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" 'Land Sparing' in a von Thünen Framework: Theory and Evidence from Brazil,"
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APPENDIX A: MODEL

Details of the Model in Section 2

The first step is to assume a utility function of the form:

$$U(Y,\ l) \qquad [A1]$$

This states that a household's utility depends on its level of consumption (*Y*) and leisure (*l*). The household's objective is to maximize A1 subject to four constraints. First, an income constraint:

$$p_y Y = (p_q - td)Q - (w_x + td)X + (w_m - td)\,M \quad [A2]$$

where, *Y* represents the total amount of consumer goods, *Q* represents output, e.g. beef or milk, *X* denotes the quantity of inputs and *M* the amount of off-farm work. The unit cost of a consumer good is given by p_y, output price is p_q, while w_x and w_m represent, respectively, the market wage for a unit of off-farm labour and the market price of a unit of input. In addition, td is a linear transport cost, where *t* represents the transport cost for a given unit of distance and *d* represents distance from the market. Since we impose linearity, this could be, e.g. fuel costs. Equation [A2] states that total expenditures on consumer goods ($p_y Y$) cannot exceed farm profits net of transport costs $\left((p_q - td)Q - (w_x + td)X\right)$ plus off-farm income net of transport costs $(w_m - td)\,M$. In our setting, farm profits can be made from selling milk or fattened cattle for beef while the inputs could be, e.g., the number of calves and animal feed.

Households face a choice between three technologies, namely to remain where they are, intensify or extensify. Choice of technology is then defined by the following concave production function:

$$Q = Q[X(\tau_t), L_g(\tau_t), P(\tau_t), \tau_t];\ \tau_t \geq 0 \qquad [A3]$$

where both the quantity and the marginal productivity of each input (where L_g represents general on-farm labour and *P* represents the amount of pasture area) depends on the technology adopted. Thus, total achievable cattle production is constrained by the chosen technology. We define the choice to extensify production as τ_1 and the choice to intensify as τ_2. The decision not engage in either of these occurs when $\tau_1 = \tau_2 = 0$. For the remainder of the model we assume that:

$$\frac{\partial P}{\partial \tau_1} > \frac{\partial P}{\partial \tau_2};\ \frac{\partial X}{\partial \tau_2} > \frac{\partial X}{\partial \tau_1};\ \frac{\partial L_g}{\partial \tau_1} = \frac{\partial L_g}{\partial \tau_2} \qquad [A4]$$

In practice, we assume that with adoption of an extensive technology, increases in pasture area *P* are higher than with an intensive technology. Conversely, the increase in other inputs *X* is higher under an intensive technology than under an extensive technology. Finally, we assume that, in terms of general labour, L_g, the two technologies do not differ from one another. We further assume that both types of technology are mutually exclusive in that a household cannot intensify and extensify cattle production simultaneously ($\tau_1 * \tau_2 = 0$). This assumption is justified on the basis that we do not always expect to observe extensification occurring alongside intensification, i.e. a rebound effect (e.g. Angelsen 1999; Lambin and Meyfroidt 2011). If we relax this assumption, extensification could occur in parts of the lot while intensification occurs in other parts. But since our results are driven by distance and the relative costs of inputs net of transport costs (also determined by distance), they essentially remain the same regardless of whether or not intensification takes place alongside extensification.

We then assume that the total land is divided among secondary forest and pasture:

$$\bar{A} = F_1 + F_2 + P \qquad [A5]$$

where $\bar{A}$ represents the total lot area, and F_1, F_2 and P denote primary forest, secondary forest and pasture, respectively. Each individual land use is then governed by the following equations:

$$F_1(\overline{F_1}, Lf_1) = \overline{F_1} - \beta_1 L_{f1}; \quad \overline{F_1} \geq \beta_1 L_{f1}, \overline{F_1} \geq 0 \qquad [A6]$$

$$F_2(\overline{F_2}, Lf_2, Lc_2) = \overline{F_2} - \beta_2 L_{f2} + \beta_{c2} Lc_2; \quad \overline{F_2} \geq 0; F_2 \geq 0 \qquad [A7]$$

