PRELIMINARY DRAFT
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FRONTIER ADVANCE, DEFORESTATION, AND LAND OWNERSHIP IN THE BRAZILIAN AMAZON

João S. Campari

The University of Texas at Austin
Department of Economics
Austin, Texas 78712-1173 U.S.A.
campari@mundo.eco.utexas.edu.

Abstract

This paper sets out to analyze the recent changes in the demographic behavior and economic performance of frontier agents that have tended to influence and redefine the motives that lead to concentrated land ownership in the Brazilian Amazon. The paper argues that deforestation by small farmers has been responding increasingly to local conditions that reward speculation and promote concentrated land ownership. Without new policies designed to change these conditions, therefore, the 1990s will probably witness continued deforestation.

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Introduction

Since colonial times, land distribution in Brazil has dealt with the general social problem of landlessness by extending the agricultural frontier westward. Successive federal- and state-level land distribution agencies—such as the Institute for Colonization and Agrarian Reform (INCRA) and the former Ministry of Agriculture and Agrarian Reform (MIRAD)--have traditionally been responsible for bringing together agrarian reform and colonization. Rather than tackle the political cost of agrarian reform, land distribution in Brazil has mostly taken from nature and given to the rich.

For the last few years, since the rapid rise and fall of MIRAD in the second half of the 1980s, the issue of government directed occupation schemes has lain relatively dormant in Brazil in general, and in the Amazon in particular. Accumulated experience over the 1970s and 1980s, whether with colonization projects in the frontier, or agrarian reform projects in established areas, was disappointing. In the Amazon, massive deforestation and inappropriate tropical farming technologies that caused soil degradation generated a growing conservationist outcry against the environmental impact of such projects. Colonization, though made in the name of distribution, quickly regressed common property into concentrated land structures, leading domestic and foreign policy communities to question their social benefit.

Although such concentration has been known to occur in the north of Brazil since the early days of occupation, the dynamics that gives rise to unequal landholding in the region today is quite different from that of two decades ago. During the 1980s, the Amazon region suffered profound demographic and economic changes that have tended to exacerbate the impact of the prevailing structure of concentrated ownership on forest clearing. In the course of the decade, as the federal government neutralized most of the policies that had promoted occupation, thriving local economies came to replace the isolation of pioneer fronts. The proliferation and rapid growth of frontier cities gave rise to a complex urban network and to a prosperous urban middle class linked by trade to the industrial south.

In response to the protracted economic crisis of the 1980s, the local urban elite began channelling resources to local real estate as a means to hedge against rampant inflation. The speculative behavior became chronic and provoked a run on land, inducing the appreciation of land values near urban centers, and impelling a growing number of small farmers to sell their plots. As

small holdings became consolidated into large ones, high turnover on farming plots, and intra-regional migrations from old to new frontiers within the Amazon gained momentum, resulting in a two-stage process of land occupation that had harsh consequences for the rain forest. Small farmers deforested, left and were replaced by newcomers who held land for different purposes than had original settlers. This has become a frontierwide phenomenon and has taken place regardless the agronomic suitability of soils~i.e., it has happened even in areas where farmers' economic rents are unambiguously positive.

Thus, although speculation in frontier land markets is not a recent phenomenon, the type of behavior described above is a marked departure from the speculative behavior that prevailed until the mid-1980s. Until then, most of those who purchased land in the Amazon were *outsiders responding to federal government incentives* that promoted occupation, i.e., tax breaks and subsidized credit. In contrast, during the latter half of the 1980s, most of those who began purchasing land in the region belonged to an emergent *local elite responding to local-level forces* during a period of crisis. Policies aimed at forest conservation must be sensitive to the fact that deforestation today is a rational and profit-maximizing response of frontier agents to local-level dynamics, as opposed to the federally implemented policies of the 1970s.

The issue of land distribution is likely to be a government priority again soon under the pressure that arises from rural violence and because of a growing local demand for stabilization. Since the end of the military regime in the mid-1980s, rural workers' unions, once severely repressed, have become larger, more widespread and better organized. Landowners' associations have become more influential as well. Due to the low priority in the allocation of government resources to land distribution policies in recent years, the conflict between these two groups has escalated, with increasing incidence of violence not only in the Amazon but also throughout Brazil, as landless farmers press for, and landowners resist, any form of land redistribution.

This paper sets out to discuss the recent changes in the demographic behavior and economic performance of frontier agents that have tended to influence and redefine the underlying motives that lead to concentrated land ownership in the Brazilian Amazon. The data used in this discussion came from a large variety of sources: (i) the most recent agricultural (1985) and demographic (1991) census, (ii) satellite vegetative land cover data (1978 and 1988), (iii) longitudinal household data on small farmers collected in 1981 and 1991 on the same plots in eight directed colonization projects in

the Brazilian Amazon, and (iv) institutional data on merchants collected in 1991 in the same colonization locations. These sources are woven together using an interpretive framework that is sensitive to linkages between the structural transformations at the national level and the micro-level factors that motivate land use decisions by different frontier agents.

The paper is organized in six sections. Section two uses census data and satellite images to trace the path of migrations to and within the Amazon during the 1970s and 1980s. The section shows that intra-regional migrations of small farmers from old to new frontiers within the Amazon have replaced the *inter-regional* Amazon-bound migrations typical of the 1970s. It explores the possibility that intra-regional migrations and deforestation by small farmers may be responding to the behavior of a local urban elite and reflecting the manner in which land is being appropriated by them.

Section three uses fiscal and other sources, plus field evidence from Amazonian merchants collected in 1991 to analyze the growth of the urban and private sectors in the region during the 1980s. The section argues that economic conditions changed dramatically during the 1980s, inside and outside the Amazon, giving rise to a different type of speculative behavior on the part of the local urban middle class that is directly related to the concentration of land and small farmer itinerancy.

Section four is based on a longitudinal survey of 500 Amazonian small farmers. The fact that the same plots were visitied in 1981 and 1991 allowed us to capture changes in behavior of those farmers who remained on their plots, and observe the common characteristics of those who left (productivity, incomes, background, and so on). In order to capture the synergy between frontier agents, farmers and merchants were interviewed in the same locations. The evidence provided in this section reveals that although rents from agriculture were unambiguously positive in some locations, turnover on plots was high, and land which had originally been deforested for farming was increasingly converted to pasture and other purposes.

Section five puts together the discussion of the previous sections and argues that high turnover (discussed in sections two and four) reflects the rational and profit-maximizing behavior of agents who have been responding increasingly to current economic conditions (discussed in section three) that reward speculation, encourage deforestation, and promote a regime of increasingly concentrated land structures.

Section six summarizes and discusses the policy implications that arise from this work.

II. *The Moving Frontier*

The Brazilian agricultural frontier has historically been short-lived. The main sending areas, once frontier areas themselves, soon began expelling emigrants at rates greater than those at which they were taking in immigrants. It was not until the 1970s that the Amazon started to show the features of a typical agricultural frontier. Table 2.1 shows that the center-west *(cerrado),* which had been a frontier area in the 1960s, became a consolidated frontier in the 1970s, absorbing rural migrants in ever fewer numbers relative to the previous decade. The north (Amazon) region, however, doubled the size of its rural population in the 1970s, becoming the new agricultural frontier of Brazil.

Table 2.1. Variation in Rural Population in Frontier Areas: 1960-70, 1970-80

Frontier Area	1960-70	1970-80
Amazon Frontier	547,745	1,047,912
Cerrado frontier	777,478	233,668
Total	1,325,223	1,281,565

Source: IBGE, Demographic Census: 1960, 1970, 1980, and Ozorio de Almeida, A. L., 1992. *The Colonization of the Amazon*, Austin: The University of Texas Press.

During the 1960s and 1970s, the geographical spread of occupied frontier areas was considerable. As the frontier shifted northwestward, it left behind low-density population pockets where small farming activities had once been carried out.[1] Small landowners sold their plots, either moving further inland to reestablish their family farms, or going to nearby towns, seeking non-farm employment. Small tenants and squatters were evicted, and commercial agriculture took over, consolidating small holdings into large ones, and often converting farmland to pastures.

