

NBER WORKING PAPER SERIES

THE DETERMINANTS AND IMPACT OF  
PROPERTY RIGHTS: LAND TITLES  
ON THE BRAZILIAN FRONTIER

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Working Paper 5405

NATIONAL BUREAU OF ECONOMIC RESEARCH  
1050 Massachusetts Avenue  
Cambridge, MA 02138  
January 1996

We give special thanks to the research assistance and comments provided by James Dalen, Jr., Jeffrey Fuller, Bernardo Mueller, and Ricardo Tarifa. We benefitted from lengthy comments provided by Ron Oaxaca and Pablo Spiller. We also received helpful suggestions from Ann Carlos, Linda Cohen, Gershon Feder, Price Fishback, Doc Ghose, Shawn Kantor, Larry Neal, Barbara Sands, Leslie Stratton, Les Taylor, the referees, and participants at seminars at Clemson University; University of California-Berkeley; University of California-Riverside; Utah State University; Conference on the Use of Quantitative Methods in Canadian Economic History, University of Western Ontario, October 1995; University of Colorado; Colorado School of Mines; University of Illinois; University of Michigan; Northwestern University; University of Washington; and Economic History Association Meetings, Tucson, September 1993. We acknowledge gratefully the financial assistance provided by the National Science Foundation grants SES 92113603 and SBR 9512107 and The World Bank. This paper is part of NBER's research program in the Development of the American Economy. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

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ABSTRACT

This paper provides new empirical results regarding the demand and supply of title, its impact on land value, and its effects on agricultural investment on Brazilian frontiers. We use survey data from 1992 and 1993 from the state of Pará with data on the characteristics of the settlers, land tenure, land agencies involved, land values, and investment. We then turn to census data from the Brazilian agricultural census from 1940 through 1985, with observations at the municipio (county) level to examine the development of property rights to land in the southern state of Paraná during the agricultural boom between 1940 and 1970 and in the Amazon state of Pará during the period of rapid migration to the region after 1970. By examining frontiers we can follow the rise in land values, the increase in the demand for title, and the response of government. The empirical findings support the predictions of the theory regarding the effects of title and investment on land value, the role of expected change in value on demand for title, and the contribution of title in promoting investment. Governments, however, have not exactly followed the predictions of the analytical framework in supplying title. Political and bureaucratic factors play an important role in the government response to demands for title. This result suggests that researchers must pay special attention to the complex political process by which property rights are assigned in studying the emergence of tenure institutions.

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“What I have done is to show the importance for the working of the economic system of what may be termed the institutional structure of production.” Ronald Coase (1992, p. 713).

## I. Introduction.

Recent work in economics, law, and political science has directed attention to the importance of a society's institutional structure in determining incentives for economic behavior and performance.<sup>1</sup> Although much of the focus of this literature has been on the firm and other organizational and political institutions within developed economies, analyses increasingly have turned to questions of economic development.<sup>2</sup> Indeed, the existence of property rights institutions and their impact on market expansion, investment, and resource use has become a central issue in attempts to explain differences in economic growth.<sup>3</sup> Further, the absence of well-defined property rights is cited as a key contributor to rapid deforestation and other examples of "wasteful" land use in developing areas.<sup>4</sup> As a case in point, Brazil is the country most often cited for deforestation and other alleged environmentally-damaging actions in the Amazon, and unclear property rights are suggested as a source of the problem.<sup>5</sup>

Despite the importance of property rights institutions as a basis for the development of markets and for encouraging long-term investment, more empirical work is necessary to better understand the development of property rights, including the supply of formal title by governments, the effects of title on asset values, and the ways in which having title may change economic behavior.<sup>6</sup> Accordingly, additional research on property rights institutions contributes both to narrower issues of economic development and to broader questions of institutional change.

In this paper, we provide new empirical results regarding the demand and supply of title, its impact on land value, and its effects on agricultural investment on Brazilian frontiers. We first draw upon household data collected from a survey conducted by the authors in 1992 and

1993 at four frontier sites in the state of Pará for 206 small holders for a more micro analysis of the development of property rights institutions. We have data on the characteristics of the settlers, the nature of their land tenure, the identity of the land agencies involved, land values, and investment. These survey data are for individuals and are more detailed than those available in the census data that we turn to next. We use census data from the Brazilian agricultural census from 1940 through 1985, with observations at the município (county) level to examine the development of property rights to land on two agricultural frontiers. We examine the emergence and impact of land titles in the southern state of Paraná during the agricultural boom between 1940 and 1970 and in the Amazon state of Pará during the period of rapid migration to the region after 1970. With census data across time, we can observe much greater variation in land value, tenure, and investment than is possible with household survey data, which do not exist over such a long time period or for comparable frontier regions. As such, we can determine whether the development of property rights to land changed over time as relative prices changed. If the results are similar for both data sets, we can have greater confidence in the robustness of the tests of the theory.

In our analyses, the frontier is defined with respect to distance from a market center, and it is the point where the net present value of land use just covers the opportunity cost of the claimant. By examining the frontier, we can follow the rise in land values with movement toward a market center, the associated increase in demand for title, and the response of government to those demands.

Although frontiers often are associated with the nineteenth century or earlier, there are cases in the twentieth century where there have been significant migrations to previously-unoccupied land. For example, there was rapid settlement of unoccupied government land in the state of Paraná after 1940. The population of the state rose from approximately 1,200,000 in

1940 to nearly 7,000,000 by 1970. Between 1940 and 1960, the amount of agricultural land almost doubled and the number of farms increased more than four fold. Migration to the Brazilian Amazon has occurred since the late 1960s, often through directed government colonization projects. For example, the population of the state of Pará in the northeast Amazon grew from just over 2,000,000 in 1970 to more than 4,000,000 in 1985.<sup>7</sup> The land in farms doubled in the 1960s and again in the 1970s, and the number of farms rose sharply. Beginning in earnest in the 1960s, new lands were opened for private claiming through construction of road systems, such as the TransAmazon and Belém-Brasília highways.

## II. The Role of Title in Documenting Property Rights to Agricultural Land.

Before describing the analytical framework and the data used in the analysis, it is important to summarize the role of title to land in Brazil and the process by which individuals can claim land and receive title to it. Title is a formal document, issued by the Brazilian federal government or the state government, depending on jurisdiction, that signifies government recognition of an individual's property rights to land. Having a title not only gives legal standing to the land owner, but the recording of the title in the local land registry (cartório) includes survey descriptions (memorial descritivo), the location of boundary markers, and the date of recording to establish precedent for the land claim. Land exchanges are recorded by the cartório in a document which includes a "cadeia dominal," a list of previous owners. This record can be valuable if there are disputes over land transfers. With title, the police power of the state is used to enforce private property rights to land, according to surveyed and recorded individual property boundaries. The courts issue eviction notices or arbitrate boundary disputes, and law-enforcement officials implement court orders.

As the most visible form of ownership recognition by the government, having title

reduces private enforcement costs, provides security and collateral for long-term investment in land improvements, and promotes the development of land markets. All of these activities are wealth enhancing. The role of title in Brazilian law is recognized throughout Brazil, and for the most part titles function well and are respected.

Although frontiers are remote by definition, there are strong reasons to believe that title on the frontier plays at least some of the roles described above. First, consider the collateral argument. Even though credit may be quite limited on a frontier, that is not the case for the rest of Brazil, where agricultural credit has been commonplace and requires title. Migrants to the frontier, mostly from rural areas, likely carry this understanding with them.<sup>8</sup> Settlers are aware that as financial markets extend to the frontier, credit will become more available and having title will assist them in obtaining funds. Moreover, practically every small urban center in Brazil has a branch of Banco do Brasil, which historically has provided credit to agriculture. Further, living under inflationary conditions of up to 50 percent a month has resulted in a population that is accustomed to dealing with banks and other financial institutions in efforts to respond to inflation.

The arguments also apply to the role of title in promoting land exchanges. Throughout Brazil title is a recognized institutional device for designating private property rights and facilitating land transfer agreements. Formal titles are exchanged with land to document the transfer of ownership of land. Land exchange contracts and titles are recognized throughout the country and defensible in court. Hence, they provide security for those more-remote, potential purchasers (say from more settled areas), who might be interested in purchasing frontier land. Absent titles, individual holdings are based on squatter claims and subject to local agreements and practices. Potential purchasers, who are not part of such arrangements, may have little understanding of local conditions or confidence in the property rights they provide. Although

there is a market for land without title, having title is perceived as an advantage by settlers for broadening the range of potential purchasers.<sup>9</sup>

Finally, consider the ability of title to reduce private enforcement costs. With state-recognized title, land owners can appeal to the police to patrol property boundaries and to evict trespassers. Further, the judicial system can be used to issue injunctions against squatters who invade private property. A review of land-conflict records held by ITERPA, the Pastoral Land Commission, and other federal and state government agencies shows that having title facilitates the introduction of the rule of law in resolving land disputes.

On Brazilian frontiers, government land (*terra devoluta*) is open for private claiming and titling, much as it was in North America in the nineteenth century.<sup>10</sup> Generally, as with the U.S. Homestead Act of 1862, the land claim must be occupied by the claimant and improved for agricultural use for a prescribed amount of time--a year for claims on government land or for five years for claims to private land based on adverse possession. Once surveyed, land claims are filed with government land agencies that monitor compliance with the land laws, process title applications, and ultimately, issue title.

To initiate the titling process, claimants generally must organize collectively, travel to a local agency office, and formally request surveys and documentation of their land claims. Group organization is necessary because land agencies usually wait until a threshold number of requests are made before traveling to the site. When they respond, agency officials take a census of settlers in the area, survey and mark claims, and grant claimants an authorization to occupy or "autorização do ocupação" or a "licença de ocupação." The authorizations are forwarded to the state or federal government, depending on the government unit involved, for final recording. Normally, title applications can be processed within two to five years, but if the initial claimant moves to a different site and sells the claim, the title application must be reprocessed, extending

the titling time.<sup>11</sup>

Within Paraná, the state government had jurisdiction over land settlement, except in the western municípios, where there was dispute over jurisdiction between the federal and state governments (Foweraker, 1981, pp. 88-92). This conflict may have delayed the assignment of clear property rights to land and encouraged conflict among settlers over claims (Westphalen, Machado, and Balhana, 1968). We examine this issue in the empirical analysis below.