Plugging equations [A6] and [A7] into equation [A5], we obtain the following equation for pasture:

$$P(Lf_1, Lf_2, Lc_2) = \bar{A} - \overline{F_1} + \beta_1 L_{f1} - \overline{F_2} + \beta_2 L_{f2} - \beta_{c2} Lc_2 \qquad [A8]$$

Equation [A6] states that each household has a certain endowment of primary forest ($\overline{F_1}$), primary forest can be cleared with labour L_{f1} and each unit of this type of labour leads to a β_1 decrease in primary forest area (and a β_1 increase in pasture area). Households clear secondary forest with labour L_{f2}. Each unit of labour leads to a β_2 decrease in secondary forest (and a β_2 increase in pasture area). However, the household can also decide to convert pasture to secondary forest, at a rate of β_{c2} for each unit of labour (Lc_2). We further assume that $\beta_2 > \beta_1$. In other words, it is cheaper to clear secondary forest than primary forest in that for a given input of labour a larger amount of land can be converted into pasture from secondary than primary forest. Finally, in terms of pasture, the household can increase the area of pasture by clearing secondary and primary forest. Similarly, the household can choose to decrease the area of pasture by converting pasture into secondary forest.

The final constraint is a time constraint where it is assumed that:

$T = L_g + L_{f1} + L_{f2} + Lc_2 + M + l; M \geq 0; L_{f1} \geq 0; L_{f2} \geq 0;\ Lc_2 \geq 0;\ L_g > 0; l \geq 0$ [A9]

Thus, the total time of the household is allocated between a strictly positive amount of general labour (L_g), a non-negative amount of land clearing labour (L_{f1}, L_{f2}), a non-negative amount of labour to convert pasture into secondary forest (Lc_2), a non-negative amount of off-farm labour (M), and a non-negative amount of leisure (*l*).

Inserting the technology constraint and using the fact that pasture can be expressed as a function of labour, we can rewrite the first constraint [A3]:

$p_y Y = (p_q - td)Q[X(\tau_t), L_g(\tau_t), L_{f1}(\tau_t), L_{f2}(\tau_t), Lc_2(\tau_t), \tau_t,] - (w_x + td)X + (w_m - td)\, M$ [A10]

We now write the Lagrangian as follows:

$L = U(Y, l) + \lambda[(p_q - td)Q[X(\tau_t), L_g(\tau_t), L_{f1}(\tau_t), L_{f2}(\tau_t), Lc_2(\tau_t), \tau_t,] - (w_x + td)X + (w_m - td)\, M - pyY] - \mu[T - L_g - L_{f1} - L_{f2} - Lc_2 - M - l]$ [A11]

Take the first order derivatives:[1]

$\frac{\partial L}{\partial Y} = \frac{\partial U}{\partial Y} - \lambda py = 0$ [A12]

$\frac{\partial L}{\partial l} = \frac{\partial U}{\partial l} - \mu = 0$ [A13]

$\frac{\partial L}{\partial X} = \lambda\left[(p_q - td)\frac{\partial Q}{\partial X} - w_x\right] = 0$ [A14]

Note: $\frac{\partial Q}{\partial L_{f1}} = \frac{\partial Q}{\partial P}\frac{\partial P}{\partial L_{f1}}$; take the derivative of $\frac{\partial P}{\partial L_{f1}}$ and we have β_1. Also: $\frac{\partial Q}{\partial L_{f2}} = \frac{\partial Q}{\partial P}\frac{\partial P}{\partial L_{f2}}$; take the derivative of $\frac{\partial P}{\partial L_{f2}}$ and we have β_2.

$\frac{\partial L}{\partial L_{f1}} = \lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P}\beta_1\right] - \mu \leq 0;\ \frac{\overline{F_1}}{\beta_1} \geq\ L_{f1} \geq 0, L_{f1}\left(\lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P}\beta_1\right] - \mu\right) = 0$ [A15]

$\frac{\partial L}{\partial L_{f2}} = \lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P}\beta_2\right] - \mu \leq 0;\ \frac{F_2}{\beta_2} \geq\ L_{f2} \geq 0, L_{f2}\left(\lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P}\beta_2\right] - \mu\right) = 0$ [A16]

$\frac{\partial L}{\partial Lc_2} = \lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P} * -\beta_{c2}\right] - \mu \leq 0;\ \frac{P}{\beta_{c2}} \geq\ Lc_2 \geq 0, Lc_2\left(\lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P} * -\beta_{c2}\right] - \mu\right) = 0$ [A17]

