Debt Peonage and Over-Deforestation in the Amazon Frontier of Brazil

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Abstract: This paper proposes that under the conditions typical of the Amazon frontier of Brazil—absence of a wage labour market and abundant supply of land—farm-family labour is a positive function of debt. This labour supply response, known as "debt peonage," provides for indirect management of farm labour by local merchants via the crop lien mechanism. A microeconomic model of the family farm shows that debt-labour leads to labour-intensive farming but land-extensive farming leads to over-deforestation. Correct colonization policy should then provide for market structures that reduce indebtedness and deforestation. This would also reduce the environmental consequences of settlement in the Amazon.

Introduction

The Amazon frontier of Brazil is being settled by a multitude of small farmers who arrive before the rest of the economy reaches each location.[2] Farmers are followed rapidly by merchants, who establish the so called "crop-lien" mechanism: advancing subsistence goods between harvests in exchange for future agricultural product.[3] Frontier merchants thus link several markets—consumer goods, agricultural product, and credit—in the manner typical of the functioning of traditional "usury-mercantile capital."[4] In a land-abundant-labour-scarce frontier economy, and in the absence of a wage-labour market,[5] merchants appropriate surplus and monitor family labour indirectly via farmer indebtedness. Different systems of "debt-peonage" exist all over the Amazon, as they have in other times and places, wherever agricultural markets are interlinked and highly concentrated.[6]

This paper calls attention to one especially grave environmental consequence of Amazonian debt-peonage: its impact in raising the intensity of family labour supply and in increasing the extent of deforestation per family.[7] The socioeconomic conditions of Amazon settlement thus provoke over-deforestation relative to what would obtain for the same population if frontier markets were more competitive. Given increasing worldwide concern for conserving the Amazon, this analysis contributes to an understanding of one of the main causes of its devastation.

Model of Indebtedness and Labour Supply

The microeconomic model in this section combines some of the key variables that influence colonist behaviour in a frontier situation, such as chronic farmer indebtedness and the cost of access to land. Settling on virgin soil imposes abrupt discontinuities on frontier agriculture. The hazards of clearing one of the most dense and inhospitable forests in the world mean that deforestation is an especially heavy burden in the case of the Amazon frontier of Brazil. Additional modelling considerations, such as risk, contractual arrangements, household economics, subjective equilibrium, as well as many others, had to be disregarded due to space limitations.

Total annual expenditure (E) comprises the costs of land (aA), labour (wL), and other current costs (cC). Given the seasonality of agricultural production, expenditure is made throughout the year, but receipts occur only at the of the period. To finance production costs, then, producers must have on hand at the end of each year enough resources to last until the end of the harvest. The budget constraint is:

(1) $E_t = wL_t + cC_t + aA_{ti}$, where t refers to the current agricultural year

Agricultural production during one agricultural year occurs according to a continuous, twice-differentiable function of land, labour, and other inputs:

(2) $Q = Q (L, C, A)$; $Q_i < 0$; $Q_{ij} > 0$ for $i, j = L, C, A$

All income is assumed to derive from agriculture, whose product is sold (all or in part) at a price p. Non-marketed output is valued at the same market price, so that the value of total income is pQ.

Incoming receipts from current loans (D_t) supplement current income (pQ_t). Obligations on previous debts, $(D_t)X(i+1)$, where i is the interest rate, add to current expenditure (E). Assuming no investment or dissaving, net income (Y) is:

(3) $Y = PQ_t - E_t$, where:

(4) $Y - D_t - D_{t-1} (i+1) - 0$ exactly equals net indebtedness

When $Y < 0$, own funds (pQ_t) are insufficient to cover current expenses (E) plus debt repayment $(D_{t-1}(i+1))$; when $Y > 0$, own funds more than cover current expenses and contribute to debt repayment; and when $Y = 0$, current incoming loans just cover previous debt repayment.

The farmer's objective is to maximize current income (pQt) subject to budget and debt constraints $(E_t + Y)$ during each agricultural year. First-order conditions for a maximum are that:

(5) $P_i Q_{ti} - \dfrac{dY}{di} = 0$

where $P_i = w, c, a$, Q_{ti} is the respective marginal product of a factor i in given year t, and $Y = 0$.