In some cases, particularly in Paraná, private land companies obtained large tracts of land from the state government, recruited settlers, and issued titles. For example, the Companhia de Terras do Norte do Paraná obtained 12,463 sq. km of land in the north, sold urban and rural lots to settlers, and extended railways and roads. The municípios included in the company's holdings accounted for over 12 percent of the size of Paraná in 1960.<sup>12</sup> Because the company gained clear legal title to its land before attracting colonists and was a residual claimant in the titling process, it may have transferred title more quickly and completely than did the state government (Nicholls and Paiva, 1969, pp. 27-30; Foweraker, 1981, p. 130). We also address this issue in the empirical analysis below.

In Pará, government policy on the frontier has been different in a number of ways from that in Paraná that may have affected the titling process and hence, the results of the statistical tests presented in Section VI. First, both the federal and state governments have been involved in titling.<sup>13</sup> In municípios with largely federal land, the federal land agency, INCRA (the National Institute for Colonization and Agrarian Reform), processed land claims, whereas in municípios with state lands, the state land agency, ITERPA, administered private claims. Because ITERPA was subject to more local political pressures to assign titles, it likely did so more rapidly and completely than did the federal agency, INCRA. ITERPA processed title applications according to state election cycles, with officials promising titles in exchange for



electoral support (Pinto, 1980, p. 187). We can test for differences in titling across agencies with both the census and survey data.

A second difference between the land claiming processes in Paraná and Pará is that in Paraná private migration decisions as land values rose drove claiming activities, while in Pará migration was stimulated by directed (subsidized) colonization programs of the federal government. Investment in infrastructure by the federal government and subsidized colonies brought settlers to the Amazon before land values had risen to a level that otherwise would have attracted migrants.<sup>14</sup> Further, in Pará declining budgets for land agencies limited their ability to process title applications. Budget problems especially affected INCRA, whose budget peaked in 1976, leading to a lag in the assignment of title (Yokota, 1981, p. 33).

A third difference between settlement and titling in the two states is violent conflict among competing claimants. Although there was confusion over property rights to land in the western municípios in Paraná where the federal and state governments competed for jurisdiction, in Pará there has been violence between small holders and ranchers, particularly in southeastern Pará along the Belém-Brasília highway in the município of Conceição do Araguaia and others near Marabá. Ranchers have been subsidized by the Superintendency for the Development of Amazonia (SUDAM), a federal agency that administered a series of credit benefits and fiscal incentives (Schneider, 1994, pp. 2-6), and settlement by small holders has been encouraged by investment in infrastructure by the federal government and by colonization projects organized by INCRA. With the census data we can examine the effects on the titling process of conflicting government jurisdiction in Paraná and violent conflict over land in Pará.

### III. Analytical Framework.

Figure 1 organizes the analytical framework for the empirical analysis. In frontier areas, distance to market is a primary determinant of land value. Transportation costs grow with distance from the market center, reducing the net profitability of economic activities. At some distance, transportation costs are high enough to make economic activity unfeasible, since the returns do not cover the opportunity costs of the marginal laborer. Hence, the land is not occupied and remains in forest. This land is beyond the economic frontier. This discussion suggests that those who settle the frontier will have relatively lower opportunity costs, with limited education and experience, all else constant.

In Figure 1 (a), assuming homogeneous land, the horizontal axis represents the distance from the market/administrative center, and the vertical axis reflects the market value of a hectare of land. Value is determined by the production possibilities from the land, which are negatively related to distance and positively related to inherent quality, land-specific investments, and market exchange. Title also adds value to land. Formal, state-enforced title represents the most secure form of property rights to land. Title signals government endorsement of an individual's land claim; that is, with title, ownership is enforced by the courts and the police power of the state. Under these circumstances, title provides claimants with the long-term security of ownership and collateral necessary to access formal capital markets for land-specific investments. Formal, enforced title also reduces the private costs of defending claims, such as private marking and patrolling of claims, because the state assumes many of those responsibilities. Finally, by signaling government recognition of current land ownership, a title increases the exchange value of land by widening the market. Those buyers from more distant areas, who may have higher-valued uses for the land and access to capital markets, have the assurance that land exchange contracts will be recognized by the courts and enforced by the state. Absent title, land exchange occurs in more narrow markets among local buyers and sellers

who are familiar with informal local property rights arrangements. These regional practices typically are not enforced by the courts or understood by potential buyers from more distant areas.<sup>15</sup>

In the figure, the two land values have different intercepts,  $V_t$  and  $V_{nt}$ , reflecting the different net present values of land with or without title (less private enforcement costs) at the market center, point A. At the market center, titled and untitled land will have different net present values because of differences in productivity-enhancing investments, exchange possibilities, and private enforcement costs. Indeed, at point A, where transportation costs are the lowest, the contribution of title to land value is the greatest. Potentially high-valued, but untitled land at the market center will be subject to more intense competition, raising private enforcement costs and increasing uncertainty of control. These conditions reduce investment, exchange, and production possibilities, lowering potential land values. By contrast, with title the state assumes most of the enforcement costs, guarantees ownership, and thereby promotes investment, exchange, and production. These activities raise land values and shift the intercepts from  $V_{nt}$  to  $V_t$  in the figure.

Moving from the market center at point A towards the frontier, the contribution of title declines. With higher transportation costs, land values are lower as the potential for exchange and production declines. Competition for ownership is reduced, requiring less state enforcement of title, and private enforcement costs decline. Hence, the titled value line has a negative slope with respect to distance, and the slope is greater than that for untitled value line. At some remote distance, D, the two value lines converge.

Figure 1 (b), illustrates individual demand for title. The vertical axis is the difference between the two intercepts  $V_t$  and  $V_{nt}$  from panel a. This difference reflects the added value of title to the individual claimant at different distances from the market/administrative center. In

the figure, the difference in the land value with and without title declines with distance.

Importantly, the position of the curve may shift across individuals. Those with more education, farming experience, and wealth likely will receive higher added values of title at any distance than will those with less human and physical capital because the former may be able to take better advantage of the opportunities made possible by title. We test for these effects below.

The private costs of obtaining title likely rise with distance because claimants must travel to the administrative center to record land claims and to file for title, as well as to lobby for titling services. Although, we do not have information on the exact nature of the individual cost function, there will be a distance whereby the expected added benefits from having title are equal to the private costs for each claimant of obtaining it. Beyond that point, individuals will hold their claims as squatters, whereas at locations closer to the market/administrative center, claimants will seek formal title. We represent this threshold distance in Figure 1 (b) with point E.

The human and physical capital assets of claimants may lower the private costs of obtaining title and thereby, shift the position of point E. Those claimants with more education, wealth, and experience are more apt to know how to use the bureaucracy to their advantage and to be able to lobby politicians to provide and police land titles. In addition, government policy will affect the private costs of obtaining title. Government policy determines who receives title (through the allocation formula), when it is assigned (through marking and survey policies, pricing, and other settlement requirements), whether it is secure (through enforcement practices), and how conflicts are adjudicated (through the police and courts). Each of these will be determined through the political process. Government may lower the private costs of obtaining title by subsidizing titles. For example, politicians may travel to the site and exchange titles with farmers for promises of electoral support. Alternatively, the existence of multiple land agencies,

confused jurisdictions over government land, violent conflict, and fluctuating agency budgets may delay the provision of tenure services and raise the private costs to individual claimants. These conditions may shift point E toward the market center, delaying the assignment of title.

In Brazil, state and federal agencies have jurisdiction in different areas, different constituents, and varying budget environments. State agencies, in response to local constituent demands, may be more likely to subsidize the private costs of obtaining title, whereas, federal land agencies may be less responsive to local demand and more vulnerable to changing national budget priorities. Even in the absence of subsidies, it seems likely that it would be more costly for local squatter organizations to effectively lobby politicians in remote Brasília, which is the nation's capital and headquarters for INCRA, than in comparatively nearby Belém, the state capital for Pará and headquarters for the state land agency, ITERPA. Hence, the private costs of obtaining title from state government land agencies may be less than those for obtaining title from federal agencies.

Governments can transfer some of the costs of titling by selling land in large blocks to private companies that in turn will subdivide and title the land for agricultural development, so long as government will recognize and enforce the titles. Since private companies are residual claimants from land sales, they may have more incentive than government officials to assign titles quickly and at low cost to settlers. We test for these different effects that may shift the costs of obtaining title and hence, the threshold point E, below.

#### IV. Characteristics of the Survey and Census Data.

The analysis of the development and impact of property rights to land employs two data sets, one from the authors' survey of 206 small holders in four sites in the state of Pará, near the communities of Altamira, Tucumã, São Felix, and Tailândia, and one from the Brazilian

Agricultural Censuses from 1940 through 1970 for Paraná and from 1970 through 1985 for Pará.<sup>16</sup> The survey data allow us to examine the determinants of title, investment and land value at the individual level. The mix of sites allows us to analyze the effects of different agency jurisdictions and settlement processes: Altamira, on the TransAmazon highway was one of the original planned colonization sites by INCRA; Tucumã was a private settlement area that reverted to INCRA's jurisdiction after an invasion; and São Felix and Tailândia were settlement sites organized by ITERPA. Table 1 provides descriptive statistics for the pooled survey sample. Because of the large number of variables, we do not provide a similar table of descriptive statistics for the census data.<sup>17</sup>

The census data are by município (county). In our data set, there are 79 municípios in Pará in the four census periods, whereas in Paraná the number of municípios grows from 49 in 1940 to 288 by 1970 through subdivision of existing municípios.<sup>18</sup> In general, the data are averages for each município, and they include average land value per hectare, distance from the município capital to the state capital (Curitiba and Belém) as a measure of remoteness from the market and administrative center, the proportion of município farmers with title, average farm size in the município, average soil quality for the município, population density, and average investment per hectare in the município.<sup>19</sup> Analysis of these census data allows us to test for the broad determinants of property rights to land as they emerge over time.