Note that, since $\beta_1 < \beta_2$, we have that if $\lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P}\beta_2\right] - \mu < 0$, then by definition, $\lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P}\beta_1\right] - \mu < 0$ will also hold. This implies two things. If the marginal productive effects of converting secondary forest into pasture do not compensate the hours worked by the household, then the household will not convert primary forest. In other words, if the optimal amount of labour for the conversion of secondary forest to pasture is zero (i.e. $L_{f2} = 0$), then the same will hold for L_{f1}. The intuition behind this is simple. Since it is cheaper to convert secondary than primary forest, the household will only convert primary forest if there is no secondary forest remaining or if there is insufficient secondary forest to create the total desired pasture area. This suggests that we are likely to see more pronounced effects on secondary forest in contrast to primary forest.

$\frac{\partial L}{\partial L_g} = \lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial L_g}\right] - \mu = 0; L_g > 0$ [A18]

$\frac{\partial L}{\partial M} = \lambda[w_m - td] - \mu = 0; M \geq 0, M(\lambda w_m - \mu) = 0$ [A19]

Finally:

$$\frac{\partial L}{\partial \tau_t} = \lambda\left[\left(p_q - td\right)\left[\frac{\partial Q}{\partial X}\frac{\partial X}{\partial \tau_t} + \frac{\partial Q}{\partial L_g}\frac{\partial L_g}{\partial \tau_t} + \frac{\partial Q}{\partial P}\frac{\partial P}{\partial L_{f1}}\frac{\partial L_{f1}}{\partial \tau_t} + \frac{\partial Q}{\partial P}\frac{\partial P}{\partial L_{f2}}\frac{\partial L_{f2}}{\partial \tau_t} + \frac{\partial Q}{\partial P}\frac{\partial P}{\partial Lc_2}\frac{\partial Lc_2}{\partial \tau_t} + \frac{\partial Q}{\partial \tau_t}\right] - \left(w_x + td\right)\frac{\partial X}{\partial \tau_t}\right] - \mu\frac{\partial L_{f1}}{\partial \tau_t} - \mu\frac{\partial L_{f2}}{\partial \tau_t} - \mu\frac{\partial Lc_2}{\partial \tau_t} - \mu\frac{\partial L_g}{\partial \tau_t} \le 0; \tau_t \ge 0, \tau_t\frac{\partial L}{\partial \tau_t} = 0 \qquad \text{[A20]}$$

Equation [A20] states that a household will adopt technology *t* if the benefits of adopting this technology exceed the costs of adoption. As such, if this equation is a strict inequality for *t*=1,2 , no technology will be adopted. Looking at the technology adoption decision separately, technologies 1 and 2 are adopted if:

$$\left(p_q - td\right)\frac{\partial Q}{\partial \tau_1} \ge \left(w_x + td\right)\frac{\partial X}{\partial \tau_1} + \frac{\mu}{\lambda}\left(\frac{\partial L_{f1}}{\partial \tau_1} + \frac{\partial L_{f2}}{\partial \tau_1} + \frac{\partial Lc_2}{\partial \tau_1} + \frac{\partial L_g}{\partial \tau_1}\right) \qquad \text{[A21]}$$

$$\left(p_q - td\right)\frac{\partial Q}{\partial \tau_2} \ge \left(w_x + td\right)\frac{\partial X}{\partial \tau_2} + \frac{\mu}{\lambda}\left(\frac{\partial L_{f1}}{\partial \tau_2} + \frac{\partial L_{f2}}{\partial \tau_2} + \frac{\partial Lc_2}{\partial \tau_2} + \frac{\partial L_g}{\partial \tau_2}\right) \qquad \text{[A22]}$$

Note from the first-order conditions [A12], [A13] and [A19] that, for non-zero quantities of off-farm labour we have:

$$\frac{\mu}{\lambda} = w_m - td = \left[\left(p_q - td\right)\frac{\partial Q}{\partial L_g}\right] \qquad \text{[A23]}$$