II.1 Intra-regional migrations

The frontier population now numbers more than 19 million people, about a third of whom live

[1] See Brazilian agricultural (1985) and demographic census (1960, 1970, 1980, and 1990).

in rural areas and show no intention of leaving the region.[2] Any realistic Amazon conservation scheme, therefore, must deal with the fact that for the foreseeable future, there will be more than six million people farming the Amazon.[3] The issue, then, is how to do so at a reduced cost to the forest.

Although the growth of total population in the frontier for the past thirty years was more than 14 million people, during the 1980s the region showed a significant decline in annual population growth rates relative to the previous decade, especially if compared with other regions of Brazil (see table 2.2).[4] The *cerrado* frontier of the center-west had the highest rates of population growth during its heyday in the 1960s, as did the Amazon frontier during the 1970s. Since then, both regions have experienced far lower population growth rates. This decline can be attributed to falling fertility rates nationwide.[5]

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[2]See Martine(1992).

[3] Several authors assert that small farmers are not the main agents of forest clearance (Partridge 1989). Both Denevan (1978, p.67) and Foweraker (1981, p.208), however, argue that peasants do clear most of the original forest, which then passes onto cattle ranchers. In fact, small farmers occupy a smaller area than any other deforester in the Amazon. In 1980, for instance, total cropped area occupied only 1 percent of total Amazon area, as compared to 4 percent occupied by ranching (Ozorio 1992). However, in spite of this apparent insignificance, small farmers are the most mobile of deforesters. Over their lifetimes, they clear an area far larger than that which they currently occupy.

[4] Although the relationship between population growth and land use is very complex, it cannot be denied that beyond certain population thresholds, population growth increases the pressure on scarce resources (Todaro 1982, p. 162f; World Commission 1987, p. 95f; Keyfitz 1989; Lele and Stone 1989; Anderson and Thampapillai 1990, p. 16; Bromley 1990, p. 2).

[5] Fertility rates in Brazil dropped from 4.8 percent in 1970 to 2.8 percent in 1992 (*World Development Report 1994).* High fertility is often believed to contribute to pressure on fragile environments by creating a large stock of potential migrants in the future. Rising fertility rates would suggest, *ceteris paribus,* a possible increase in the propensity to migrate, whereas declining fertility rates would suggest a decrease. These hypothesized relationships have not held well in Brazil during the past thirty years, however. On the contrary, during the 1960s and 1970s throughout much of the country, inter-regional migrations and urban growth accelerated despite severe declines in the overall fertility rate.

This indicates that internal migrations in general, and to the Amazon in particular, seem to have been spurred more by economic and social factors than by population increase. Even if fertility were to have an impact on migration, such impact would probably decrease internal migrations in Brazil in general, and to the Amazon in particular, as fertility rates continue to decline towards a projected 2.2 percent by 2000 (*World Development Report 1994).*

Table 2.2. Population and Average Rates of Growth: Brazil and Regions (1960-1991)

Area	Growth	Average Annual Geom. Growth Rate		
	1960-91	60-70	70-80	80-91
Frontier:				
North	7,585,436	3.47	5.02	3.96
Center-west	6,456,168	5.58	3.99	3.00
Total	14,040,604	4.65	4.43	3.48
Other Regions:				
Northeast	20,205,448	2.40	2.16	1.81
Southeast	31,490,629	2.67	2.64	1.68
South	10,326,628	3.45	1.44	1.36
Total	62,022,705	2.72	2.26	1.66
Brazil	76,063,309	2.89	2.48	1.89

Source: IBGE, Censos Demograficos; IBGE/CTD, Censo 1991, Resultados Preliminares; DOPO/DPE.

These trends suggest that, until the early 1980s, migrations from old to new frontiers were inter-regional, from the *cerrado* and from other regions to the Amazon. Nowadays, migrations from old to new frontiers seem to have become an *intra*-Amazonian phenomenon.

II. 2 Urbanization and rural exodus

In 1970, 44 percent of the Brazilian population lived in rural areas, as opposed to only 23 percent in 1992.[6] The twenty year period that spanned from the beginning of the decade of Amazon occupation until the chaotic aftermath of the 1980s witnessed the reduction of more than 20 percent of the total rural population in Brazil. In the Amazon, a similar phenomenon occurred during the same period. In fact, ever since the 1960s, the urban population in the frontier has grown at a much higher rate than the rural.[7] The frontier, therefore, is no exception to the process of urbanization that has been occurring throughout Brazil since the 1960s. What is unique about Amazonian urbanization,

[6] These percentages were obtained from the *World Development Report 1994*.

[7] See Martine (1992) for a discussion of urbanization trends in Brazil and in the Amazon.

however, is that it occurs despite the low population density of 0.23 inhabitants per squared kilometer.[8] For this reason, the process of Amazonian urbanization may be considered precocious.

During the 1980s, cities in the Amazon grew and proliferated. Shrinking opportunities in frontier agriculture stimulated the massive migration of would-be settlers to the region's cities. Urbanization, therefore, has become an overriding demographic tendency nationwide, against which frontier expansion is but a weak counter-trend. Increasingly, potential migrants choose to earn a living in urban settings, rather than venture into the forest. Nowadays, the significance of the moving frontier tends to come less from its demographic and social magnitudes than from its environmental consequences.