In equilibrium, (5) is exactly satisfied. As $dy/di = 0$, this means that (5) collapses to the usual condition $(Q_{ti} = P_i/p)$, whereby each factor of production (L, C, A) is used up to the point where its marginal productivity is equal to its opportunity cost; i.e., its real market price $(w/p, c/p, a/p)$. If second-order conditions for a maximum are satisfied, these equations jointly determine demand for labour, inputs, and land as well as the supply of agricultural product. The corresponding land demand and product supply equations were directly submitted to statistical testing elsewhere, where land productivity (Q_A) turned out to be statistically sensitive to relative prices of land and agricultural product (a/p).[8]

When the system is in disequilibrium, the respective inequalities are equalized by slack variables, which tend to move it back towards equilibrium. In this model, indebtedness (D_t, D_{t-1}) and investment are the slack variables that balance the budget constraint.

Over-Deforestation as a Consequence of Indebtedness

If $y \neq 0$, then $dY/di \neq 0$ holds entirely. Rearranging (5) then yields:

(6) $\dfrac{di}{dY} = \dfrac{1}{pQ_i - p_i} > 0 \Rightarrow Q_i > \dfrac{P_i}{p}$ for $i = L, C, A$

This means that the response to indebtedness is positive, in terms of labour supply (dL/dY), land area (dA/dY), and other inputs (dC/dY) as long as marginal productivities are greater than respective real costs. In a new frontier there may yet be no land, labour, or input markets $(p_i = 0)$, and only the product market may be operative $(p > 0)$. The indebtedness response will then be positive as long as marginal productivities are positive $(Q_i > 0)$. The initial phases of a frontier, then, should be labour-intensive family farming, as shown in Figure 1 by the horizontal tangent to the production curve A_1 at L_2, where $Q_L = 0$.

The horizontal axis indicates the quantity of total family labour supply. The vertical axis indicates the quantity of output. The slope of the ray from the origin indicates the real market wage rate (w/p). Farmers clear as much land $(A_1,)$ and work as much (L_1) as necessary to

equate marginal productivity (Q_L) to the real wage rate (w/p), producing Q_1 along a production function with initially increasing and then decreasing marginal productivities.
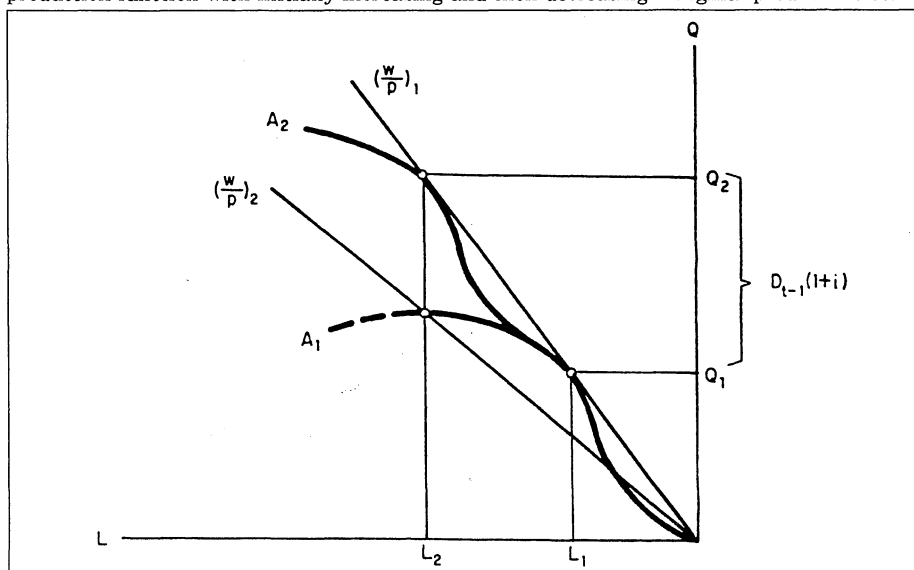

Figure 1—Debt Repayment, Deforestation, and Labour Supply

The initial section of the production curve displays increasing marginal productivity of labour, which is justified by the condition of land abundance in a frontier area. The supply of land, however, comes only from deforestation, as fallow plots are never reused in Amazonian agriculture.[9] So Equation (6) is also an equation for small farmers' demand for deforestation. In the Amazon, newly cleared land is much more fertile than "old" land, which enhances initial marginal productivities.

