prevention *vs.* time/labor in agricultural production or other activities**
- **Maximizing burn efficiency by burning during driest points *vs.* minimizing risk of accidental fire by waiting**
- **Increased agricultural productivity from fire *vs.* potential effect on forest production (both timber/non-timber)**
- **Is it economically viable for traditional households to invest in fire prevention and management, and what makes them more likely to do so?**

Capturing household behavior in an economic model…

The household maximizes expected utility in the presence of accidental fire risk.

$$U \equiv P \cdot U^{F}(\cdot) + (1-P) \cdot U^{O}(\cdot)$$

exogenous probability of accidental fire

Household utility in the case of accidental fire (F) and non-fire (O)

$$U^{j} \equiv U[X, N, Q_c, l; \Omega]$$

Maximization of expected utility occurs subject to the household budget constraint, time constraint, and land clearing constraint.

The model, continued.

Fire prevention enters into the model in several ways:

1. **Through non-timber forest product collection**

$$N^O \equiv N(L_N, A_F; \Omega)$$

$$N^F \equiv \alpha(L_p) N(L_N, A_F; \Omega)$$

2. **Through agricultural production**

$$Q_p^O \equiv Q_p[A_B, K, L_A, L_H; \Omega]$$

$$Q_p^F \equiv \alpha(L_p) Q_p[A_B, K, L_A, L_H; \Omega]$$

3. **Through the time constraint**

$$l \equiv T - L_A - L_p - L_N$$

Fire prevention, α, is increasing in labor spent in fire prevention, L_p. It provides protection to agricultural and non-timber goods in the case of fire.

The model, continued.

The smallholder will not engage in fire prevention if the marginal benefit to production and non-timber forest product collection of doing fire prevention is less than marginal cost of land taken from other uses plus the opportunity cost of time.

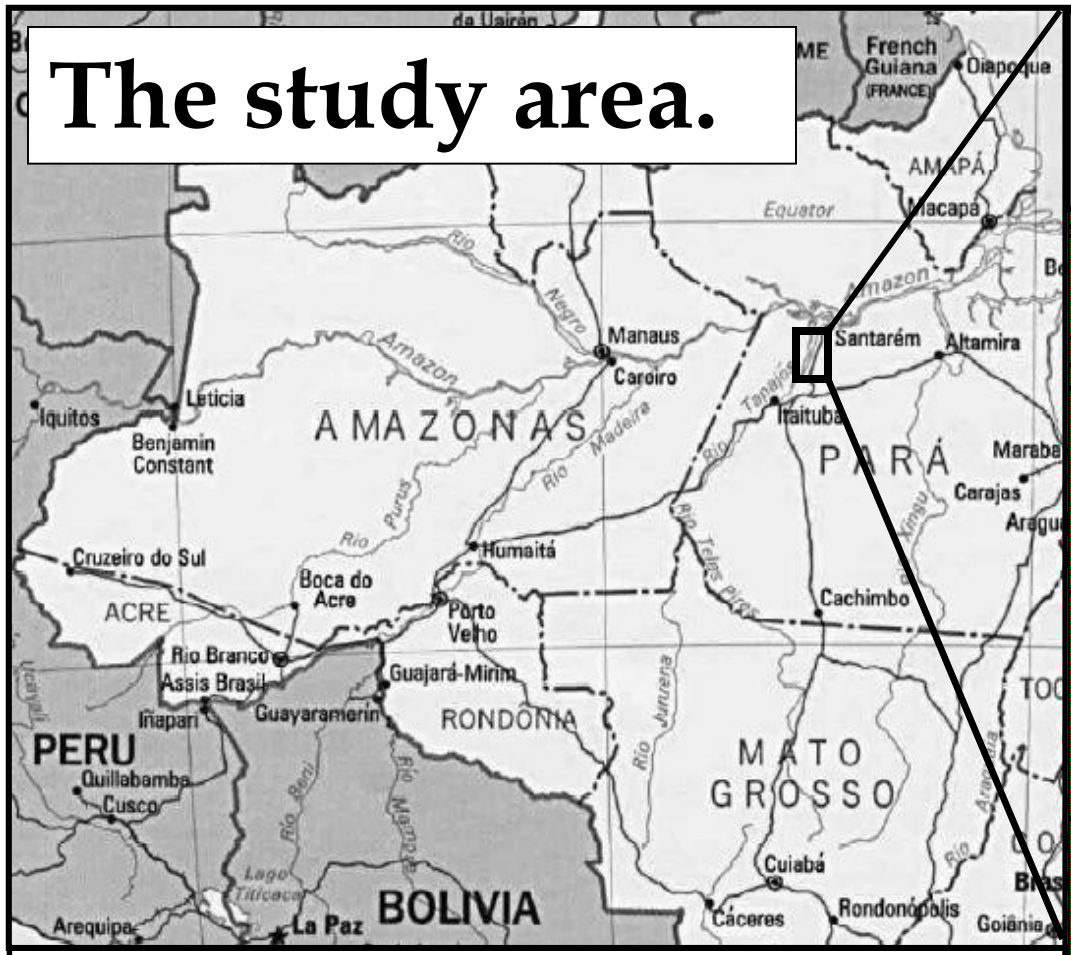
$$\underbrace{P\alpha'(L_p)\left(\frac{\partial U^F(\cdot)}{\partial N^F}\right)+\lambda P_c P\alpha'(L_p)Q_p^F}_{\text{Marginal Benefit}} < \underbrace{\left\{\begin{array}{l} A_E'(L_p)\left[P\left(\frac{\partial U^F(\cdot)}{\partial N^F}\frac{\partial N^F(\cdot)}{\partial A_F}\right)+(1-P)\left(\frac{\partial U^O(\cdot)}{\partial N^O}\frac{\partial N^O(\cdot)}{\partial A_F}\right)\right] \\ +\lambda A_E'(L_p)P_c\left[P\left(\frac{\partial Q_p^F(\cdot)}{\partial A_B}\right)+(1-P)\left(\frac{\partial Q_p^O(\cdot)}{\partial A_B}\right)\right]+\mu \end{array}\right\}}_{\text{Marginal Cost}}$$