As a result, if we assume that $\frac{\partial Q}{\partial L_g}$ is the same under τ_1 and τ_2, we have that, the further away the households are from the market the lowest $\frac{\mu}{\lambda}$ but the highest input costs $(w_x + td)$. This result implies that, if extensification and intensification affect revenues in the same way, the further a household is from the market the more likely it is to extensify. Suppose for simplicity that $\left[\frac{\partial Q}{\partial \tau_1}\right] = \left[\frac{\partial Q}{\partial \tau_2}\right]$, i.e. a one-unit increase in adoption of a more intensive technology leads to the same output increase as a one-unit output increase from adopting an extensive technology. The household will adopt a more extensive production system if:

$$(w_x + td)\frac{\partial X}{\partial \tau_1} + \frac{\mu}{\lambda}\frac{\partial L_{f1}}{\partial \tau_1} + \frac{\mu}{\lambda}\frac{\partial L_{f2}}{\partial \tau_1} + \frac{\mu}{\lambda}\frac{\partial Lc_2}{\partial \tau_1} + \frac{\mu}{\lambda}\frac{\partial L_g}{\partial \tau_1} \leq (w_x + td)\frac{\partial X}{\partial \tau_2} + \frac{\mu}{\lambda}\frac{\partial L_{f1}}{\partial \tau_2} + \frac{\mu}{\lambda}\frac{\partial L_{f2}}{\partial \tau_2} + \frac{\mu}{\lambda}\frac{\partial Lc_2}{\partial \tau_2} + \frac{\mu}{\lambda}\frac{\partial L_g}{\partial \tau_2} \qquad [A24]$$

We can rearrange this such that:

$$\frac{\mu}{\lambda}\left(\frac{\partial L_{f1}}{\partial \tau_1} + \frac{\partial L_{f2}}{\partial \tau_1} + \frac{\partial Lc_2}{\partial \tau_1} + \frac{\partial L_g}{\partial \tau_1} - \frac{\partial L_{f1}}{\partial \tau_2} - \frac{\partial L_{f2}}{\partial \tau_2} - \frac{\partial Lc_2}{\partial \tau_2} - \frac{\partial L_g}{\partial \tau_2}\right) \leq (w_x + td)\left(\frac{\partial X}{\partial \tau_2} - \frac{\partial X}{\partial \tau_1}\right)$$

[A25]

Since we assume that $\frac{\partial L_g}{\partial \tau_1} = \frac{\partial L_g}{\partial \tau_2}$ these terms disappear. And, since $\frac{\mu}{\lambda}$ is decreasing in distance to market and $(w_x + td)$ is increasing in distance to market, then the further away the household is from the market, the more likely it is to adopt an extensive technology, i.e. given lower net benefits of working off-farm (due to higher transportation costs), higher costs of purchasing capital inputs (again due to higher transportation costs), and the assumption that extensive production systems are more labour-intensive as opposed to more intensive in other inputs.

Incorporating PES

We begin by re-stating the equations for forest cover, namely:

$$F_1(\overline{F_1}, Lf_1) = \overline{F_1} - \beta_1 L_{f1}; \quad \overline{F_1} \geq \beta_1 L_{f1}, \overline{F_1} \geq 0 \qquad [A26]$$

$$F_2(\overline{F_2}, Lf_2, Lc_2) = \overline{F_2} - \beta_2 L_{f2} + \beta_{c2} Lc_2; \quad \overline{F_2} \geq 0; F_2 \geq 0 \qquad [A27]$$

$$P(Lf_1, Lf_2, Lc_2) = \bar{A} - \overline{F_1} + \beta_1 L_{f1} - \overline{F_2} + \beta_2 L_{f2} - \beta_{c2} Lc_2 \qquad [A28]$$

We then assume that for each unit of forest in the lot, primary or secondary, the household is offered a subsidy or PES of an amount ***s*** in order to preserve forest, rather than converting it to pasture. Our augmented full income constraint then becomes:

$$p_y Y = \left(p_q - td\right) Q\left[X(\tau_t), L_g(\tau_t), L_{f1}(\tau_t), L_{f2}(\tau_t), Lc_2(\tau_t), \tau_t\right] - (w_x + td)X(\tau_t) + (w_m - td)\, M + s(\overline{F_1} - \beta_1 L_{f1}(\tau_t) + \overline{F_2} - \beta_2 L_{f2}(\tau_t) + \beta_{c2} Lc_2(\tau_t)) \quad \text{[A29]}$$