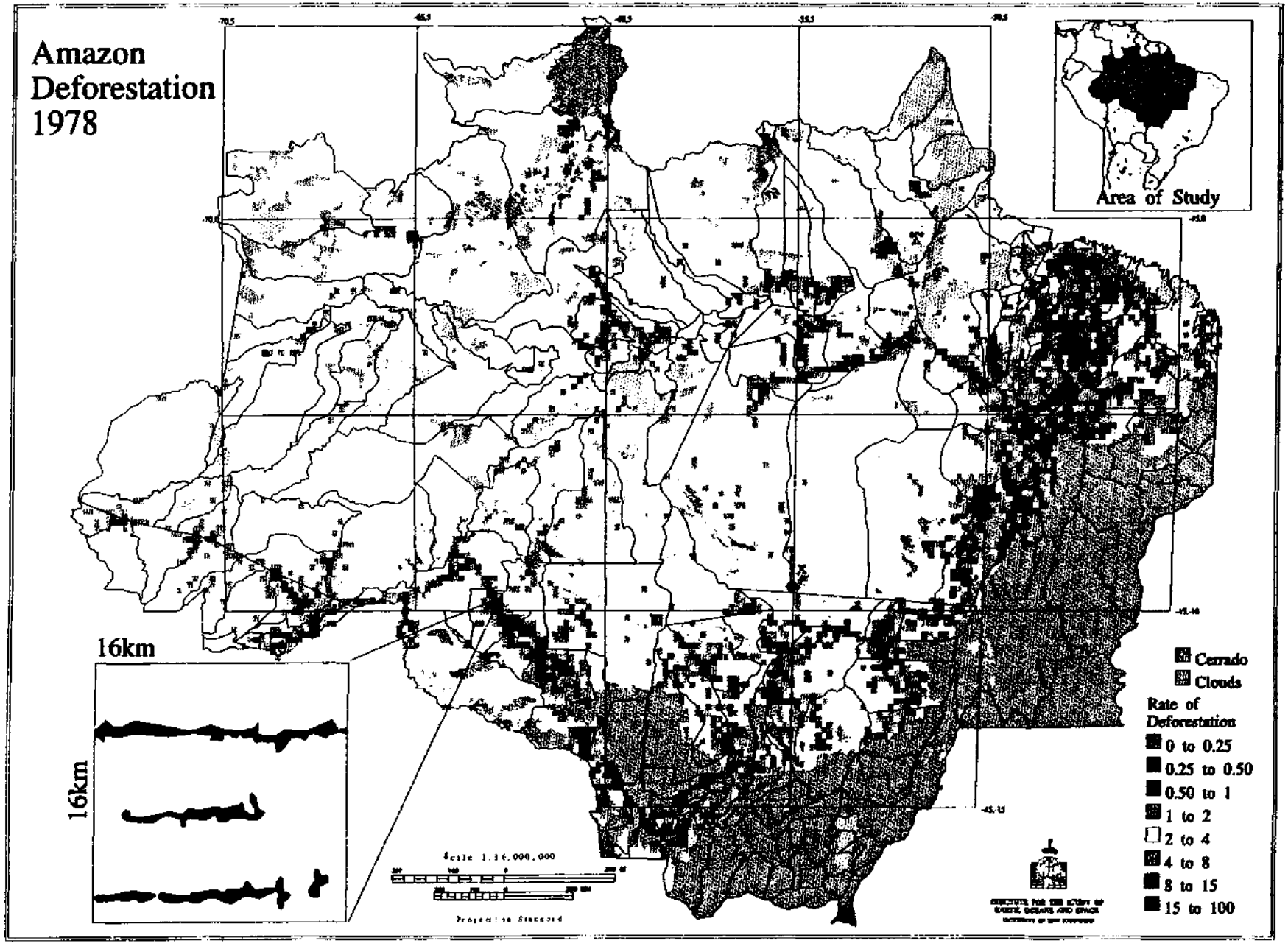
II. *3 Itinerancy and deforestation*

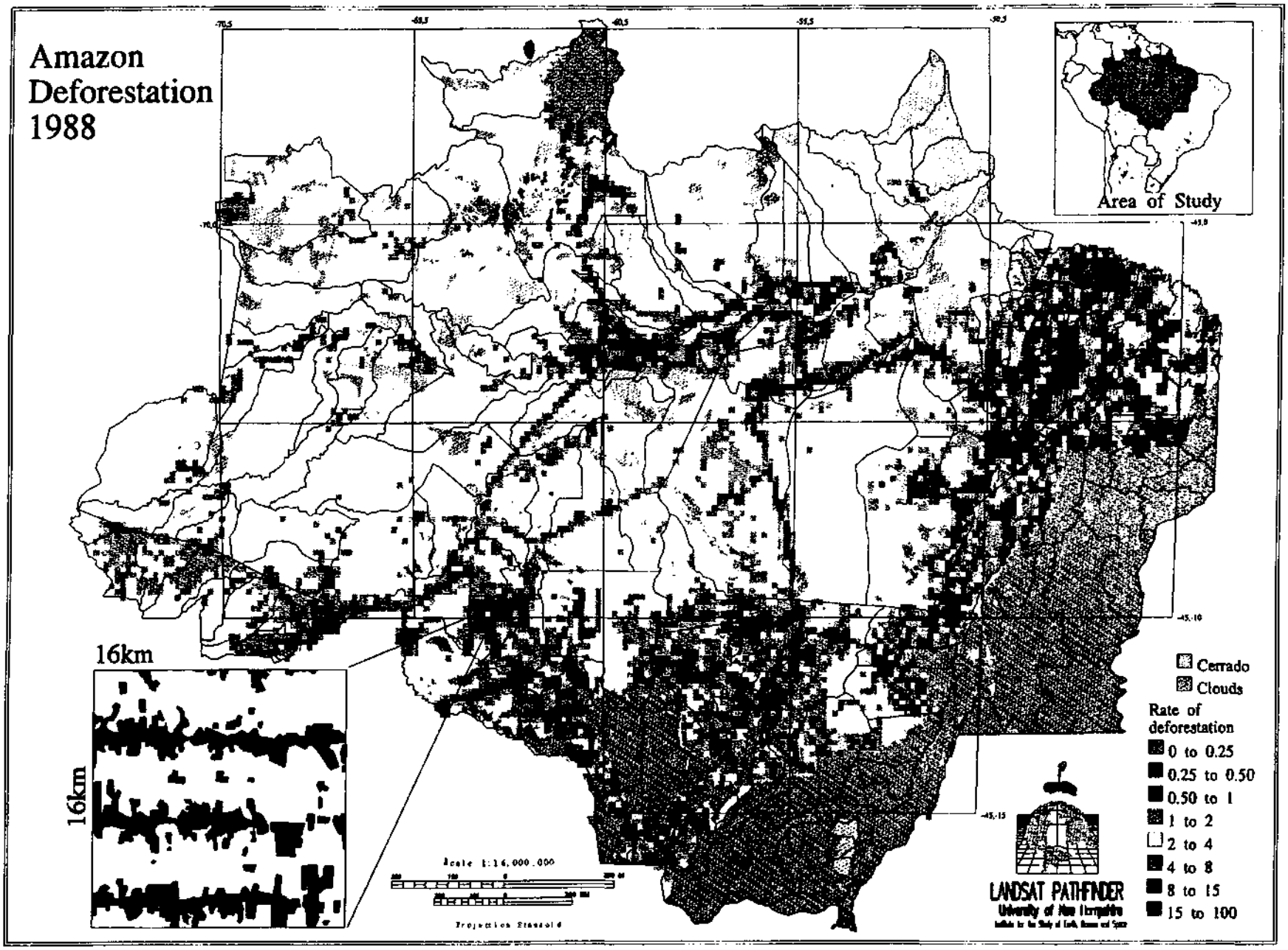
The process of Amazon occupation and the magnitude of small farmer itinerancy and deforestation during the 1980s can be observed by interpreting maps 2.1 and 2.2 in the light of the discussion of previous sections. These maps show vegetative land cover data aggregated at the county level and were obtained by incorporating LANDSAT images to geographic information systems (GIS).

Map 2.1 shows the extension of land that had been cleared by the end of the 1970s, during the formative years of the Amazon frontier. In that decade, continuous tracts of land were cleared for occupation in the states of Para, along the Transamazon highway (labelled 4 in map 2.3), and in Mato Grosso~all of which were targets of the government's National Integration Plan (PIN) of the 1970s. With the closing of the *cerrado* frontier in the late 1960s, the Amazon became the newest agricultural frontier of Brazil, absorbing migrants from the ageing frontier of the center-west and from other regions.

The moving character of the frontier can be more clearly observed by comparing map 2.1 to 2.2. In the 1980s, Para and Mato Grosso-which had become consolidated frontiers—began expelling migrants in the same way that the *cerrado* frontier had expelled its pioneers a decade before. The linear deforestation path that can be observed in map 2.2, coincides with the spatial disposition of

[8] Ozorio and Campari (1995).


Amazon
Deforestation
1978
Area of Study
16km
16km
Cerrado
Clouds
Rate of
Deforestation
0 to 0.25
0.25 to 0.50
0.50 to 1
1 to 2
2 to 4
4 to 8
8 to 15
15 to 100


Amazon
Deforestation
1988
Area of Study
16km
16km
Cerrado
Clouds
Rate of
deforestation
0 to 0.25
0.25 to 0.50
0.50 to 1
1 to 2
2 to 4
4 to 8
8 to 15
15 to 100
LANDSAT PATHFINDER
University of New Hampshire


ATLANTIC OCEAN
equator
RORAIMA
AMAPA
PARA
Belém
São Luis
Manaus
Santarém
Marabá
MARANHÃO
AMAZONAS
CEARA
RIO GRANDE DO NORTE
PARAIBA
PIAUI
PERNAMBUCO
ALAGOAS
SERGIPE
BAHIA
ACRE
RONDONIA
TOCANTINS
MATO GROSSO
Cuiaba
Brasilia
D.F.
GOIAS
MINAS GERAIS
MATO GROSSO DO SUL
ESPIRITO SANTO
SÃO PAULO
RIO DE JANEIRO
PARANÁ
SANTA CATARINA
RIO GRANDE DO SUL
PACIFIC OCEAN
0 400 800
Kilometers
AMAZONIA
National Capital
Cities, Towns
Railroad
Selected Highways
1. PA-150
2. PA-279
3. Belém-Brasília (BR-010)
4. Transamazon (BR-230)
5. BR-364
6. Boa Vista-Pôrto Velho
7. Santarém-Cuiabá

federal roads in the region, mainly with the Transamazon and the Cuiaba-Santarem highways, labelled 4 and 7 in map 2.3, respectively. These roads form true corridors at the core of the rain forest, and small fanners are generally the first ones to take advantage of them as they venture into new frontiers.