Before turning to the analysis, we provide information about each of the survey sites in order to better understand the assignment of title and its possible effects. Settlement along the TransAmazon highway running east from Altamira was to be a model of organized colonization by the federal government, beginning in 1970 with the first Plan for National Integration (PIN).<sup>20</sup>

This plan called for construction of the TransAmazon and other regional highways and for colonization of lands made accessible by new roads. A 10-km strip of land on either side of the highway was set aside for small farmers who could receive up to 100-hectare plots. Infrastructure was to be provided. By the late 1970s, however, federal priorities had changed, and far fewer settlers were brought to the region than originally planned (Butler, 1985). Nevertheless, individual settlement did occur at intervals along the highway, running east from the city of Altamira and along rough side roads that were constructed by logging companies. Many of those roads extended 30-60 km from the TransAmazon highway, with some as far as 120 km.

The sample includes 47 farmers, scattered along the TransAmazon highway and side roads at intervals of 18, 27, 55, 105, and 160 kilometers from Altamira, a city of 20-30,000 people.<sup>21</sup> These interview points were based on the existence of farms and feeder roads along the TransAmazon. This procedure was used to capture the effect of distance from the market as a major determinant of land value, titling, and investment. Mean farm size is 132 hectares, with 10 hectares the minimum and 600 the maximum. 82 percent of the farmers have title to their land. On average, by 1993, farmers had been on their plots for 15 years, suggesting that most arrived during the directed colonization period in the mid 1970s. Mean reported land value per hectare is \$60.00. INCRA was to provide settlers with title within two to five years of settlement, but after 1976, with declining budgets, the agency processed applications more slowly (Moran, 1984, p. 291). Altamira is the baseline in the pooled regressions of survey data reported below.

Another INCRA site is near Tucumã, which began as a private colonization effort by CONSAG (Construtora Andrade Gutierrez) a large private construction firm that built highway PA-270 to link the area with PA-150 and the Belém-Brasília highway (Butler, 1985). CONSAG

recruited farmers from southern Brazil, beginning in 1981. After invasion of unoccupied areas in 1985, the company abandoned the project, and it eventually reverted to INCRA. The sample includes 54 small farmers chosen randomly at various distances along two roads from the community of Tucumã, which has 5-10,000 people. Mean distance is 26 km. 32 percent of the farmers in the sample have title, with the remainder occupying their claims as squatters. Mean farm size is 94 hectares, and mean per hectare farm value is \$237.00. On average settlers have been on site for 5 years.

The next site is administered by ITERPA along state highway PA-150 from the market town of Tailândia. Tailândia is a community of approximately 10,000 people, 200 km south of Belém. PA-150 was built in the mid 1970s and asphalted in 1985 as a major road for linking Belém with mineral deposits in southern Pará. The colony was established in 1978 when ITERPA awarded 50-hectare plots to settlers in an area of 3-8 km on each side of the highway, for approximately 150 km from Tailândia. We selected this site and one other to see if jurisdiction differences among land agencies with different constituents and funding conditions would have an impact on titling. The survey includes 59 small farmers along PA-150. The mean distance from Tailândia is 45 km. Of the 59 small holders in Tailândia in our sample, 71 percent have title. Mean farm value per hectare is \$24 with mean size of farm 78 hectares. On average, farmers had been on their plot for 8 years.

The next ITERPA site is near the community of São Felix, with fewer than 7,000 people in the area.<sup>22</sup> São Felix is a very small town with little infrastructure, and the ITERPA colony stretches 35 km along the Xingu river. The closest market town is Tucumã. We surveyed 46 small holders at two sites, one 45 minutes down river at a colony, Santa Rosa, and another, five hours up river at Chadazinho. ITERPA has been active in assigning title in the area. 59 percent of those interviewed have title to their claims. Average value of land is \$16 per hectare, the



lowest of the interview sites, mean distance to market is 153 km, the furthest for the survey, and mean time on the plot is 6 years.

## V. Estimation.

The analytical framework suggests the following system of equations for analyzing the determinants of land value, title, and investment on the frontier. These equations make use of the variables available to us in the Brazilian census and in our survey. For the estimations using the census data, we used a log-linear specification and OLS for the land value and investment equations and OLS for the title equation.<sup>23</sup> For the survey data, we used a log-linear specification and OLS for the land value equation; Tobit for the investment equation; and Probit for the title equation because title is a binary variable:

$$(1). \text{LnValue} = a_1 + a_2\text{LnDistance} + a_3\text{LnDistance}\cdot\text{Title} + a_4\text{LnSoil} + a_5\text{LnClear} + a_6\text{LnInvestment} + a_7\text{LnDensity} + a_8\text{Title} + a_9\text{Jurisdiction} + a_{10}\text{Conflict} + e.$$

$$(2). \text{Title} = b_1 + b_2\text{Change in Value} + b_3\text{Size} + b_4\text{Jurisdiction} + b_5\text{Conflict} + b_6\text{Distance} + b\text{-Characteristics} + e.$$

$$(3). \text{LnInvestment} = d_1 + d_2\text{LnDistance} + d_3\text{Title} + d_4\text{LnSoil} + d_5\text{LnCharacteristics} + d_6\text{Jurisdiction} + b\text{-Conflict} + e.$$

As shown in equation (1), having title increases land value, and hence, should affect the demand for title, as reflected in equation (2) through the change-in-value variable. This variable, however, is not directly observable in either of our data sets. Accordingly, we introduce an instrument for the expected change-in-value from having title, calculated from equation (1). We take the difference in the antilogs of the value equation when title equals one and zero, and this expression contains both exogenous variables and investment. Because of simultaneity between title and investment, we use a two-stage procedure to estimate those variables.<sup>24</sup> Predicted investment is used to calculate the change-in-value variable, and predicted title is used in

estimating investment in equation (3). The two-stage procedure addresses possible correlation of the errors in the investment and title equations. Because title and investment are in the value equation there is the possibility of correlated shocks across the equations; accordingly, we performed the Breusch and Pagan (1980) test for correlation in the error terms in all three equations and found none.<sup>25</sup> Based on these results, estimating the land value equation with OLS yields consistent results.

#### A. Land Value.

The rationale for equation (1) is as follows: Land is an input to agricultural production. Its derived value is a function of supply factors, primarily the amount of available land, and demand factors that include population density, agricultural productivity, the net prices of agricultural output (gross agricultural prices less transportation costs), and the nature of property rights to land. Productivity is determined by soil quality (inherent land productivity), past investment in improvements, and other characteristics, such as land contours, access to water or irrigation, and the degree to which the land has been cleared of forest, which is a precondition for most agricultural activity. The effect of clearing on land value depends upon whether forests were considered valuable (Paraná) or an impediment to farming (Pará).

Having title should increase demand, and hence, land values by reducing private enforcement costs, promoting investment, and expanding market exchange. Distance from the market center towards the frontier should reduce demand and land values per hectare because of increased transportation costs and lower net returns to farming. As illustrated in Figure 1(a), the effect of distance is different for titled and untitled land. Up to some remote point, distance should have a greater negative effect on the value of titled land than on the value of untitled land because of the declining contribution of title to value with greater distance.

Accordingly, the estimated equation (1) using the survey data contains the following variables. Value is the reported per hectare value of a settler's farm.<sup>26</sup> Site dummies for São Felix, Tailândia, and Tucumã with respect to Altamira are included to account for the impact of differences in soil quality or other site-specific variables, such as agency jurisdiction, on land value, which would affect the demand for land. We do not have information about differences in soil quality along the roads within each of the four sites, where we interviewed. There are no indications, however, that soil quality differs importantly within each site. We include other demand variables--the extent of forest clearing, land-specific investment, the existence of title, and distance from the market center. Distance is reflected in two variables. The distance variable accounts for the expected negative effect that distance from the market center has on land values. The title-distance interaction variable reveals the effect having title has on land value with respect to distance. The distance variable reflects the additional effect of distance on the value of untitled land. Hence, we expect both coefficients to be negative, making the slope for the estimated line describing the value of the titled land larger in an absolute sense. Clear is the percent of the farm that is cleared of forest. Investment is the percent of the farm that is placed in pasture or permanent crops. This variable should capture the effect of past improvements on land value, leaving the exchange and enforcement effects on land value to be captured by the title variable.

The estimation of equation (1) using the census data contains the following variables. The value of agricultural land per hectare in the município as the dependent variable;<sup>27</sup> the percent of município farmers with title to their land;<sup>28</sup> land-specific investment per hectare in the município as of the census year;<sup>29</sup> distance from the município capital to the state market center, Curitiba and Belém;<sup>30</sup> average soil quality in the município;<sup>31</sup> the percent of município agricultural land that is cleared of forest;<sup>32</sup> município population density; whether the município

was administered by a private land company or whether it was one of the municípios contested between the state and federal governments (Paraná); whether the município was administered by INCRA or whether the município was the site of conflict over land (Pará); and the effects of distance from the market center on titled and untitled land values, introduced through an interaction term for distance and title.

We discuss the role of private land companies in the settlement of Paraná below. Here we test whether the most important private land company, Companhia de Terras do Norte do Paraná, was granted the most valuable land or whether it added extra infrastructure by using dummy variables for the northern municípios under its jurisdiction.<sup>33</sup> Additionally, we test whether conflict over land lowered values in those western municípios in Paraná characterized by jurisdictional disputes between the state and federal governments.<sup>34</sup>

We test for similar jurisdictional and conflict effects in Pará. Private land companies were much less important in the settlement of Pará, but the federal government may have claimed the best land along major highways and assigned the land to its land agency, INCRA. We assign a dummy variable for those municípios under INCRA's jurisdiction.<sup>35</sup> As in Paraná, we expect that conflict over land would reduce land values. In the late 1970s and 1980s there was conflict in 44 of the 79 municípios in our data set (Pará Pastoral Land Commission), especially in the southeastern part of Pará. For those municípios we assign a dummy variable the value of one. We do not have data on conflict for 1970 and 1975, although disputes likely were more limited at that time because of the early stage of settlement.

#### B. Title.

Equation (2) contains both demand and cost variables for title as suggested by the analytical framework in Figure 1 (b). For the survey data, the dependent variable is a

dichotomous variable, taking the value 1 if the farmer had title and 0 otherwise, and for the census data, the dependent variable is the percent of município farmers with title to their land. In general, the demand for title should be a function of expected private net returns, which in turn are due to the increase in land value from having title, less the private costs of obtaining title. Land values will increase with title because of a greater opportunity for investment in land improvements, greater exchange opportunities for land sales, and reduced private enforcement costs. The private costs of securing title, and hence demand, also will be affected by the requirements of the land laws, such as beneficial use, occupation, boundary marking, and documentation. Unfortunately, we do not have systematic census or survey data on these factors. Additionally, costs will be an increasing function of distance due to the higher costs of traveling to and from remote farm sites to the administrative center and surveying and recording claims.