The resulting Lagrangian is:

$$L = U(Y, l) + \lambda\left[\left(p_q - td\right) Q\left[X(\tau_t), L_g(\tau_t), L_{f1}(\tau_t), L_{f2}(\tau_t), Lc_2(\tau_t), \tau_t,\right] - (w_x + td)X + (w_m - td)\, M + \; s(\overline{F_1} - \beta_1 L_{f1} + \overline{F_2} - \beta_2 L_{f2} + \beta_{c2} Lc_2) - pyY\right] - \mu\left[T - \; L_g - L_{f1} - L_{f2} - Lc_2 - M - l\right] \quad \text{[A30]}$$

The first-order derivatives are very similar to those derived before, with the exception of:

$$\frac{\partial L}{\partial L_{f1}} = \lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P}\beta_1 - \beta_1 s\right] - \mu \leq 0; \; \frac{\overline{F_1}}{\beta_1} \geq \; L_{f1} \geq 0, L_{f1}\left(\lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P}\beta_1 - \beta_1 s\right] - \mu\right) = 0 \quad \text{[A31]}$$

$$\frac{\partial L}{\partial L_{f2}} = \lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P}\beta_2 - \beta_2 s\right] - \mu \leq 0; \; \frac{F_2}{\beta_2} \geq \; L_{f2} \geq 0, L_{f2}\left(\lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P}\beta_2 \; - \beta_2 s\right] - \mu\right) = 0 \quad \text{[A32]}$$

$$\frac{\partial L}{\partial Lc_2} = \lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P} * -\beta_{c2} + \beta_{c2} s\right] - \mu \leq 0; \; \frac{P}{\beta_{c2}} \geq \; Lc_2 \geq 0, Lc_2\left(\lambda\left[\left(p_q - td\right)\frac{\partial Q}{\partial P} * -\beta_{c2} + \beta_{c2} s\right] - \mu\right) = 0 \quad \text{[A33]}$$

$$\frac{\partial L}{\partial \tau_t} = \lambda\left[\left(p_q - td\right)\left[\frac{\partial Q}{\partial X}\frac{\partial X}{\partial \tau_t} + \frac{\partial Q}{\partial L_g}\frac{\partial L_g}{\partial \tau_t} + \frac{\partial Q}{\partial P}\frac{\partial P}{\partial L_{f1}}\frac{\partial L_{f1}}{\partial \tau_t} + \frac{\partial Q}{\partial P}\frac{\partial P}{\partial L_{f2}}\frac{\partial L_{f2}}{\partial \tau_t} \; + \frac{\partial Q}{\partial P}\frac{\partial P}{\partial Lc_2}\frac{\partial Lc_2}{\partial \tau_t} + \frac{\partial Q}{\partial \tau_t}\right] - (w_x + td)\frac{\partial X}{\partial \tau_t} - s\left(\frac{\partial L_{f1}}{\partial \tau_t} + \frac{\partial L_{f2}}{\partial \tau_t}\right)\right] - \mu\frac{\partial L_{f1}}{\partial \tau_t} \; - \mu\frac{\partial L_{f2}}{\partial \tau_t} \; - \mu\frac{\partial Lc_2}{\partial \tau_t} - \mu\frac{\partial L_g}{\partial \tau_t} \leq 0; \tau_t \geq 0, \tau_t\frac{\partial L}{\partial \tau_t} = 0 \quad \text{[A34]}$$

A household will adopt technology *t* if the benefits of adopting this technology exceed the costs of adoption. The main difference is that the costs now also include PES income forgone as a result of technology adoption $s\left(\frac{\partial L_{f1}}{\partial \tau_t}+\frac{\partial L_{f2}}{\partial \tau_t}\right)$. As a result, technologies 1 and 2 are adopted if:

$$(p_q - td)\frac{\partial Q}{\partial \tau_1} \geq (w_x + td)\frac{\partial X}{\partial \tau_1} + s\left(\frac{\partial L_{f1}}{\partial \tau_1}+\frac{\partial L_{f2}}{\partial \tau_1}\right) + \frac{\mu}{\lambda}\left(\frac{\partial L_{f1}}{\partial \tau_1}+\frac{\partial L_{f2}}{\partial \tau_1}+\frac{\partial Lc_2}{\partial \tau_1}+\frac{\partial L_g}{\partial \tau_1}\right)$$