Moving further inland may not seem to be a rational behavior as new frontiers are inhospitable, distant from urban centers, and lack the social and physical infrastructure necessary to support occupation.[9] However, new frontiers select for agents with relatively low opportunity costs.[10] Since a family farmer's only opportunity cost is household labor, the farmer will choose to sell out and move once such cost is covered, advancing the frontier and deforesting as he goes. As the frontier closes and access conditions improve, the land that was left behind accrues to a new constituency who may not be farmers at all, but speculators who may choose to hold land for different purposes than did early settlers. Unlike the liquidity-constrained pioneer farmers, newcomers have relatively higher opportunity costs and will tend to put land to its highest value use. In the Amazon, during the 1980s, this translated into the extensive use of land for pastures, which explains the highest rates of deforestation that occurred by the late 1980s in the consolidated areas of Para and Mato Grosso.[11] The successive expulsions of small fanners that have accompanied the consolidation of property in old frontiers created a demographic hollow, mainly along the federal highways which had drawn migrants in one period earlier.

III. *Changing Economic Dynamics*

Since migratory patterns tend to reflect the nature of economic activity, the boom of the 1970s and the crisis of the 1980s affected migratory patterns differently. As opposed to the 1970s, during the 1980s much of the migration-prone population in Brazil (i.e., former share tenants, ex-

[9] Although this is a contested issue, many authors agree that farmers in developing countries are quite rational, considering the risks and uncertainties involved in their activities (Wharton 1969; Kelsey and Quiggin 1989; Winston 1989).

[10] A thorough treatment of different opportunity costs across agents can be found in Anderson and Hill (1990), and in Schneider (1993).

[11] Since the costs associated with the maintenance of cattle are lower relative to the costs associated with commercial agriculture, and since the market price of meat is more stable than that of agricultural products, the encroachment of pastures in the region occurs regardless the agricultural potential of soils. This issue will be discussed in detail in section four.

minifundiarios, and ex-squatters) was gradually absorbed at the source, mostly by cities and towns, reducing the pool of potential inter-regional migrants to the Amazon. The main factors that had induced Amazon-bound migration and deforestation in the 1970s were missing by the mid-1980s:

- the long peak in the business cycle that had originated the "Brazilian miracle" ended and was replaced by a systemic crisis;[12]
- the development aspirations of the centralized military regime that had promoted Amazon occupation was replaced by a decentralized democratic government.[13]

These two events spanned a vector of changes during the 1980s that gave rise to a new regional economic dynamics which endures until the present.

III. 1 *The national context: transition to democracy under economic crisis*

The political transition to democracy and decentralized fiscal federalism dramatically weakened the decision-making power of the federal government, under the provisions of the new Constitution of 1988.[14] Escalating external debt and deteriorating commodity prices made the government more vulnerable to those who opposed expanding the agricultural frontier. As pressures from international agencies and NGOs grew, the general public became more interested in, and informed on, Amazonian issues.

During the decade of the crisis, dwindling federal budgets killed many federal infrastructure investments, while urban centers in the Amazon, swelled by newly urbanized voters with political clout, increasingly defined local priorities. Political/economic opposition to large-scale federal projects such as hydroelectric dams grew while state and municipal projects multiplied.

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[12] During the 1970s, the long peak in the economic cycle drove up real estate prices, mainly in the south, impelling a large population of family farmers to sell their plots (Rezende 1981; Brito 1987). There were obviously other factors that promoted Amazon-bound migrations in the 1970s. Among them, the most important were (1) the legal and political changes in labor relations in agriculture, (2) the penetration of the soybean crop in the south and center-west, consolidating small holdings into large ones, and (3) a severe drought in the northeast in the early 1970s which expelled the rural population from a vast area (Mesquita and Silva 1987).

[13] The military regime coincided with a period of easy access to international finance for large-scale, third-world projects. Characterized by concentrated decision-making and executive power, the military promoted vast resource-using projects in mining/smelting, hydroelectric power, and other industries, which attracted hordes of workers and farmers from other regions of Brazil (Ozorio and Campari 1995).

[14] See Shah (1990); andBonfun and Shah (1991).

Federal investments during the decade of colonization—road construction, titling, settlement, services-that had cost billions of dollars during the 1970s, fell drastically, further discouraging potential migrants during the 1980s.[15] Although vast tracts of land continued to be auctioned off to private colonization firms, or to forestry/agro-industrial concerns from the south and from abroad, they were no longer outrageous giveaways as they had been during the heyday of land purchasing credit and other fiscal incentives. Some large-scale projects were initiated and/or continued during the 1980s in mining/smelting, hydroelectric, and other industries, although these tended to have local impact only (the broadest, by far, being that of Carajás) and to attract migrants from adjacent areas.

III. 2 The weakening role of the federal government

The recent growth of frontier economic activity and the constitutional reform of 1988 inserted the Amazon into the broader national economic context—yet allowing the region to maintain its local dynamics. The fact that most strikingly distinguishes the Amazon of the 1970s from that of today is the capability to generate revenues locally, counterbalancing the loss in fiscal and credit incentives that happened during the crisis of the 1980s.

Fiscal and credit incentives have been held responsible for much of the acquisition and deforestation of large tracts of land in the Amazon during the 1970s.[16] These incentives began to decline during the early 1980s, as can be seen in Table 3.1, and subsidized rural credit in the 1990s is practically non-existent. During the 1970s, fiscal incentives augmented the demand for farm, pasture, and ranch land, thereby increasing deforestation on the frontier of settlement and accelerating the conversion of forest to farmland in already settled areas.

The tax code, until recently, essentially exempted agriculture, and converted it into a tax shelter.[17] Since it was relatively easy to claim any frontier activity as agricultural in nature, this exemption contributed to the run on land by urban investors and corporations attempting to diversify their asset portfolio.

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[15] Approximately US$4 billion was spent on the construction of roads in the 1970s. See Ozorio (1992).

[16] A detailed discussion of government policies that promoted occupation and deforestation in the Brazilian Amazon during the 1970s and early 1980s can be found in Mahar (1989) and Binswanger (1994).

[17] See Binswanger (1994) for a detailed analysis of the impact of agricultural taxation and how it affected deforestation.

Table 3.1 Official Rural Credit in Classic Amazonia 1970-1985 (US$1000)[a]

Year	Total	Year	Total
1970	61,691.60	1978	775,219.02
1971	89,220.02	1979	1,062,084.98
1972	153,763.41	1980	1,095,666.17
1973	178,498.25	1981	748,272.60
1974	118,669.03	1982	506,627.76
1975	288,320.94	1983	275,167.85
1976	523,505.64	1984	115,351.66
1977	573,673.71	1985	172,794.68

[a] All figures were based on constant 1991 cruzados. *Sources:* Adapted from Mahar, D. 1989. *Government Policies and Deforestation in Brazil's Amazon Region*, Washington, D.C.: World Bank. Average 1985 exchange rate: Cr$2,144/US$. Inflation in the United States 1985-1991 = 24.78 percent (World Tables, World Bank).

Tax havens, together with credit subsidies, provoked an early boom in speculative demand for Amazonian land.[18]

As a result of the reforms that occurred during the 1980s, today frontier agents can no longer exclude most of their agricultural profits from their taxable income. This contributes to an increase in locally collected tax revenues—which increased from an average growth rate of 7.10 percent in the pre-reform period (1982-88) to 27.20 percent after the new constitution was in place (1989-1991), compared to increases of 0.44 and 9.31 percentage points during the same periods for the rest of Brazil[19]~and empowers local governments to invest in local physical and social infrastructure. New revenues are, therefore, compensating for the loss in credit and subsidies.[20] This rapid growth shows

[18] See Mahar (1989); and Brandao and Rezende (1992).