For the survey data we have the distance in kilometers from each farm to the local community and land office site, which is the city of Altamira for the Altamira colony, the city of Tucumã for the Tucumã and São Felix colonies, and the city of Tailândia for the Tailândia colony. For the census data, we have evidence on the distance from the município capital to the main administrative center, which is the state capital (Curitiba, Paraná or Belém, Pará). Other demand variables, for which we have some data include the size of the farm (average farm size in the município for the census); the characteristics of the individual farmer; and the expected change in land value from having title.

Because private enforcement costs are likely to be higher for large farms or ranches, we expect that larger average farm sizes would increase the demand for title, hence the sign of the coefficient is anticipated to be positive. Although we test for the effects of farm size in the estimation using census data, we do not include farm size in the demand for title in the estimation using the survey data because the sampled farms are all uniformly small. Both formal

colonization projects for small farmers and invasions by squatters of a particular area lead to a clustering of small farms in the Amazon with few neighboring large farms or ranches.<sup>36</sup> For example, the four sites we sampled are almost totally made up of small holders. 80 percent of the 206 farmers in the survey had under 100 hectares and 93 percent had under 200 hectares. Among small holders in the Amazon there is comparatively little conflict. In our survey, small farmers repeatedly stated that their claims were "safe," indicating that there were few private enforcement costs that would differ by farm size.

There are several reasons why there are few disputes over land claims among small holders. One is that the land is in beneficial use. Small holders with 200 hectares or less use much of their land to earn a nearly subsistence living for their families. Their plots are either in full production or are gradually being cleared at a rate of three to five hectares per year.<sup>37</sup> Further, since small farmers typically occupy the land, they can observe intrusion by neighbors or other squatters on their small holdings. Land claims are marked with cleared boundaries and planted trees, often cashews. Finally, small holders in an area organize groups to lobby the local land offices to provide formal titles.<sup>38</sup> These collective actions create a sense of cohesion or community among small holders that promotes recognition of individual land claims.<sup>39</sup> There are occasional disputes between adjacent small holders over the location of boundary lines or the drift of cattle and between small holders and loggers, who trespass to harvest valuable timber species. Both our survey responses and the land dispute records of ITERPA and the Pastoral Land Commission in Brasília, however, clearly indicate that disagreements among small holders over property rights are resolved routinely.

With regard to individual characteristics, for the survey estimation we have time on the farm, age, education, and wealth (value of livestock). For the census estimation, we have data for the average age, income, and education in the município only for the 1980 census year.<sup>40</sup>

Age and time on the farm, as proxies for experience, education, and income or wealth could both increase the demand for title and reduce the private costs of obtaining title. Individuals with greater experience, education, and income or wealth may be better able to take advantage of having title and realize the extra returns made possible by it, and they may understand the political process and bureaucratic requirements better to secure title at lower private cost.<sup>41</sup> Hence, the estimated coefficients on these characteristics variables should be positive.

The final demand variable is the expected change in value from having title. The change in land value from having title should be a factor affecting the individual demand for title as indicated in Figure 1(b). We do not have direct evidence for this variable for either the census or the survey estimations, and construct the change-in-value variable from equation (1) as described above.

The cost of obtaining title will be affected by jurisdictional issues, which in terms of Figure 1(b) would be shown by shifts in threshold distance  $E$ . For the survey estimations, the jurisdictional effects are represented with site dummy variables to capture agency and other site-specific factors that might affect the private cost of title. The intercepts are with respect to Altamira, the baseline. We chose Altamira as the baseline because it was a showcase INCRA settlement. Because Altamira was an early colonization site along the TransAmazon highway, established when INCRA had large budgets to provide title at low private cost, we expect that settlers close to the market will have title in that colony. Tucumã is another INCRA site, however, it was placed under the agency's jurisdiction late, after budgets had declined, reducing its capability to process titles. This factor may have raised the private costs of obtaining title in that colony. The ITERPA areas of Tailândia and São Felix may be more likely to have titles than at Altamira, because of the aggressive actions of ITERPA to subsidize the provision of titles to small holders in exchange for political support and the closer proximity of ITERPA

headquarters in Belém.

For the census estimations, we include dummy variables for the western municípios in Paraná where there were conflicts between the state and federal government over which government had authority to grant title. This factor likely would raise the private costs of obtaining title. These effects should lead to a negative estimated coefficient. In addition, in Paraná private land companies played an important role in settlement and the provision of title. Because the private land companies were residual claimants for increases in land value from providing title, we anticipate that they would provide title at lower cost to claimants. Hence, those municípios under private jurisdiction would have more titles, on average, giving a predicted positive coefficient to the jurisdiction variable in Paraná. In the estimation, the northern municípios under the jurisdiction of the private land company, Companhia de Terras do Norte do Paraná, are indicated with dummy variables.

In Pará for the census estimations, we add two variables. One is also a jurisdictional dummy variable. Private land companies have been less important in that state, but as described above the federal and state governments had different land agencies, INCRA and ITERPA, respectively, that had separate jurisdictions. We expect that the state agency, ITERPA, with local constituencies and headquarters in nearby Belém would be more responsive to local demands for title and provide title at comparatively lower private cost. Accordingly, those municípios under its jurisdiction would be titled more extensively than would those under the federal agency, INCRA, which had national constituencies and was headquartered in more distant Brasília. In the equation, INCRA municípios are represented with a dummy variable with a value of one, zero otherwise. As a result, the estimated coefficient on the INCRA variable is predicted to be negative. The other variable is used to identify those municípios in Pará characterized by violent conflict over land between ranchers and squatters as described above.



We view this conflict as a demand variable since the returns to secure title would be particularly large in areas where ownership was uncertain. Accordingly we anticipate a positive coefficient on the violence variable.

### C. Land-Specific Investment.

The rationale for equation (3) is as follows: Investments in land improvements will be made on the basis of expected returns, which in turn, are a function of the private costs of investment and the increase in farm revenue that results from the investment. For the survey estimations, investment is measured as the portion of the farm placed in improved pasture and permanent crops. Preparing pasture and planting permanent crops, such as cacao, coffee, pepper, and citrus, represent the most important investments made by the small holders in our sample. Most costs are labor devoted to improving pasture--building fences, chopping brush and weeds--and planting and tending permanent crops. Using the census data, we calculate the average land-specific investment per hectare in the município from a broad census investment variable by deleting livestock and other mobile agricultural investments. The agricultural census provides a combined variable that includes the value of land and investment in buildings, fences, corrals, equipment, and animals. Since the census separately provides land value and livestock data, we can remove land and livestock values to get an overall land-specific investment variable.<sup>42</sup>

Expected returns from investment depend upon livestock and commodity prices, transportation costs, and land quality. Distance from the market should reduce the expected returns from investment by raising transportation costs. For the survey estimations, site dummies with respect to Altamira are used to control for site-specific differences, such as soil quality, in the private returns to investment. Distance is kilometers from the market center to the farm. For the census data, distance is distance between the município capital and the major state

market center, which is Curitiba, Paraná and Belém, Pará. Average soil quality in the município is included. Although livestock and commodity prices generally will not vary across municípios for any census period, transportation costs will be different across the sample. We add dummy variables for those municípios where conflict occurred in Paraná and Pará and property rights were uncertain, even with title, to determine whether investment was reduced. Moreover, private land companies in Paraná and INCRA in Pará provided some subsidies for permanent crops, fertilizers, and other infrastructure that may have raised the net private returns from investment, and we control for these effects with dummy variables for the municípios involved.

The private costs of investment include the costs of capital plus the costs of the actual investment. Access to and the cost of funds to purchase inputs for investment depend in part on whether the farmer has title, and hence can use the farm as collateral. Having title also will provide more security for long-term investments. For the survey data, a dummy variable is included to indicate whether or not the farmer has title. For the census data, title is represented by the percent of farmers in a município with title. Title should provide greater security for long-term investment in pasture and permanent crops and assist in accessing credit. Human capital variables, such as age, education, wealth, and time on the farm, available from the survey, also should raise the expected returns from investment. Those with greater education should be more aware of market conditions and how to respond to them. Personal wealth may increase an individual's ability to obtain additional funds for investment. Age and time on the farm may reflect greater farming experience.

## VI. Empirical Results.

Table 2 contains the estimated coefficients and t-statistics for the estimations of equations (1), (2), and (3) using the survey data, and tables 3 through 5 contain the results using

the census data.<sup>43</sup>

Column 2 of Table 2 provides the estimation of equation (1) for the determinants of land value using OLS and a log-linear specification. The site dummies in the equation account for the differences within each region that might affect land value, such as soil quality. Hence, the intercepts can be different across the sites. The results indicate that land values are higher at Tucumã than at the base line of Altamira, and soil conditions are known to be relatively good at Tucumã (Butler, 1985). The estimated values per hectare are \$34.12, \$28.22, \$21.76, and \$148.41 for Altamira, São Felix, Tailândia, and Tucumã, respectively.<sup>44</sup> As predicted, the effect of title on land value is positive and significant. Because we have controlled for the impact of investment, as in the census estimations, the title variable largely reflects the gain in value due to increased exchange opportunities and lower private enforcement costs.

The log specification of the model implies that the percentage increase in land value due to having title will be the same across all of the sites, holding distance constant. If distance is zero so that the farm is at the market center, where values and competition for control are potentially the greatest, the estimated coefficient suggests that title would raise values by 189 percent.<sup>45</sup> Similarly, at a distance of 40 kilometers, land values would be increased by 72 percent.<sup>46</sup> This estimated increase in value is consistent for the actual observations. For instance, for farms in the range of 20-39 kilometers from the market, actual land values per hectare are 71 percent higher for titled land, as compared to untitled land.<sup>47</sup> The regression predicts that at a distance of 140 kilometers, land values would be 45 percent higher for titled land. Actual observations for all farms 140 kilometers or greater from market reveal a 35 percent difference in land value between titled and untitled land.

Title also affects the slope of the estimated relationship between land value and distance. The estimated coefficients for the distance and title-distance interaction variables indicate that a one percent increase in distance from the market leads to a .37 percent decline in the value of titled land.<sup>48</sup> The estimated impact of distance on untitled land is negative, with a 1 percent increase in distance reducing land value by 0.23 percent.