The higher the market wage rate (w) and the lower product prices (p), the more hiring out of labour and the less family farming there will be. The lower the market wage rate and the higher are product prices, the more family farming and the less hiring out. At the limit, when real wages rise above $(w/p)_1$, where $Q_L = Q/L$, there is no family farming. In a frontier area, where the wage-labour market is as yet non-existent, there is only family farming.

In the case of previous indebtedness (D_{t-1}), requirements that repayment be in kind imply that more than Q_1 be produced. Given the low technological level of most frontier farming, additional labour (L_2) along A_1 would reduce marginal productivity to zero, which contradicts Equation (6) whenever $(w/p) = 0$. More land is therefore deforested along A_2, adding to previous productive land and expanding production to Q_2. This discontinuous sequence of land additions implies that, along the way, itinerant farmers continuously reap the benefits of the high fertility of recently cleared land. This is why A_2 is "grafted" on to A_1, as shown in Figure 1. In order to appropriate a given level of income (pQ_1), then, farm families must work more and clear more forest off the land than before becoming indebted. The higher the interest rate, the greater the impact of previous debt on labour supply and deforestation.

Where the farmer cannot reach Q_2, current indebtedness $(D_t > 0)$ can be resorted to as an income supplement, as shown in Figure 2. This reduces the reservation wage from $(w/p)_1$ to $(w/p)_3$ and increases labour intensity on each plot of land; i.e., family farming persists even at marginal productivities below the real market wage rate.

Equation (6) is of particular interest, as it refers to the labour supply response to indebtedness. This relationship is fundamental to the operation of usury-mercantile capital. Although this relationship is not tested statistically here, it is supported elsewhere by field

data from small farmers in the Brazilian Amazon. Those most deeply caught in consumer indebtedness farmed their plots most extensively and cleared more additional plots.[10] Thus, debt-peonage may be an important cause of itinerant frontier farming and of over-deforestation in the Amazon.
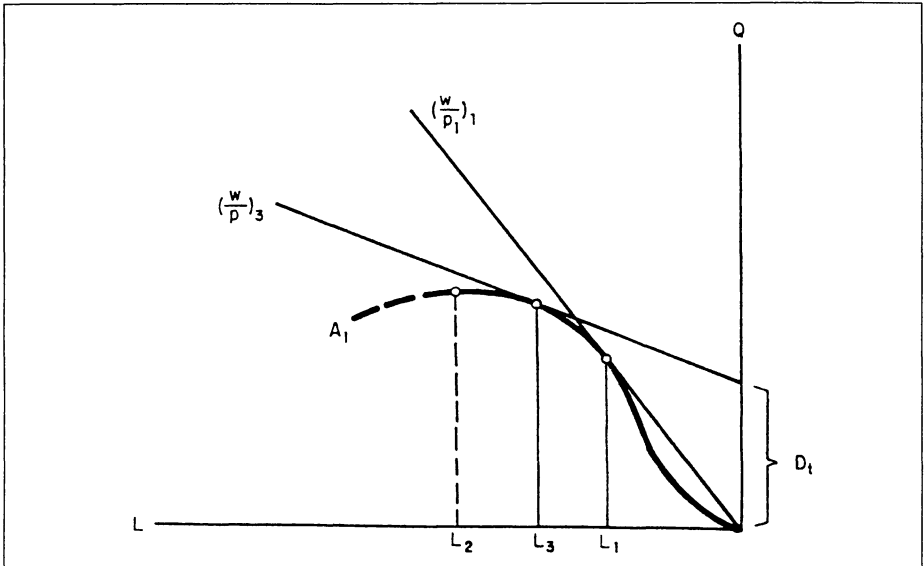

Figure 2—Current Indebtedness and Labour Supply

In summary, under the stated assumptions, recurrent indebtedness $(D_{t-1}>0;\ D_t>0)$ increases deforestation, labour supply, and labour intensity in family farming. Although the model, for simplicity of exposition, lumps former debt (D_{t-1}) and current debt (D_t) together into Y in Equations (3) and (4), Figures 1 and 2 show that their impacts differ.

Conclusions and Policy Implications

Under typical Amazon frontier conditions, the lack of well structured market systems leads to farmer indebtedness. Debt, in its turn, increases the intensity of labour supply and the extent of deforestation per family on the frontier.