[19] The relative high rates of growth in tax income on the frontier over the 1980s, especially after 1989, is apparently due to two events: (a) an increase in the tax base as a result of local economic growth, and (b) improved enforcement, which reduced tax evasion. Aside from these two factors, a large variety of tax instruments began to accrue to state and local governments directly, due to the tax reforms of the 1980s, such as value-added tax and service tax. These tax instruments also increased local tax income. Source: SAFEM, *Execucao Orcamentaria.* For average annual growth rates of federal transfers to and current revenues in the region, refer to Ozorio and Campari (1995, chapter 3).

[20] For example, according to Table 3.1, total official rural credit to Classic Amazonia amounted to almost US$1.10 billion in 1980, its largest year. Two years later, 1982, rural credit had already begun to decline, reaching US$506.60 million. Meanwhile, fiscal revenues for the region were US$360.00 million (SAFEM data, using 1991 constant

that the Amazon has changed from being simply an alternative to penury for floating populations from outside the region, as it was in the 1970s, into a richer and more complex economy with well-defined and fast-growing markets.

III. 3 The Amazonian economic context: shifts in economic activities

Despite the strong reduction in credit and fiscal incentives to agriculture, and in other federal initiatives in the Amazon, forest clearing by small farmers did not correspondingly decline during the 1980s.[21] This suggests that recent deforestation has responded to intra-frontier forces different from those of the 1970s, or even those of the early- or mid-1980s.[22] Although the speculative motive for land clearing may have begun with federal credit and fiscal incentives, it is now being fed by local stimuli.

The local forces that gave rise to the current regime of land rights in the Amazon is closely associated with the behavior of the local urban middle class during the 1980s. The following sections discuss the emergence and economic evolution of a large segment of that middle class, namely merchants, and the implications of their speculative behavior for small-farmer itinerancy and deforestation. Because of space limitations and data constraints, it has not been possible to deal with all members of the Amazon's rising and highly diversified urban middle-class, including persons

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Cruzeiros and exchange rate = Cr$963.80/US$). A decade later, in 1991, total fiscal revenues were US$1.10 billion, which is exactly the value of subsidized credit at its height in 1980. This calculation does not take into account the amount of incomes brought into the Amazon via tax subsidies and shelters. The consensus in the literature, however, appears to be that the rate of return on such subsidized projects was negative and that very little was gained by them in the region. See Ozorio (1991) for a discussion of this literature.

[21] Although the extinction of tax havens did actually reduce the overall rate at which land was being cleared (from 22,000 km^2/yr during 1978-88 to 11,000 km^2/yr during 1990-91) that part of deforestation caused by small farmers increased considerably during the 1980s (Fearnside 1993). This was due to two factors. First, as Binswanger (1994) correctly argues, the tax regime in place until the mid-1980s failed to benefit small farmers, who were poor and generally exempted from taxation. Their share of Amazon deforestation, therefore, never responded significantly to the tax incentives that benefited the rich. Second, in the 1980s, the local-level forces that directly affected small farmer deforestation accelerated. Thus, as that part of deforestation that responded to the earlier tax system declined, the share of deforestation that responded to local conditions increased during the same period.

[22] This *response* was measured econometrically by Ozorio and Campari (1995). Using a panel of 500 households (small farmers) from eight different Amazon locations, the authors found that while deforestation in the 1970s could be explained by characteristics related to the farmers past and access to credit, current deforestation is responding to local conditions.

associated with mining, hydroelectric, manufacturing, processing, and other sectors, or with governmental agencies and NGOs active in Amazonian affairs.

III. *3.1 The merchant frontier*

Although the Amazon is typically thought of as an agricultural frontier, it is more urban than rural, due to the staffing of local public sector agencies and the growth of local commercial activity. The precocious urbanization of the frontier, discussed in section II.2, did not happen solely because of changes in the demographic aspects of the region. An economic dimension of urbanization lies in the presence of a diversified and voluminous tertiary sector: commerce, services, and the public sector. Although many urban services, especially personal services, are undoubtedly swelled by the disguised unemployment of former farmers expelled from their land, frontier commerce is nonetheless highly profitable with outstanding rates of accumulation.

The importance of local merchants can hardly be overemphasized in a discussion of the recent expansion of the Amazonian frontier. These economic agents practice a varied set of activities, all of which have some role in linking primary frontier activities—farming and extraction—to the rest of the economy through market transactions for agricultural or extractive products, productive inputs, consumer goods, credit, land, and labor.

These local transactions determine the appropriation of income and the rate of return both of primary producers—farmers and extractivists~and of merchants. Rates that are above opportunity costs for merchants should invite new entries. However, distance, lack of communications, high transport costs, and other factors may constitute barriers to such entries and foster natural monopolies among merchants, especially when a frontier is relatively new. Such local monopolies may, in turn, increase prices charged (or reduce prices paid) to farmers and reduce farmers' incomes. According to standard long-run microeconomic analysis, rates of return in a given market signal entries, exits, or equilibrium in that market. But in a frontier, where markets are still incipient, the rates of return of merchants become important also in determining entries, exits, or equilibrium among local small farmers. Whether a frontier consolidates with its pioneering small farmers, or whether pioneers are expelled by newcomers and by land concentration, depends greatly on the operation of frontier markets and their merchants.

The merchant frontier seems to lag behind the farming frontier.[23] In the 1970s, businesses in frontier towns were mainly associated with primary activities. This pattern, however, changed in the course of the 1980s, yielding a spectrum of tertiary sector activities with very high rates of accumulation of physical and financial assets.

Overall, the *monthly* average rate of accumulation of frontier merchants in 1991 was an impressive 2.56 percent, although this was in fact low when compared to the average of 14.5 percent ten years earlier.[24] What had been beginners' monopoly power apparently eroded during the 1980s as new entrants competed for local markets, as the towns themselves grew with diversified commercial activities, and as local agricultural lands were increasingly turned to pasture. The most successful among the local merchants—and therefore the ones who purchased land and converted it into other uses the most rapidly-were those who functioned as intermediaries in frontier commerce, serving as a liaison between local farmers and the rest of the economy. Most of these merchants had trading partners outside the region, whom benefited from a large share of profits generated by local commerce. Commercial profits not sent to trading partners outside the Amazon tended to be invested in local land purchases.

III. 3.2 Merchant accumulation in land

Frontier merchants are accumulating in two different activities, namely commerce and agriculture. Many of those who migrated to the Amazon did so because they wanted to become landowners, and commerce may have been a stepping stone to that end. Table 3.2 shows that in 1991 agricultural assets represented approximately one third of merchants' total assets. The highest average was in Western Amazonia, indicating that such merchants invested proportionately more in land than did

[23] The field work in the Amazon provided corroborating evidence to the hypotheses raised by Anderson and Hill (1990) on the optimal timing for settlement in a frontier. Although these authors tested their hypotheses against evidence from instances in U.S. history, the Amazon frontier fit their model extremely well. Section five will discuss such extension in more detail.

[24] The rate of accumulation measures the rate of increase in real net worth over time, i.e. the geometric average rate of increase in real value of physical and financial assets minus debt outstanding since arrival to the frontier to the present. In cross sections, it is a better measurement of performance over time than the rate of return, which requires observations of an income stream in several different moments in time. By disregarding all incomes not reinvested in the business, the rate of accumulation can be considered an underestimate of the rate of return. See Ozorio and Campari (1995).

their Eastern counterparts. In fact, the Gini coefficients of land concentration in Western Amazonia was 0.91 as opposed to 0.81 in Eastern Amazonia in 1985.[25]

Table 3.2 Agricultural assets/Total assets
Frontier Merchants (1991)
(Weighted Averages)

Eastern Amazonia	28.87
Western Amazonia	33.32
Frontier Total	32.13

Source: Angela Moulin Penalva Santos, *Comércio: Fronteira de Negócios na Colonização da Amazônia*, Rio de Janeiro: IPEA, 1993.