As distance from the market center increases, values fall for titled and untitled land. The results suggest that, as predicted, the decline in value with distance is greatest for titled land. Hence at some point the two estimated relationships meet. Using the estimated coefficients for title and the title-distance interaction, we can solve for the distance where land values with title equal those without title. In the case at hand, the distance is 1,942 kilometers, which is beyond any of our sampled locations.<sup>49</sup> Hence, having title provides some value to all of our sampled small holders.

Agricultural investment in permanent crops and pasture has the predicted positive effect on land values with a 1 percent increase in the percentage of farm land in pasture and permanent crops resulting in a 0.97 percent increase in value per hectare. Clearing also has a statistically-weak, positive effect on land value, with a 1 percent increase in the percent of the farm that is cleared yielding a 0.58 percent increase in value per hectare.

Column 3 of Table 2 provides the estimation of equation (2) for title for the pooled sample with a Probit model, where title, is a binary variable, 1 if the individual had a definite or provisional title, and 0 otherwise.<sup>50</sup> The estimation is reasonably accurate as a predictor, correctly predicting the existence of title in 84 percent of the cases and correctly predicting no title in 53 percent of the cases.<sup>51</sup> The lower prediction success for the absence of title reflects the aggressive titling practices of the state land agency, ITERPA in São Felix and Tailândia, where low-valued, remote land claims are granted title for political reasons.

The regression also tends to over predict title; that is, we predict a title for 144 settlers while only 127 have title. This result suggests that the government titling agencies are not exactly following the process outlined in the analytical framework in Figure 1. We describe governments as providing title when individual private net benefit calculations lead claimants to demand formal recognition of their claims. We recognize, though, that political and bureaucratic factors, such as constituent lobbying, election pressures, budget allocations, and staffing levels will affect the government response. How the government responds will influence the private costs of obtaining title and hence, shift the cost curve. We do not have sufficient information about agency titling to effectively model the process or to include political variables in the regressions. We attempt to control for political differences associated with federal and state jurisdictions and land agencies, INCRA or ITERPA, through the site dummy variables. But the results indicate that the problem of undertitling claimants who have comparatively high value land close to markets exists across the sites, at least to some degree. For example, there are plots in both Altamira and Tailândia with reasonably high values and short distances that are not titled.<sup>52</sup> This problem is most pronounced in the INCRA community of Tucumã. INCRA's budget and staffing for processing claims have declined as the federal government has allocated budgets to other national issues (Yokota, 1981, p. 33 and Schneider, 1994, p. 8). The under titling in Tucumã is reflected by the intercept, which indicates that settlers are less likely to have title there than in the baseline, Altamira, or in the ITERPA colonies of São Felix and Tailândia. In the latter colonies, there are no significant differences in the probability of having title from that found in Altamira, where titling by INCRA initially was aggressive, but now also is lagging (Moran, 1984, p. 291). Mean distances from the market are 26 km in Tucumã, 63 km in Altamira, 153 km in São Felix, and 45 km in Tailândia. Further, mean land values in Tucumã are \$237.34 per hectare, while in Altamira they are \$59.66 and

\$16.64 and \$24.10 in São Felix and Tailândia, respectively.

To examine this issue further, using the estimated coefficients evaluated at the means for each site and the cumulative normal density function, the predicted probability of having title in each area is 89 percent at Altamira, 59 percent at São Felix, 73 percent at Tailândia, and 32 percent at Tucumã. Alternatively, if settlers with the mean characteristics for each site were located in the baseline colony of Altamira, then the predicted probability of having title is 75 percent for Tailândia, only 46 percent for São Felix, and a much greater 96 percent for Tucumã.<sup>53</sup>

The role of political and bureaucratic variables in influencing agency response to demands for title also is indicated in the apparent over titling in São Felix and Tailândia by the state agency ITERPA, whose agents in some cases have handed out titles prior to local elections. By granting titles in remote locations prior to election, the agency appears to have lowered the private costs of obtaining title, even though the social costs of providing title in these areas to low-valued sites may be quite high, but those costs are not completely internalized by the agency.<sup>54</sup>

For the human capital variables, only time on the farm has a statistically significant contribution to having title, although education comes close. Those who have been on their claim longer are more likely to understand the requirements of the land agencies and meet their requirements. For instance, evaluated at the means, the marginal increase in the probability of having title, given a one year increase in time on the farm is 0.8 percentage points in Altamira, 1.6 percentage points in Tucumã, 1.7 percentage points in São Felix and 1.5 percentage points in Tailândia. A half-standard deviation move from the mean number of years raises the probability of having title by 4.3 percentage points in Altamira, 2.0 percentage points in Tucumã, 4.6 percentage points in São Felix and 3.8 percentage points in Tailândia.<sup>55</sup> Similarly, evaluated at the means, the marginal increase in the probability of having title, given a one year increase in

education is 1.6 percentage points in Altamira, 3.0 percentage points in Tucumã, 3.2 percentage points in São Felix and 2.8 percentage points in Tailândia. A half-standard deviation move from the mean number of years of education raises the probability of having title by 1.6 percentage points in Altamira, 4.1 percentage points in Tucumã, 2.3 percentage points in São Felix, and 2.3 percentage points in Tailândia.<sup>56</sup>

Distance has the predicted negative effect on the incidence of title, likely by raising the costs of obtaining title. Evaluated at the means, the marginal effects on the probability of having title, given a one kilometer increase in distance is -0.1 percentage points in Altamira, -0.2 percentage points in Tucumã, -0.2 percentage points in São Felix, and -0.2 percentage points in Tailândia. A half-standard deviation move from the mean distance lowers the probability of having title by 2.7 percentage points in Altamira, 0.9 percentage points in Tucumã, 4.2 percentage points in São Felix and 2.7 percentage points in Tailândia.<sup>57</sup>

The expected change in land value from having title has the predicted effect on the incidence of title, although the significance level is low. The regression suggests that, evaluated at the means, the marginal increase in the probability of having title, given a \$1 increase in the expected change in value due to title is 0.2 percentage points in Altamira, 0.3 percentage points in Tucumã, 0.4 percentage points in São Felix and 0.3 percentage points in Tailândia. A half-standard deviation move from the mean change in value raises the probability of having title by 1.3 percentage points in Altamira, 5.2 percentage points in Tucumã, 0.2 percentage points in São Felix and 0.8 percentage points in Tailândia.<sup>58</sup>

Column 5 of Table 2 provides the estimation of equation (3) for agricultural investment using a Tobit model. The regression shows that investment varies considerably across the sites. The results suggest that settlers in Tucumã have more investments than do those in Altamira. Tucumã has the shortest mean distance to market for the four sites, and it is a relatively

prosperous market town. The existence of title has a positive effect on investment. The effect of title on the percent of farm land in pasture and permanent crops can be estimated, using the mean values for settlers at each of the four sites. The results suggest that the ownership assurance provided by title provides support for investment in costly fencing, other pasture development activities, and in cultivating permanent crops. For Altamira, having title adds 29 percentage points to the proportion of farm land in pasture and permanent crops. The mean proportion of land so devoted in Altamira is 25.5 percent. Similarly, for São Felix and Tailândia, having title raises the share of farm land in pasture and permanent crops by 21 percentage points at each site, and for Tucumã, the increase is 48 percentage points.<sup>59</sup> The mean percent of land in pasture and permanent crops in those sites is 7.3 percent, 12.1 percent, and 31.6 percent, respectively. Of those who have pasture, the mean level of fencing is 1,181 meters, which represents an investment of approximately \$550.<sup>60</sup> Accordingly, title plays a very important role in promoting investment in land improvements. In comparison, the human capital characteristics do not appear to have an impact on the private returns to investment.<sup>61</sup>

To summarize, the statistical tests using survey data support the analytical framework described in Figure 1 above. Land value per hectare is a positive function of title. Moreover, for titled and untitled land distance differentially reduces value. The contribution of title to land value is greatest at the market center, where competition and private enforcement costs would otherwise be the highest. The role of title, however, appears to decline with distance as competition for control declines and production and exchange opportunities diminish. The estimations suggest that for all of our sampled small holders, title always offers some added value. Whether or not it pays a settler to seek title depends upon the corresponding private costs of obtaining it. Land agencies influence those costs, with the state agency, ITERPA, appearing to provide title liberally, whereas the federal agency, INCRA, appears to be very slow in titling



in the colony of Tucumã, where land values are relatively high and distances comparatively short. ITERPA is as likely to provide title to settlers in its remote colonies as is INCRA in its show case and more accessible TransAmazon colony of Altamira. We find strong empirical support for the notion that formal property rights to land promote farm-specific investments, which in turn, raise land values directly.

Tables 3 through 5 report the statistical analyses of the general forces underlying land values, the development of property rights to land, and land-specific investment across time in the two Brazilian frontier areas using the census data. As noted earlier, the census estimations are performed using OLS, and a log-linear specification is used for the land value and investment equations. In general, the estimations perform better for the state of Paraná than for Pará, perhaps because of much lower land values in Pará and the other differences in frontier settlement between the two states described above.

As indicated in Table 3, title and investment have the predicted positive effects on land value for seven of the eight census periods in the case of title and for all eight census years for investment, where the estimated coefficient is statistically significant in all periods, but 1985 for Pará. Title has a significant impact at the 90 percent level or better in two of the four runs for Paraná, but the variable never has that statistical punch for Pará. The impact of title on land value is captured partially by the investment variable, so that the title variable in equation (1) reflects the gain in value due to increased exchange opportunities and lower private enforcement costs. These results are consistent with the findings for the relationship between land value and title and investment with the survey data. The effect of title on land value tends to decline with distance from the market center, with a negative coefficient for the title-distance interaction variable for seven of the eight census periods. The effect is weak, however, particularly for Pará. For non-titled land, the effect of distance always is negative as expected for Pará (although

not significant), but positive for Paraná. The other explanatory variables for land value tend to have the predicted signs, and generally have greater statistical significance for Paraná, where the overall regressions explain more of the variance. Greater population density, reflecting demand for land, leads to higher land values in at least five of the eight census periods. *Municípios* under the jurisdiction of private land companies in Paraná, at least in 1950 and 1960, and under INCRA in Pará in 1980 tend to have higher land values, likely due to greater infrastructure and investment. Confused property rights due to conflict between the state and federal government in parts of Paraná appear to lower land values, particularly in 1970.