The main policy implication of the model is that Amazon colonization should entail more than the usual measures aimed at physical, institutional, and legal settlement; e.g., the mere provision of land, roads, and titles. It must also include measures aimed at forming a market structure consistent with agricultural production and income appropriation by colonists. If this is not done, perverse effects ensue, such as over-deforestation, already well-known in the Amazon frontier of Brazil. Such a reaction, which represents microeconomically rational behaviour under local market disequilibria, can lead to the failure of colonization policy as a whole. The effectiveness of a social policy of land distribution to small farmers in the Amazon, therefore, requires market structures that reduce farmer indebtedness and curb over-deforestation.

Notes

[1]Instituto de Pesquisa Econômica Aplicada, Brazil. I am grateful for comments by William Savedoff, though errors and omissions are my own responsibility.

[2]See de Almeida (1991) for a measurement of the extent of Brazilian Amazon colonization in terms of number of settlers and occupied area.

[3]See Musumeci (1988) and de Almeida (1992) for analyses and bibliographies on the role of frontier merchants in the occupation of the Brazilian Amazon.

[4]The interlinking of rural markets has been studied by several authors, such as Bardhan and Rudra (1978) and Braverman (1981). For the operation of different types of capital in Brazilian agriculture, including usury-mercantile capital, see Goodman and Redclift (1977).

[5]The absence of a wage-labour market under conditions of land abundance has general consequences studied by Domar (1970); the present paper draws specific implications for deforestation.

[6]For the post-slavery South of the USA, see Ransom and Sutch (1972). For the Indian case, see Bhaduri (1973). For Caribbean plantation economies, see Harris (1988).

[7]Ransom and Sutch (1975) have already called attention to the over-production consequences of debt-peonage. This paper extends its implications to a frontier context, where over-production implies over-deforestation.

[8]See de Almeida (1992), panel 19.1.

[9]Empirical evidence and a bibliography to this effect are in de Almeida (1991, Chap. 19).

[10]Empirical evidence and a bibliography to this effect are in de Almeida (1991, Chaps. 16 and 20). The debt-peonage effect on family labour supply also yielded significant and interesting econometric results for data from the rural Brazilian Northeast (de Almeida, 1977).

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Discussion Opening—*Jorge A. Torres-Zorrilla* (Instituto Interamericano de Cooperación para la Agricultura)

My first comment refers to the price of the land factor in the Amazon frontier zone. It is stated in the paper that, in equilibrium, the land factor is used up to the point where the value of its marginal product equals the market price. It is also advanced that land productivity has been shown to be statistically sensitive to relative prices of land and agricultural product.

However, in the Amazon frontier, we would really not find a market for land nor a price of land since the frontier is being settled by many small farmers in an informal manner. The model should therefore perhaps use not the price of land but the cost of access to new land, a cost which is highly variable depending on the location and the particular characteristics of the local forests or the actual terrain.

Furthermore, in the Amazon, newly cleared land is much more fertile than "old" land, which will increase the dispersion of costs and values. The model and the analysis of the paper should be refined to incorporate the fact that land markets are non-existent in the Amazon frontier. Should we assume that land prices are zero? Or should we propose that the cost of deforestation and access to new land be used as the price for land?

The situation is different for the other inputs (labour, fertilizer, etc.) because there will always be a market even in a frontier area, and prices will always be positive. Labour has an alternative cost, and other inputs always have to be purchased in the modern sector of the economy and transported to the frontier, and will bear a much higher price.

The model is useful in showing that, if land markets fail to be present, marginal productivities are greater than real costs and more inputs will be used, including land. The other consequence is that debt will increase and that farm families must work more and clear more land than before. The final result will be itinerant frontier farming and a pattern of over-deforestation.

The policy implications of the paper include that development of a well structured market system could help to control the perverse effects of farmers' debt and over-deforestation in the Amazon frontier. But there is always the concern that even competitive markets may fail to produce appropriate prices for land resources. The market may imply private prices for land and forests well below the social price levels. Here, resource evaluation methods and the optimal control theory of renewable resources may give better estimates of the appropriate valuation of these ever-decreasing scarce resources.

Finally, I cannot refrain from making a comparison between these poor farmers of the Brazilian frontier and those in other poor countries in Latin America. These countries have also accumulated a large external debt that they have to repay now, making it necessary to overuse their natural resources. This also contributes to deforestation through a great expansion of agricultural exports.