In a frontier, becoming a commercial farmer or rancher requires investments with long gestation periods. Gaining title to land implies mapping, demarcating, litigating, and registering the plot with different, loosely coordinated official entities and authorities, who must be present for contracts to be enforceable. Surveying, forest cutting, burning, stumpage, and soil correction must all be done before ordinary farming or ranching begin, and markets for credit, agricultural products, inputs, and labor must be established for commercial farming to be able to operate. Since commercial farming cannot function outside the standard institutions of a market economy—with local wage-labor scarcity posing a potential problem for those who intend to engage in such activity in new frontiers-many migrants tend first to operate urban businesses and only slowly, over the years, to invest in agriculture. The consolidation and concentration of land ownership, the occurrence of rural exodus and urbanization, and the formation of a wage-based labor force contribute to easing the way for local commercial agriculture to develop. Until this becomes possible, merchants bide their time purchasing land. Whether they will eventually become productive commercial farmers or hold land for speculative purposes will depend on relative returns.

Of course, Amazon reality is far more complex and varied than would appear from such a schematic rendering. In many locations, commercial farming precedes and preempts small farmer settlements. In others, there is no attempt to farm whatsoever; only ranching or outright speculative land-grabbing exist. What is clear is that in old frontiers during the inflationary economy of the

[25] See Margulis (1990) for these Gini coefficients.

1980s, merchant demand for land for speculative rather than for productive purposes increased. The lands these merchants bought were sold to them by poor (although not exclusively so) local farmers, many of whom moved on to deforest further inland. Whether because of lack of expertise or outright speculation, newcomers have tended to eradicate crops, even productive perennials such as coffee and cocoa, and turned much of the land to pasture.

IV. Turnover on plots[26]

Evidence from a recent household survey on colonization projects in the Brazilian Amazon reveals that the region has better agricultural potential than is generally accepted. Table Al of appendix A shows that during the 1980s average annual agricultural yields rose considerably (and almost unambiguosly) in all sampled locations. Overall, yields of rice have increased 29% over the 10-year period, that of corn by over half, and that of coffee by over 300% during the decade.[27] Also consistent with this record of success, table A2 shows that land prices have also increased by an overall (unweighted) average of 15% in real terms during the decade.[28] The survey also shows that during the 1980s, colonists' incomes and asset accumulation were high relative to similar indicators elsewhere in Brazil (see tables A3 and A4).

Despite the excellent economic performance of agriculture in many locations, table A5 shows that, overall, only about 64% of those who were interviewed in 1981 were still in the same farms in 1991, i.e. over a third had moved during the 10-year period. Strikingly, table A6 shows that, on average, farmers remained on the same farm for 13 years, varying from 9 to 25 years.[29] This

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[26] The evidence of this section is based on empirical evidence based on five hundred households visited in 1981 and 1991 in eight colonization projects in the Brazilian Amazon. The complete theoretical and empirical models, as well as the econometric analysis of this panel are thoroughly discussed in Ozorio and Campari (1995).

[27] It may be argued that coffee is not representative here because it is only one specific location (Pacal) that is bringing up the average of the sample.

[28] This average masks large variation among settlements, however, varying from nearly 200% for Anapu-Pacaja, to -44% for Alta Floresta, with land prices increasing on the remaining settlements between 24% and 100%.

[29] The average of the sample seems to be an overestimate of the actual number of years that a farmer remains on the same plot. A simple numerical example illustrates this point. According to *World Resources* (1992, table 19.1, p. 287), during the period 1981-85, the rate of deforestation in the Amazon was approximately 0.5 percent of total area per year. According to Ozorio (1992), in 1980, total cropped area covered only 1 percent of total area. Dividing total cropped area (1 percent) by total yearly deforested area (0.5 percent) implies that crops remain, on average, only two years on

indicates that turnover on plots and deforestation in many locations must be responding to local-level forces that are unrelated to productivity decline.

Tables A5 and A7 show that the turnover of small farmers on plots within the Amazon is closely associated with the high deforestation in the region. Small farmers, once displaced from the lots they currently occupy, may decide to deforest and farm elsewhere, expanding the frontier. The decision to move is made independently of the economic rents that accrue from the agricultural use of land. Given that in consolidated frontiers land values were observed to vary haphazardly and independently of soil productivity,[30] selling out is indeed a best response to the speculative behavior that operates everywhere in the Amazon. In any given plot, if rents from agriculture are negative, a farmer's best response is to sell out. If normal rents from agriculture are accruing, the farmer will only hold on to his land so long as no one makes an offer that compensates for the discounted rent gains. Newcomers (speculators), not having to face the liquidity constraints that are generally binding for early settlers, can afford to pay more for the plot than the value of the discounted rents that would accrue to small farmers—which, after all, may not be much compared to the capital gains that can be made from speculation in an inflationary economy. As the potential gains from speculation in frontier land markets came to compete directly with the agricultural potential of soils, selling the plot became a rational and profit-maximizing response to the operating mechanism of the highly segmented frontier land market.

The fact that real rents from agriculture are accruing, but yet turnover on plots and

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each deforested plot. The underutilization of, and turnover on, deforested plots in the Amazon is very high indeed. In this sense, the most effective way to reduce small farmer deforestation would be to increase the duration of the farmer on each deforested plot.

[30] In established economies, land values tend to vary with productivity, which becomes capitalized into land rent and real estate value. This is not so in the Amazon frontier, however, where many other factors affect the formation and evolution of land values. According to results of field surveys analyzed in Ozorio and Campari (1995) and reproduced in the tables of the appendix, the most spectacular fall in land values occurred where coffee growers gave up on agriculture and turned most of their land to pasture, as coffee prices plummeted during the 1980s (see Alta Floresta-Paranaita in table A2). The largest percentage increase occurred where productivity was lowest and where original price was also lowest (see Anapu-Pacaja in table A1). The latter was the location where land was turned to pasture the most rapidly. Thus, the evolution of land values depends on several other factors aside from soil productivity, such as: distance to markets, road conditions, tenure security, access to social infrastructure (education, health services, extension, amenities), income level of potential residents, and many others.

consequent deforestation remain high, puzzle some authors as an apparent paradox.[31] When such behavior is discussed under the light of the recent changes in frontier dynamics, however, the puzzle is resolved. As a frontier closes, land values near cities appreciate, impelling a growing number of small farmers to sell their plots.[32] Those who do not sell are mainly the outstandingly productive, whose profits are plowed back into expanding agriculture, and the outstandingly indebted, whose repayment obligations lock them into their shrinking farms.

V. Unequal Ownership and Deforestation

Small farmers in the Brazilian Amazon have typically farmed along many migratory steps. Many were squatters and tenants who moved from farm to farm, living off lands that were never theirs. Some were landowners, who bought, deforested, sold, and profited from successive plots. Relative high returns to household labor and capital, and relative low returns to land, have kept small farmers moving, shifting the frontier forward.

In recent years, frontier land values have appreciated beyond the growth of agricultural productivity mainly because of an inflationary economy in general, and a prospering urban frontier economy in particular. Rising land values set off different reactions among farmers. Many original settlers reaped capital gains and moved from old to new frontiers within the Amazon, which they proceeded to deforest and leave once again. Others held on to their lands, but diversified out of agriculture. The more urban groups held onto land mainly for speculative motives. Last but not least, some highly successful farmers neither moved out of their lands, nor of agriculture. On the contrary, they expanded their holdings and increased their agricultural production. They also deforested at an accelerated pace. In sum, relative to other farmers, more successful farmers can be observed to deforest very rapidly where they are (in consolidated frontiers), while less successful farmers deforest where they are moving to (new frontiers). Meanwhile, land originally cleared of forest for farming is being added to the net worth of a non-farming and mostly urban middle class.

The above discussion provides corroborating evidence to the hypothesized relationships raised

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[31] See Schneider (1993) for a literature review on this paradox.

[32] During the 1980s, the economic crisis enhanced the magnitude of this process.

by Anderson and Hill (1990) on the optimal timing for settlement in a frontier. They argue that some form of settlement first occurs with the arrival of squatters, who define and enforce activity, i.e., occupy and deforest, before rents become positive. This early arrival is part of a process of self-selection, in which individuals with relatively low opportunity costs can afford to move to the frontier sooner. In the case of a small farmer, such costs are generally represented by household labor.