With regard to the determinants of private property rights to land as reported in Table 4, jurisdictional conflict in Paraná in the western *municípios* over whether the federal or state government had authorization to issue titles reduced the portion of farmers with title, particularly in the last three census periods. In Pará, however, there is no observed difference between the proportion of farmers with title in those *municípios* characterized by violent conflict over land from elsewhere in the state. INCRA *municípios* may have had a smaller percent of farms with title than elsewhere, but the census estimations reveal no significant effect. Recall that in the survey data, the INCRA colony of Altamira in Pará had extensive titling, whereas the INCRA colony of Tucumã, also in Pará, appeared to be under titled, given land values and distances to market. In Paraná those *municípios* under the jurisdiction of the private land company had a greater percentage of titled farms only by the 1970 census. As hypothesized, distance from the market/administrative center tends to reduce the portion of farmers with title, a finding consistent with the notion that administrative costs rise with remoteness. This result also is consistent with the survey estimation. The distance variable is significant at the 95 percent level in four of the eight census runs. The relationship between farm size and title is mixed in both states. The estimated coefficient generally is positive as predicted, but there is a census period in

each state where the effect is negative and significant. We had hypothesized that private enforcement costs would rise with *farm size*, increasing the demand for title by large farmers. For the 1980 census in Pará, we have socio-economic measures by município for age, income, and education. All three have a positive impact, but only age leads to greater titling statistically. Finally, the expected change in value from having title has a positive effect on the incidence of title in five of the eight census periods, with the greatest statistical significance in two of the census periods in Pará. These results are consistent with those found for the survey data.

Table 5 provides the estimates for agricultural investment per hectare. Having title has the predicted positive impact in seven of the eight census periods and is statistically significant six of those periods. This result underscores the role of title in promoting investment found with the survey data. With regard to distance from the market, in the two cases where the coefficient is significant at the 95 percent level, the effect is to reduce investment. In most cases the variable is not significant, a result also identified with the survey data. Confused property rights associated with conflicting government jurisdictions over land in Paraná appears to reduce investment in that state, especially in the 1940 census period. There is a similar weak effect for violent conflict in Pará. The private land development companies that sold land to farmers in Paraná and the federal agency, INCRA, that established colonies of settlers in Pará provided infrastructure and some subsidies for investment, and these practices are reflected in the regression results.<sup>62</sup> Soil quality plays a positive and generally significant role in investment in Paraná.

Over time, the factors identified in equation (3) contributed to the growth in investment in land in Paraná (in constant 1970 cruzeiros) from Cr\$ 31 per hectare in 1940 to Cr\$ 453 in 1970.<sup>63</sup> Although the same forces appear to have been active in Pará, the amount of investment in that state is considerably less than in Paraná. For example, in 1980 per hectare investment in

Pará was Cr\$ 79 (1970 cruzeiros), which was less than one-fifth the level in Paraná in 1970.<sup>64</sup>

All in all, the predictions of the theory outlined with Figure 1 also are supported by the empirical evidence drawn from the census between 1940 and 1985. In general, title and/or investment raised land values on both Brazilian frontiers across time. The independent effect of title on land value, however, tended to decline with distance from major market centers in Paraná, while the distance effect on the value of titled land was not significant in Pará. Higher costs associated with greater distance from administrative centers tended to reduce the proportion of farmers in a município with title in both states, with the strongest results in Pará. Jurisdictional confusion as to which government had authority to issue titles also lowered titling on the frontier in Paraná. Except for one census period, neither the private land company in Paraná nor the federal agency, INCRA, in Pará provided significantly different titling services from elsewhere in the two states. The expected change in value from having title also generally had the predicted positive effect on the incidence of title in both states. As predicted in most cases, title led to more land-specific investment in both states across the census periods.

The results regarding the determinants and impact of property rights to land are similar for both the survey and census data. The revealed relationships provide empirical support for the theory of institutional change described in Section III above.

## VI. Concluding Remarks.

There is a growing literature on both the roles played by institutions in economic behavior and the determinants of those institutions. In this paper, we have examined the development and impact of the most basic institution for markets, secure property rights in the form of title to land. We focused on frontier settlements in Brazil, where property rights to land are being established as land values increase. The empirical analysis begins with micro-level

individual observations from sample data from 1992 and 1993. These data are appropriate for drawing conclusions about individual behavior. The analysis is supplemented with estimations that use aggregate census data with observations at the município level for early frontiers in the state of Paraná between 1940 and 1970 and for more recent frontiers in the Amazon state of Pará between 1970 and 1985.

In both cases, the predictions of the theory generally are supported by the empirical analyses using the two data sets. Most critically, title and investment contribute to land value, and title promotes farm-specific investment. Additionally, the expected change in value from having title appears to increase the incidence of title. Although we estimated this variable, the results are consistent with actual survey evidence for a subsample of the group. We asked 14 of the 54 sampled farmers in Tucumã to give estimates of the change in land value attributable to title. Of those 14, 11 replied that title would raise their land values by at least 20 percent and eight reported that title would increase their land values by 50 percent or more (Alston, Libecap, and Schneider, 1995).

The general consistency of the econometric results for both the census and survey data sets underscores the robustness of the theoretical predictions about the role of property rights in influencing investment and raising land values. Additionally, this case study of Brazilian frontiers provides evidence regarding the political and economic processes that underlie the demand and supply of title. These empirical results provide insights into the contribution of property rights for economic behavior and the development of markets. This information adds to the growing literature in the new institutional economics and to the literature on economic development.

A basic tenet of the new institutional economics is that property rights regimes affect economic behavior. Tenure institutions have the potential to create wealth by promoting

investment, by reducing enforcement costs, and by extending the gains from trade. As a result, individuals have incentives to organize collectively for the provision of secure rights to valuable assets. Typically, these institutions are provided by the state, and political factors will influence how effectively the state will respond to demands for property rights. To date, there have been few opportunities to examine empirically the demand for and supply of property rights. This study has provided such an investigation. It has focused on the factors that affect the demand for title and the government response to those demands. By and large, the demand variables have performed as predicted. The political response, however, has not been perfect. Where government jurisdictions have been confused, as in Paraná, title has been less prevalent. Further, the survey data in Pará reveal that titling agencies for both the federal and state governments do not perform exactly as the economic framework predicts. Claimants to low value, remote plots receive title, especially by ITERPA, prior to elections, whereas claimants to some more valuable plots near to markets are neglected, often due to budget and staff limitations. This phenomenon is particularly apparent for the INCRA colony of Tucumã, where land values are high and distances are short, but titling is limited. Unfortunately, the problem exists elsewhere as well. These results suggest that researchers must pay special attention to the complex political and bureaucratic process by which property rights are assigned in studying the emergence of tenure institutions. Clearly, more work in modeling and testing hypotheses regarding the provision of property rights is warranted. These results also are relevant for the development literature. At least in situations where no previous, durable property structure exists (as in the case of frontiers), governments can increase economic performance and wealth through the provision of clear, secure title. As this study shows, however, the government response to the demand for property rights will be influenced by a variety of political factors, including competing constituent pressures, electoral demands, conflicting agency and government jurisdictions, and

fluctuating budgets and staffing for titling agencies. All of these can have important consequences for the provision of rights institutions, and hence for the path and success of economic development programs.

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## Endnotes

1. The literature is large and has a broad span, and a few citations cannot do justice to the range of work that exists. Representative citations, however, include the papers in: Empirical Studies in Institutional Change, edited by Lee J. Alston, Thráinn Eggertsson, and Douglass North (1996); the special issue of the Journal of Institutional and Theoretical Economics, March 1993, edited by Eirik Furubotn and Rudolf Richter; the readings edited by Oliver Williamson and Sidney Winter (1991); the articles on political organizations in the "Conference on 'The Organization of Political Institutions,'" special issue, 1990, Journal of Law, Economics, and Organization; as well as Becker (1983) and North (1990). Levy and Spiller (1994) use transactions costs economics to analyze the determinants of performance of privatized utilities in five countries where institutional conditions vary.
2. For example, see Ostrom (1990), Feder and Feeny (1991), Hoff, Braverman, and Stiglitz (1993), and Besley (1994).
3. The recognition of the importance of property rights in economic behavior follows from the work of Demsetz (1967), North (1981), and others. Barro (1991) examines differences in property rights security in cross country growth comparisons.
4. For discussion, see Berge, Ott, and Stenseth (1994), Gillis and Repetto (1989), and Deacon (forthcoming).
5. See Binswanger (1989) and Mahar (1989).
6. For summary of the literature, see Eggertsson (1990). There have been analyses of property rights institutions in contemporary developing areas and in an historical context. See Feder and Feeny (1991), Besley (1994), Ostrom (1990), Hazell and Place (1993), Migot-Adholla, Hazell, Blarel, and Place (1991), and Ensminger (1995) for analyses in contemporary development. Besley provides an analysis with respect to tenure and investment in Ghana. Feder and Onchan (1987) and Feder, Onchan, Chalamwong, and Hongladarom (1988) compare the performance of farmers and land values on titled and untitled land in Thailand. These studies examine the nature and impact of tenure in more-or-less settled regions. Our analysis is of frontiers, allowing us to examine the development of property institutions as land values rise. For more historical studies and contemporary natural resource problems, see Libecap (1989). Another study is provided by Kantor (1995).
7. IBGE, Anuário Estatístico do Brasil (1990, p. 183; 1991, pp.180-183).
8. Certainly, those we interviewed stressed the role of title for accessing capital for investments. For example, 31 small holders near the town of Tucumã were asked in May 1993 what effect having title would have, and the dominant response (by eight of those interviewed) was that title would provide collateral to obtain credit. These responses are representative of those from the other survey sites.
9. Field notes by Ricardo Tarifa, May 18, 1993, for Tucumã indicate that between 40 and 50 percent of the colonists had sold land, even without title, between visits in 1991 and 1993. The sales appear to be to other colonists in the community. Similarly, in the community of Nova Aliança, Tarifa noted active land exchanges among small holders, none of whom had title. Active land markets exist in all of the survey sites.