[A35]

$$(p_q - td)\frac{\partial Q}{\partial \tau_2} \geq (w_x + td)\frac{\partial X}{\partial \tau_2} + s\left(\frac{\partial L_{f1}}{\partial \tau_2}+\frac{\partial L_{f2}}{\partial \tau_2}\right) + \frac{\mu}{\lambda}\left(\frac{\partial L_{f1}}{\partial \tau_2}+\frac{\partial L_{f2}}{\partial \tau_2}+\frac{\partial Lc_2}{\partial \tau_2}+\frac{\partial L_g}{\partial \tau_2}\right)$$

[A36]

Assume again that $\left[\frac{\partial Q}{\partial \tau_1}\right] = \left[\frac{\partial Q}{\partial \tau_2}\right]$, i.e. a one-unit increase in adoption of a more intensive technology leads to the same output increase as a one-unit output increase from adopting an extensive technology. The household will adopt the extensive system over the intensive system if:

$$(w_x + td)\frac{\partial X}{\partial \tau_1} + \frac{\mu}{\lambda}\frac{\partial L_{f1}}{\partial \tau_1} + \frac{\mu}{\lambda}\frac{\partial L_{f2}}{\partial \tau_1} + \frac{\mu}{\lambda}\frac{\partial Lc_2}{\partial \tau_1} + \frac{\mu}{\lambda}\frac{\partial L_g}{\partial \tau_1} + s\left(\frac{\partial L_{f1}}{\partial \tau_1}+\frac{\partial L_{f2}}{\partial \tau_1}\right) \leq (w_x + td)\frac{\partial X}{\partial \tau_2} + \frac{\mu}{\lambda}\frac{\partial L_{f1}}{\partial \tau_2} + \frac{\mu}{\lambda}\frac{\partial L_{f2}}{\partial \tau_2} + \frac{\mu}{\lambda}\frac{\partial Lc_2}{\partial \tau_2} + \frac{\mu}{\lambda}\frac{\partial L_g}{\partial \tau_2} + s\left(\frac{\partial L_{f1}}{\partial \tau_2}+\frac{\partial L_{f2}}{\partial \tau_2}\right) \quad [A37]$$

We can rearrange this such that:

$$\frac{\mu}{\lambda}\left(\frac{\partial L_{f1}}{\partial \tau_1}+\frac{\partial L_{f2}}{\partial \tau_1}+\frac{\partial Lc_2}{\partial \tau_1}+\frac{\partial L_g}{\partial \tau_1}-\frac{\partial L_{f1}}{\partial \tau_2}-\frac{\partial L_{f2}}{\partial \tau_2}-\frac{\partial Lc_2}{\partial \tau_2}-\frac{\partial L_g}{\partial \tau_2}\right) + s\left(\frac{\partial L_{f1}}{\partial \tau_1}+\frac{\partial L_{f2}}{\partial \tau_1}-\frac{\partial L_{f1}}{\partial \tau_2}-\frac{\partial L_{f2}}{\partial \tau_2}\right) \leq (w_x + td)\left(\frac{\partial X}{\partial \tau_2}-\frac{\partial X}{\partial \tau_1}\right) \quad [A38]$$

As before, since $\frac{\mu}{\lambda}$ is decreasing in distance to market and $(w_x + td)$ is increasing in distance to market, then the further away the household is from the market, the more likely it is to adopt an extensive technology. The difference this time, however, is that the option of volunteering into a PES scheme would make technology adoption less desirable for any technology that requires land conversion since the revenue from a

PES is forgone once forest is converted into pasture. That said, the PES would promote an intensive over an extensive technology: it would make [A38] harder to satisfy because, by definition, the term $(s(\frac{\partial L_{f1}}{\partial \tau_1}+\frac{\partial L_{f2}}{\partial \tau_1}-\frac{\partial L_{f1}}{\partial \tau_2}-\frac{\partial L_{f2}}{\partial \tau_2}))$ on the left-hand side is always positive. Moreover, the higher is the payment *s* the less likely [A38] is satisfied, holding all else equal.