Commercial agriculture will only begin at a later period, when the discounted value of future rents is at least equal to the price paid for the land. In the Brazilian Amazon, commercial farming generally will not begin before the frontier consolidates, i.e., before transport conditions improve (to support the flow of output) and urban centers emerge (to provide agricultural inputs as well as the minimum required social infrastructure to support settlement).

According to the above hypothesis, speculators who purchase land before true rents begin to accrue will hold such land out of production. This is a rational behavior since these agents tend to have higher opportunity costs than did early settlers, i.e. the opportunity cost of capital. Since land values in the Amazon frontier have increasingly appreciated during the 1980s, the gains from speculation came to compete directly with the agricultural potential of soils. As land ownership became more and more concentrated in the hands of speculators (Gini coefficient of 0.91 in the state of Mato Grosso in 1985), farmland was increasingly converted to pasture or held in fallow, regardless the agronomic suitability of soils. This was a frontierwide phenomenon which can be accounted for much of the deforestation in the region until today. Thus, though much of Amazon deforestation has been done by small farmers, they have not necessarily kept the land they cleared.

VI. Summary and Policy Implications

A defining characteristic of a frontier settlement area—and the feature that analysts find the most perplexing to contend with—is rapid change. Because history moves at high speeds in such places, it has a persistent habit of leaping ahead of analytical grasp, rendering obsolete hard won conclusions that now seem to apply only to a previous period. It is no exaggeration to say that much of what is known about the Amazon today is outdated.

This paper attempted to convey the changing character of the Amazon frontier and its impact on the current regime of land rights in the region. By observing the behavior of frontier agents from

the major thrust toward occupation during the 1970s, until the chaotic aftermath of the 1980s, this paper pinpoints a central "paradox": despite high incomes, turnover on plots is high in some Amazon locations. A thorough discussion of current frontier dynamics, however, shows that this apparent paradox is truly a rational and profit-maximizing response of different agents to intra-frontier conditions, that is being reflected on the structure of the land rights regime. The disentangling of these agents' trajectories and logics makes a compelling platform for designing appropriate policies for the conservation of the rain forest. Small fanners have been responding increasingly to economic conditions that reward speculation and encourage deforestation. Without new policies designed to change these conditions, therefore, the 1990s will probably witness continued deforestation, fuelled by growing intra-regional expulsions and migrations.

Small farmers who deforested the Amazon during the 1970s and 1980's had mostly migrated there from *outside* the basin. The small farmers deforesters of today, however, have apparently mostly come from *within* the region. The greatest threat from small farmers to the forest, therefore, now seems to come from intra-regional migrations. The issue now is thus no longer how to prevent deforesting farmers from migrating to the Amazon from the rest of Brazil, but how to ensure that farmers already in the Amazon stay where they have already deforested, thus reducing migration (and deforestation) further inland. Intra-regional migrations can be stemmed only by establishing sustainable farming in already deforested areas. Such sustainability does not appear likely to attract inter-regional migrants, because of irreversible changes that have occurred during the 1980s in Brazil's population and economy.

The crisis of the 1980s brought changes to both the overall Brazilian economy and that of the Amazonian frontier. Factors such as federal fiscal subsidies and credit, as well as expenditures on colonization, land titling, and roads that had promoted inter-regional migration throughout the 1970s began to disappear in the 1980s. Meanwhile, the transition to democracy, increasingly decentralized fiscal federalism, and a growing urban economy promoted intra-regional migration. A frontier middle class, composed of merchants and other groups, such as public servants, private sector employees, and others, is becoming the ultimate beneficiary of deforestation in the Amazon.

Markets for land, labor credit, consumer goods, and agricultural inputs and products have favored the development of urban private businesses. As urban activity grew in areas that had been

frontiers in the 1970s, land ownership became concentrated and commercial agriculture replaced small farming practices. These old frontiers are linked to the rest of the Brazilian economy by merchants who transact with local farmers and extractivists, a role that appears to benefit both the merchants and their outside trading partners, but not poor small farmers. The number of agents interested in, and actively involved with, the growth of the Amazonian economy is far greater than those actually living in the region. Thus, economic policies that alter frontier trends will affect a large and growing business community, inside and outside the Amazon.

The process of urbanization in old frontiers culminates with highly concentrated ownership structures and high turnover on lots. Whether in response to inflation and the protracted economic crisis, or for the sake of speculative gains, the urban middle class is purchasing more and more land. This further inflates frontier land prices, pushes pioneer farmers out, stimulates intra-regional migration, and causes the spread of unfarmed, deforested land. Policies aimed at curbing deforestation must take into account who these newcomers are and what their motives are for holding land.

One approach for those concerned with forest conservation would be to support obstructions to the migratory flow. On the one hand, conservationists may oppose infrastructure that is necessary for sustainable farming systems, such as roads and energy, social overhead investments, and any form of directed settlement. On the other hand, they may encourage setting up forest reserves and increasingly protect them from encroachment. This approach has limitations, however. It does not address what is causing small farmers to leave old frontiers, and it bars them from the new ones they desperately need. Increasing the sustainability of settlement in old Amazonian frontiers requires learning from the errors of the past, which led to unsustainable colonization, and avoiding those of the present, which oppose any new settlement.

TABLE A1 Distribution of Annual Yields, 1981 and 1991
(kilograms per hectare)

	Rice		Corn		Coffee	
	1981	1991	1981	1991	1981	1991
Para: Official colonization						
Pacal	1,097	1,765	859	1,500	200	2975
Anapu-Pacaja	1,068	1,007	704	902	415	658
Monte Alegre	1,010	1,369	941	1,500		
Average	1,077	1,402	844	1,301	307	1,816
Mato Grosso: Private colonization						
Alta Floresta	1,541	1,390	1,527	1,573	696	933
Paranaita*		1,683				
Mutum	1,244	1,861	1,230	2400	485	
S.J.Rio Claro	807		1,092	1,500	599	549
Average	1,352	1,671	1,255	1,824	550	741
Total	1,166	1,502	1,005	1,563	396	1,278

* Paranaita means included in Alta Floresta means.

TABLE A2 Prices for Crops and Land, 1981 and 1991
(U.S. dollars per kilogram)

	Rice		Corn		Coffee		Land (U.S. dollars per hectare)	
	1981	1991	1981	1991	1981	1991	1981	1991
Para: Official colonization								
Pacal	.14	.14	.09	.14	.16	.17	130	248
Anapu-Pacaja	.13	.12	.09	.14	.90	.17	20	59
Monte Alegre	.14	.	.10				70	87
Aver e	.13	.12	.09	.14	1.13	.17	80	131
Mat Grosso: Private colonization								
Alta Floresta	.13	.10	.10	.09	.38	.29	460	258
Paranaita*		.14						
Mutum	.14	.11	.13	.08			220	398
S.J.Rio Claro	.11	.15	.09	.11	.39		200	267
Average	.13	.11	.10	.09	.38	.29	290	308
Tot	.16	.12	.10	.12	.76	.23	190	219

* With exception of one, all other Paranaita means are included in Alta Floresta means.

TABLE A3 Net Income, 1991
(thousands of U.S. dollars)

	Southerner	Other	Total
Para: Official colonization			
Pacal	-6.3	8.5	.8
Anapu-Pacaja	1.8	2.5	2.5
Monte Alegre	.2	-13.8	-12.0
Average	-4.6	.2	-1.4[x]
Mato Grosso: Private colonization			
Alta Floresta	28.2		28.2
Paranaita	24.1		24.1
Mutum	72.3		72.3
S.J.Rio Claro	11.3		11.3
Average	32.2		32.2[y]
Total	22.0	.2	14.0

Upper Case C:
The presence of a common letter superscript indicates that there is a difference at the 10% level of significance between origin groups,
(ie. Southerner vs. Other).