10. In some cases, private land (generally on very large ranches) that is not put to beneficial use can be invaded by squatters (posseiros) and claimed by them. Forested land is particularly susceptible to invasion by squatters because of the appearance of non use, the difficulty of monitoring occupancy by squatters, and the attraction to itinerant loggers who build roads to access valuable species and thereby provide access for squatters. Where invasions occur, the government attempts to enforce title for private land. If land is of low value, the formal owner may not object to the invasion. Where land values are higher, however, owners will attempt to evict or to negotiate either a voluntary exodus or a transfer to the squatters. The government may purchase the land from the large owner or negotiate payment from the land owner to the squatters for their improvements and assist them in locating other lands for settlement. We are addressing this process in on-going research.

11. If the settler improves and occupies the land, agency officials will return and grant a provisional title, while final title is being processed in Brasília or Belém. If, when the agency returns to the colony, the claimant has moved on or "sold" his squatter claim, the process of titling begins again. The agency tends to acknowledge the new claimant who holds the authorization or provisional title so long as the individual is a genuine settler and not a large land speculator.

12. This percentage was calculated using the map in Nicholls and Paiva (1969, p. 28) and the area of the municípios within the company's jurisdiction from IBGE, Anuario Estatístico do Brazil (1965, pp. 42-43).

13. The federal government claimed all state lands essential to national security. This action was followed by decree law 1164 in 1971 by which the federal government took control of all land up to 100 km on either side of all roads constructed, under construction, or projected.

14. Pará real land values in 1970 were less than half those in Paraná in 1940 (in constant 1970 prices), and 1980 Pará land prices remained less than half of Paraná land prices in 1950. These data are from the Brazilian Agricultural Censuses, Paraná (1940, p. 244; 1950, p. 184); Pará (1980, p. 282). The factors for converting nominal prices to 1970 prices can be obtained from the authors. Beginning in 1966 and continuing into the 1970s, the federal government provided tax and credit incentives to private firms for investment in the Amazon. These initiatives were joined in the early 1970s with road-building programs, pledges of other infrastructure investment, and directed colonization efforts. INCRA organized colonization projects, especially along the Transamazon highway, bringing colonists from southern Brazil with pledges of infrastructure and credit. In 1971, the Program for National Integration (PIN) was launched to bring colonists to the Amazon. In Pará, INCRA established three colonization areas: Marabá, Altamira, and Itaituba. A goal of placing 100,000 families, each with 100-hectare plots, in organized colonies and planned urban centers was established, although not achieved (Fearnside, 1986, pp. 19-20; Wood and Wilson, 1984, p. 142; Sawyer, 1984, p. 189). For an assessment of government settlement projects, see Moran (1989b). In 1974, a policy shift led to greater emphasis on colonization by large ranchers in plots of 500 to 3,000 hectares and less on small-holder settlement (Fearnside, 1986, p. 21).

15. On the nineteenth century U.S. mining frontier, the need to obtain formal judicial recognition of mineral claims was a major reason for the establishment of government institutions. See, Libecap (1978).

16. Because of missing data, four records are lost, three from Altamira and one from Tucumã.

17. Descriptive statistics for the eight census years for both states can be obtained from the authors.

18. For 1970 for Pará, we have only 78 municípios because of problems with the census measure of investment in one município.
19. As we describe below, some of the variables, such as investment, are constructed using census data. In all cases where prices are involved it is necessary to deflate. All values for Paraná are in 1970 cruzeiros and all values for Pará are in 1985 cruzeiros. The index used to deflate prices was the General Price Index calculated by Fundação Getúlio Vargas. For the period 1940-1944, the price index for São Paulo found in IBGE, "Estatísticas Históricas do Brasil," (1990, pp. 226-236, 285-286) was used.
20. See Moran (1984, p.287), Fearnside (1986), and Schmink and Wood (1992, p.70).
21. Field notes, Robert Schneider, June 24, 1992.
22. Field notes by Ricardo Tarifa, May 31, 1993 and the IBGE 1985 Census.
23. We performed a test proposed by Davidson and Mackinnon (1981) to decide between a linear and log-linear specification for the value of land and investment equations in the four census periods in each state and for the survey data. Of the eight equations estimated for each state, the test either led to the rejection of the linear specification (nine of the sixteen estimations) or was inconclusive regarding the use of the linear or log specification (five of the sixteen estimations). In only two cases (one in each state) was the log specification rejected. We performed the test outlined by Breusch and Pagan (1979) for heteroskedasticity in the census estimations and corrected for it as necessary. Where heteroskedasticity is found, the estimation is corrected by using White's (1980) consistent estimator of the covariance matrix. The problem was greatest in the Paraná estimations where 10 of the 12 runs required correction. For the Pará estimations, only three of the 12 runs required correction, two in the early value runs and one in the early investment estimation. We also estimated the title equation for the census data, where the proportion of município farmers with title is the dependent variable, with a Probit specification. The results were essentially the same as with OLS, and for ease of coefficient interpretation, we chose the OLS specification. In Pará, the municípios of Belém, Ananindeua, and Benevides were not used in the analysis because they are primarily urban areas.
24. The two-stage procedure introduced the problem of biased standard errors. Where we corrected for heteroskedasticity using White's (1980) consistent estimator of the covariance matrix, the problem is addressed. However, where no heteroskedasticity existed, we adjusted the standard errors following Kelejian and Oates (1981, pp. 248-249).
25. The Breusch and Pagan (1980) technique involves a Lagrange multiplier test for correlation between the error terms of the model equations. The chi-square statistics for Pará and Paraná were all well below the critical value.
26. Although the land prices are those reported by individual farmers and are not actual transactions, as noted above, there are active land markets in all four sites. Hence, individuals would have opportunities to observe actual sales prices of nearby farms.
27. Land values for 1940-1980 are from the Censo Agropecuário, published by IBGE (Fundação Instituto Brasileiro de Geografia e Estatística). The values are those declared by the proprietor or administrator of the farm to the census interviewer. The agricultural census is done over the universe of agricultural establishments in each state and the results are presented aggregated at the município or county level. The value of land in 1985 in Pará was not provided in the census. It was estimated by



taking the ratio of land value to the value of farms (which included the value of investments, machinery, and animals) for 1970, 1975, and 1980. The growth rates of this ratio were obtained and an average growth rate calculated. The 1980 ratio was then multiplied by this average growth rate to give the 1985 ratio, which in turn, was multiplied times the 1985 agricultural farm value as provided in the census.

28. The census provides the proportion of município farmers who occupy their land without title (squatters). Hence, our measure is 1-the proportion of farmers who are squatters.

29. Below we describe how the investment variable was created from the census data.

30. The distance between the município capital and the state capital was calculated using maps. For Pará the data are provided in a map, Republica Federativa do Brasil, Estado do Pará, Rodoviario, Politico e Estatistico, Third Edition, 1988, published by Editora Turistica e Estatistica Ltda, Goiania. The data are from DER (Departamento Estadual de Rodagem) and from DETRAN (Departamento Nacional de Transito), respectively the state and national highway agencies. The distances are to Belém. Because of the importance of river transport in Pará, we used distance by river if this were less than distance by road or if no roads existed. For Paraná, the distance variable is created from a map prepared by the state of Paraná road department (DER) in 1966. The distances are to Curitiba, the capital of the state, even though some municípios in the north of Paraná probably are more under the influence of the markets in Sao Paulo, which is closer. Lacking more complete information, we maintained the same market for all of the municípios in Paraná.

31. Soil quality for each município was constructed using the maps in *Geografia do Brasil, Região Sul* (volume 2, p. 133) and *Região Norte* (volume 5, p. 90-1), published by IBGE, Rio de Janeiro, 1990. The maps classify the potentiality of the soil for agriculture in five categories, considering fertility and topography. Each município was assigned a number ranging from 1 to 5, increasing with the quality of the soil's potential.

32. The cleared variable was constructed by dividing the number of hectares of agricultural land cleared by the total amount of agricultural land in the município. The area cleared was defined as the sum of the land in permanent crops, temporary (annual) crops, planted pasture, natural pasture, planted forest, and unused, but usable land. These variables are defined by the agricultural census.

33. The dummy variable for the municípios in which the private land company, Companhia de Terras do Norte do Paraná, allocated land was created using the map in Nicholls and Paiva (1969, p. 28). By examining maps by IBGE (DT-SUEGE DEGEO/DIATA) that designate municípios, it is possible to identify those municípios included in the company's holdings. These areas then can be projected to 1970 and extended back to 1950 and 1940 to identify the municípios involved.

34. Determination of whether a município was involved in government jurisdictional disputes is based on discussion of Paraná settlement in Westphalen, Machado, and Balhana (1968). These authors clearly define 11 municípios where there were disputes in the 1950s between the federal and state governments. They also indicate that such conflicts were long standing and not settled until the mid 1960s, although they do not identify the contested municípios in earlier or later years. Due to subdivision, the number of municípios grew in Paraná over time. In the estimation, we traced the municípios as identified in the 1960 census back to 1950 and 1940 and extended them forward to 1970. Of the 49 municípios that existed in 1940, one was classified as private and three with jurisdictional conflict. In 1950, of 80 municípios, eight were private and four were in the disputed area. In 1960, there were 162 municípios in Paraná, with 29 having private land company holdings and 11 in the

disputed area. By 1970, there were 288 municípios, with 49 having large private company holdings and 61 within the area of jurisdiction confusion.

35. Municípios were considered as being under INCRA's jurisdiction if the capital of the município was within 100 km of a federal highway following Brazilian law.

36. Although this is the general case in Pará, there are a few municípios where federal subsidies for ranching under SUDAM were also attractive for squatting. These areas are characterized by both large ranchers and small holders, and these counties, not surprisingly, are where violence occurs. See Alston, Libecap, and Mueller (1995). These municípios are included in the estimations using census data.

37. Field notes by Ricardo Tarifa, May 18, 1993, for Tucumã.

38. The role of sindicatos and church groups in squatter efforts in the Amazon are well known. Similar activities were undertaken by local claims clubs in the U.S. in the nineteenth century.

39. A discussion of local "networks" and corresponding recognition of individual land claims is provided in Ricardo Tarifa's field notes, May 18, 1993, for Tucumã. For a discussion of local enforcement of property rights in a different context, see Ellickson (1991).