$$\Leftrightarrow$$

$$L_p = 0$$


Photo courtesy of Ailton, IPAM, Santarém

The study area.



Sample Communities of the FLONA Tapajós

São Domingos	Piquiatuba	Prainha I
Maguari	Marai	Prainha II
Jamaraqua	Nazare	Itapiúna
Acaratinga	Tauari	Paraiso
Pedreira	Pinim	Martanxin

Political map of Brazil (2004) from the Perry Castañeda map collection (University of Texas) and map of FLONA from IBAMA, 2004

Estimation.

1. Tobit estimation of the agricultural production function

2. Probit estimation of the household decision to hunt and to collect non-timber forest products

3. Shadow wage from 1 and predicted values from 2 (to correct for endogeneity bias) used in:
    1. Probit estimation of the household decision to engage in fire prevention
    2. Tobit estimation of hectares burned for agriculture and labor allocation to fire prevention

4. Likelihood Ratio tests for contribution of household characteristics and economic variables to burning and fire prevention

Independent variables for burning and fire prevention regressions

Sum of years of education of all household members

Number of years household has lived on lot

Wage at which household hires labor ($R/day)

Shadow wage of planting labor ($R/day)

Household has direct access to Santarém by road (four northernmost communities) (0,1)

Household reported experiencing accidental fire in the past (0,1)

Household took out a formal loan in the past year (0,1)

Number of household members

Number of children age <15

Head of cattle owned by household

Exogenous income to the household in the past year ($R)

Price of Manioc Flour ($R/sack)

Value of crops produced in the last year ($R)

Household collects non-timber forest products (predicted (0,1))

Household hunts (predicted (0,1))

Hectares of land burned for agriculture in the past year (predicted value)

Significant Results from Tobit estimation of hectares of land burned for agriculture

Independent Variable	Tobit Coefficient
Number of household members	-0.618** (0.255)[a]
Number of children age <15	0.329* (0.174)
Head of cattle owned by household	-0.254** (0.128)
Shadow wage of planting labor ($R/day)	0.206*** (0.056)
Wage at which household hires labor ($R/day)	-2.083*** (0.715)
Price of manioc flour ($R/sack)	-0.954** (0.374)
Household hunts (predicted (0,1))	-3.666*** (1.252)

[a] Asymptotically robust standard errors of coefficients reported in parentheses
n=206
Functional form: log-log
Log likelihood = -150.0228
Selection Lambda = -0.617(0.845) is non-significant.
*** <0.01, ** <0.05, * <0.10

Significant Results from Probit and Tobit estimations of Fire Prevention

Independent Variable	Probit Coefficient	Tobit Coefficient
Shadow wage of planting labor ($R/day)	0.769*** (0.155)[a]	0.203*** (0.045)[a]
Price of manioc flour ($R/sack)	1.462* (0.806)	0.360 (0.275)
Household hunts (predicted (0,1))	5.328* (2.806)	1.684* (0.907)

[a] Asymptotically robust standard errors of coefficients reported in parentheses
n=206
All independent variables in log form

Probit: Log likelihood = -68.843 Restricted log likelihood = -113.013
Percent dependent variable correctly predicted = 81.068
Tobit: Log likelihood = -196.4232
LM test [df] for Tobit = 61.688[17]
Selection Lambda = 0.079(0.244) is insignificant.

*** <0.01, ** <0.05, * <0.10

Likelihood Ratio tests of household characteristics and economic variables in land burned and fire prevention regressions

	Land burned for agriculture	Labor time spent clearing aceiros	
	Tobit	Probit	Tobit
Household characteristics[a]	8.658*	3.222	8.210*
Economic variables[b]	36.533***	56.622***	32.172***

[a] household characteristics dropped for estimation of restricted models: sum of years of education, number of years household has lived on lot, number of household members, number of dependents

[b] economic variables dropped for estimation of restricted models: hiring wage, shadow wage of planting labor, exogenous income, price of manioc flour, value of crops produced in the last year

Conclusions.

Relationship between increased smallholder productivity/ investment in agriculture and investment in fire prevention

Importance of considering economic variables when designing effective policy

Potential tradeoffs associated with market integration and increases in agricultural productivity

Limitations of study and potential for future research

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