Lower Case Letters:
The presence of a common letter superscript indicates that there is no difference at the 10% level of significance in the following cases:
Vertically (within column) - lower case letters.
a, b, c, d - Between locations (ex. Pacal vs. Mutum vs. Monte Alegre...).
x, y - Between States (Para vs. Mato Grosso).

TABLE A4 Distribution of Total Net Worth
(thousands of U.S. dollars)

	Southerner			Other			Total		
	1981	1991		1981	1991		1981	1991	
	Total	Survivor	Total	Total	Survivor	Total	Total	Survivor	Total
Para: Official colonization									
Pacal	38.7^{cd}	38.9^{bc}	50.4^{b}	37.4^{a}	60.4^{a}	63.1^{a}	38.1^{cd}	50.1^{bc}	57.7^{c}
Anapu-Pacaja	13.2^{d}	9.9^{c}	79.4^{b}	15.2^{b}	17.1^{ab}	29.2^{b}	15.0^{d}	15.3^{c}	36.6^{c}
Monte Alegre	172.9^{Ab}	168.7^{Bb}	168.7^{Cb}	19.7^{Ab}	11.3^{Bb}	11.6^{Cb}	37.0^{cd}	42.8^{bc}	33.5^{c}
..verage	43.9^{x}	51.4^{x}	68.0^{x}	23.3^{D}	34.6	37.5^{D}	29.5	40.7^{x}	45.8^{x}
Mato Grosso: ivate lonization									
Alta Floresta	54.0^{Dcd}	64.1^{bc}	106.3^{Db}				54.0^{Dbc}	64.1^{bc}	106.3^{Dbc}
Paranaita	39.3^{Dcd}	63.4^{bc}	106.0^{Db}				39.3^{Dcd}	63.4^{bc}	106.0^{Dbc}
Mutum	264.2^{Da}	564.1^{a}	513.0^{Da}				264.2^{Da}	564.1^{a}	513.0^{Da}
S.J.Rio Claro	80.4^{c}	124.8^{bc}	141.2^{b}				80.4^{b}	124.8^{b}	141.2^{b}
Average	78.0^{Dy}	164.5^{y}	176.5^{Dy}				78.0^{D}	164.5^{y}	176.5^{Dy}
Total	68.9^{D}	127.6	147.2^{D}	23.3^{D}	34.6	37.5^{D}	51.6^{D}	93.7	101.4^{D}

Upper Case Letters:
The presence of a common letter superscript indicates that there is a difference at the 10% level of significance in the following cases:

rizontally Between Subgroups (Southerner, Other, Total):
Southerner 1981 vs. Other 1981.
B - Southerner Survivor vs. Other Survivor.
C - Southerner 1991 Total vs. Other 1991 Total.

rizontally Within Subgroups (Southerner, Other, Total):
D - 1981 vs. 1991 Total.
E - Survivor vs. 1991 Total.

Lower Case Letters:
The presence of a common letter superscript indicates that there is **no** difference at the 10% level of significance in the following cases:
Vertically (within column) - lower case letters.
a, b, c, d - Between locations (ex. Pacal vs. Mutum vs. Monte Alegre...).
x, y - Between States (Para vs. Mato Grosso). Surv - 'Survivors'; farmers who were interviewed in both 1981 and 1991 on the same plot of land.

TABLE A5 Distribution of Survivors, 1991

	Southerner				Other				Total			
	Survivors		Total		Survivors		Total		Survivors		Total	
Para: Official colonization	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Pacal	39	83	47	100	33	66	50	100	72	74	97	100
Anapu-Pacaja	8	67	12	100	24	44	55	100	32	48	67	100
Monre Alt[illegible]	6	100	6	100	29	78	37	100	35	81	43	100
Total	53	82	65	100	86	61	142	100	139	67	207	100
Ma[illegible] Gr[illegible]: Priv[illegible]e colonization												
Alta Floresta	48	63	76	100					48	63	76	100
Paranaita	20	56	36	100					20	56	36	100
Mutum	17	68	25	100					17	68	25	100
S.J.Rio Claro	10	53	19	100					10	53	19	100
Total	95	61	156	100					95	61	156	100
Total	148	67	221	100	86	61	142	100	234	64	363	100

TABLE A6 TIME ON LOT, 1981 and 1991
(years)

	Southerner			Other			Total		
	1981	1991		1981	1991		1981	1991	
	Total	Survivor	Total	Total	Survivor	Total	Total	Survivor	Total
Para: Official colonization									
Pacal	6.1^{b}	16^{bc}	14^{b}	6.8^{b}	17^{b}	14^{b}	6.4^{Db}	16^{b}	14^{Db}
Anapu-Pacaja	3.8^{Dbcd}	14^{bc}	14^{Db}	3.7^{c}	13^{b}	8.5^{c}	3.7^{Dc}	13^{b}	9.3^{Dc}
Monte Alegre	19^{Da}	29^{a}	28^{Da}	16^{a}	33^{a}	25^{a}	17^{Da}	32^{Ea}	25^{DEa}
Average	6.6^{D}	17^{B}	16^{D}	7.8^{D}	21^{BE}	15^{DE}	7.4^{D}	19^{E}	15^{DE}
Mato Grosso: Private colonization									
Alta Floresta	2.8^{cd}	13^{bc}	10^{b}				2.8^{Dc}	13^{b}	10^{Dbc}
Paranaita	1.5^{d}	12^{bc}	9.5^{b}				1.5^{Dc}	12^{b}	9.5^{Dbc}
Mutum	1.5^{d}	12^{c}	10^{b}				1.5^{Da}	12^{b}	10^{Dbc}
S.J.Rio Claro	4.2^{bc}	16^{b}	13^{b}				4.2^{Dbc}	16^{b}	13^{Dbc}
Average	2.6^{D}	13	10^{D}				2.6^{D}	13^{E}	10^{DE}
Total	3.7^{DA}	14^{EB}	12^{DEC}	7.8^{DA}	21^{EB}	15^{DEC}	5.3^{D}	16^{E}	13^{DE}

Upper Case Letters:
The presence of a common letter superscript indicates that there is a difference at the 10% level of significance in the following cases:

Horizontally Between Subgroups (Southerner, Other, Total):
A - Southerner 1981 vs. Other 1981.
B - Southerner Survivor vs. Other Survivor.
C - Southerner 1991 Total vs. Other 1991 Total.

Horizontally Within Subgroups (Southerner, Other, Total):
D - 1981 vs. 1991 Total.
E - Survivor vs. 1991 Total.

Lower Case Letters:
The presence of a common letter superscript indicates that there is no difference at the 10% level of significance in the following cases:
Vertically (within column) - lower case letters.
a, b, c, d - Between locations (ex. Pacal vs. Mutum vs. Monte Alegre...).
x, y - Between States (Para vs. Mato Grosso). Surv - 'Survivors'; farmers who were interviewed in both 1981 and 1991 on the same plot of land.

TABLE A7 Deforestation Since Arrival on the Frontier
(not necessarily in current plot)
(hectares)

	Southerner	Other	Total
Para: Official colonization			
Pacal	71.78^{b}	74.89	73.30^{b}
Anapu-Pacaja	410.25^{ab}	164.62	206.19^{b}
Monte Alegre	530.75^{Ca}	60.70^{C}	129.49^{b}
Average	177.96	108.09	130.29
Mato Grosso: Private colonization			
Alta Floresta	133.18^{b}		133.18^{b}
Paranaita	92.89^{b}		92.89^{b}
Mutum	581.71^{a}		581.71^{a}
S.J.Rio Claro	203.11^{ab}		203.11^{b}
Average	198.46		198.46
Total	192.24^{C}	108.09^{C}	159.03

Upper Case C:
The presence of a common letter superscript indicates that there is a difference at the 10% level of significance between origin groups,
(ie. Southerner vs. Other).

Lower Case Letters:
The presence of a common letter superscript indicates that there is no difference at the 10% level of significance in the following cases:
Vertically (within column) - lower case letters.
a, b, c, d - Between locations (ex. Pacal vs. Mutum vs. Monte Alegre...).
x, y - Between States (Para vs. Mato Grosso).

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