40. Before 1980, socio-economic data are at the state level only and are not by município.

41. We considered whether clearing was an explanatory variable affecting the costs of obtaining title. The farmers we surveyed in Pará indicated that having title had little impact on their clearing activity. Additionally, they claimed that clearing did not promote title. According to them, in a densely-forested region such as the Amazon, everyone cleared as a precondition to engaging in any agricultural activity. Including clear as an explanatory variable in the title equation revealed no significant impact, nor did title have a significant impact on clearing. With regard to the wealth variable, ideally, a wealth measure would include other assets, but we do not have such data. Moreover, among frontier settlers with few assets, livestock are an important source of wealth.

42. For 1985, livestock values are not provided, but were estimated by multiplying the number of animals (as given) by estimated prices. The prices were calculated by dividing the value of sales for each category as provided in the census by the number sold. All values for Paraná were converted to 1970 cruzeiros and for Pará to 1985 cruzeiros. The price index used for this was the Índice Geral de Preços as described by Fundação Getúlio Vargas, Rio de Janeiro. The investment amount then was divided by the amount of agricultural land in the county as provided in the census.

43. We did not pool the census data for two reasons. One was that we wanted to examine changes across time, which can be best illustrated with the individual census year runs. Further, there are problems with pooling Paraná data in particular since the number of municípios and hence, observations, changes across time from 49 to 288. This increase in the number of municípios is through subdivision of municípios so that the observation base is not the same across time. Additionally, for Pará we do not have information on all of the variables across time. On another point, in the estimations for 1970, for Pará one record is lost due to a negative value for investment, giving 78 observations.

44. The estimated values are drawn directly from the site dummy coefficients:  $e^{3.53} = 34.12$ ,  $e^{3.53-19} = 28.22$ ,  $e^{3.53-45} = 21.76$ , and  $e^{3.53+1.47} = 148.41$ .

45. The change in land value is  $e^{1.06}-1$  or 189 percent. Although the coefficient 1.06 represents an approximation of the percentage change in the land value due to having title, the magnitude of the coefficient makes it a less accurate approximation. Accordingly, it is preferable to directly calculate the percentage change in value due to having title.
46. The change in land value with title is  $e^{1.06-0.14\text{Indist}}-1$ , or at 40 km, 72 percent.
47. Alston, Libecap, and Schneider (1995) have the responses of 14 settlers in Tucumã who report increases in land value with title ranging from 0 percent to 100 percent. All of these settlers, however, are remote from the market center in Tucumã. Hence, a 189 percent increase in value is conceivable when distances are zero. See also the text where the values of titled and untitled land are described for different distances.
48. This result is obtained by adding the coefficient for the title-distance interaction to the estimated coefficient for the distance variable,  $-0.14 + -0.23 = -0.37$ .
49. We solve for the distance by setting the two estimated lines equal to each other. Dividing the estimated coefficient for title by the estimated coefficient for the title-distance interaction ( $1.06/0.14$ ) gives 7.57, and  $e^{7.57} = 1,942$  km.
50. Some farmers have a provisional title, rather than a final or definitive title. A provisional title may be issued while final processing of the title application takes place. Based on the survey of settlers and discussion with land agency officials a provisional and definitive title were viewed as essentially the same, and we treat them as equals in the analysis. We estimated the equation reported in the text using only definitive title, and the results essentially are the same.
51. The regression correctly predicts 42 farms without title and 107 with title when 79 did not have title and 127 had title. Overall, the regression correctly predicts 149 out of the sample of 206 or 72 percent.
52. Examination of the data reveals at least two plots without title in Altamira that are only 12 and 13 km from the market, and both are reasonably high valued, although somewhat below the mean price per hectare. Similarly, there are two plots in Tailândia with values above the mean price per hectare that are not titled.
53. For the alternative probabilities of having title, each site was estimated as if the settlers were in Altamira. The dummy variables for the sites other than the baseline were set to zero (Greene, 1993, 696-698).
54. Schmink and Wood (1992, p. 303) state that ITERPA handed out titles prior to local elections in 1982 as a means of generating political support. Our field surveyor argues that a similar process is anticipated in Tailândia: "The settlers that do not have a title are still waiting for ITERPA because these titles are in process. They told me that they are waiting for election time, when ITERPA issues titles for political interests." Quoted from the field survey report of Ricardo Tarifa dated May 12, 1993.
55. The standard deviations from the mean time on farm are 10.35, 5.38, 5.13, 2.51 for Altamira, São Felix, Tailândia, and Tucumã, respectively.

56. The standard deviations from the mean years of education are 2.06, 1.39, 1.68, 2.72 for Altamira, São Felix, Tailândia, and Tucumã, respectively.
57. The standard deviations from the mean distances are 50.27, 37.76, 28.52, and 9.00 for Altamira, São Felix, Tailândia, and Tucumã, respectively.
58. The standard deviations from the mean change in value are \$15.36, \$1.26, \$5.12, and \$ \$32.05 for Altamira, São Felix, Tailândia, and Tucumã, respectively.
59. Following Greene (1993, 696-698) and McDonald and Moffit (1980), the effect of having title on investment was estimated by calculating the cumulative density at the means of each site. The result is used to scale the estimated coefficients.
60. Our field surveyor, Ricardo Tarifa, reported that 1000 meters of fence cost approximately \$500 including labor and wire with poles coming from the farm. .
61. There may a spurious relationship between investment (pasture) and our wealth measure, which is value of livestock. Hence, we do not draw strong conclusions about the variable.
62. For example, after its creation in 1971, INCRA provided a variety of subsidies, including housing, other infrastructure, and seeds to Amazon settlers in its colonies (Moran, 1981, pp. 79-83). Regarding the performance of the soil quality variable, as noted earlier the average-soil-quality-in-the-município variable appears to be especially weak, giving expected results for Paraná, but negative results for Pará.
63. *Brazilian Agricultural Census, Paraná* (1970, p. 252). The values reported in the text are total farm investment in each state as we define it, divided by total farm area.
64. *Brazilian Agricultural Census, Paraná* (1970, p. 252) and *Pará* (1980, p. 282).

**Table 1**  
**Descriptive Statistics for the Survey Sample**  
**206 observations**

| Variable                                       | Mean       | S.D.        | Minimum | Maximum   |
|--|------------|-------------|---------|-----------|
| Percent of Farmers with Title                  | 61         | 49          |         |           |
| Value Per Hectare                              | \$86.78    | \$200.95    | \$2.72  | \$1902.00 |
| Total Distance to Market (km)                  | 68.14      | 57.70       | 4.00    | 190.00    |
| Area (hectares)                                | 119.70     | 261.82      | 5.00    | 3500.00   |
| Percent of Farm Cleared                        | 40.00      | 24.00       | 0.00    | 100.00    |
| Percent of Farm in Pasture and Permanent Crops | 19.00      | 19.00       | 0.00    | 100.00    |
| Education (years)                              | 1.99       | 2.21        | 0.00    | 10.00     |
| Time on Plot (years)                           | 8.60       | 7.32        | 0.00    | 58.00     |
| Age (years)                                    | 43.67      | 13.01       | 16.00   | 78.00     |
| Wealth (value of livestock)                    | \$3,651.20 | \$10,734.00 | 0.00    | \$114,300 |

Table 2

Determinants of Land Value, Title, and Investment: Survey Data for Small Farmers  
(t-statistics in parenthesis)

|                                 | Land Value Per Hectare | Title                                | Investment                            |
|---------------------------------|------------------------|--------------------------------------|---------------------------------------|
| Constant                        | 3.53<br>(6.00)         | 0.51<br>(0.82)                       | -0.23<br>(-1.43)                      |
| Tucumã                          | 1.47<br>(8.87)         | -2.28<br>(-3.32)                     | 0.22<br>(4.08)                        |
| São Felix                       | -0.19<br>(-1.06)       | 0.33<br>(0.78)                       | -0.09<br>(-2.75)                      |
| Tailândia                       | -0.45<br>(-3.12)       | -0.07<br>(-0.21)                     | -0.07<br>(-2.31)                      |
| Title                           | 1.06<br>(2.14)         |                                      | 0.36<br>(3.50)                        |
| Distance                        | -0.23<br>(-1.75)       | -0.006<br>(-1.74)                    | 0.003<br>(0.19)                       |
| Distance·Title                  | -0.14<br>(-1.14)       |                                      |                                       |
| Clear                           | 0.58<br>(1.33)         |                                      |                                       |
| Investment                      | 0.97<br>(2.14)         |                                      |                                       |
| Time                            |                        | 0.04<br>(2.38)                       | -0.02<br>(-1.09)                      |
| Education                       |                        | 0.08<br>(1.59)                       | -0.01<br>(-0.92)                      |
| Wealth                          |                        | 0.00002<br>(1.18)                    | 0.01<br>(2.33)                        |
| Age                             |                        | -0.007<br>(-0.83)                    | 0.03<br>(0.95)                        |
| Change in Value                 |                        | 0.01<br>(1.35)                       |                                       |
| Calculated Log-Likelihood Ratio |                        | 59.61<br>( $\chi^2_{3,05} = 16.92$ ) | 119.54<br>( $\chi^2_{3,05} = 16.92$ ) |
| R <sup>2</sup>                  | .69                    |                                      |                                       |

**Table 3**  
**The Determinants of Land Value on the Frontier: Census Data**

Dependant Variable: Land Value Per Hectare.  
Paraná (t-statistics in parenthesis)

|      | Constant         | Title          | Title-Distance   | Invest         | Pop Density    | Cleared Area     | Soil Quality     | Distance       | Private Company  | Govt. Dispute    | R <sup>2</sup> | N   |
|------|------------------|----------------|------------------|----------------|----------------|------------------|------------------|----------------|------------------|------------------|----------------|-----|
| 1940 | -9.70<br>-(1.75) | 8.88<br>(1.63) | -1.41<br>-(1.59) | 0.52<br>(3.72) | 0.14<br>(0.77) | -0.27<br>-(0.96) | 0.18<br>(1.21)   | 1.47<br>(1.65) | 0.17<br>(0.42)   | -0.27<br>-(0.88) | .73            | 49  |
| 1950 | -6.17<br>-(1.58) | 5.93<br>(1.40) | -0.87<br>-(1.18) | 1.05<br>(8.69) | 0.04<br>(0.22) | -0.93<br>-(2.70) | -0.07<br>-(0.64) | 1.14<br>(1.68) | 0.68<br>(3.93)   | -0.38<br>-(0.72) | .86            | 80  |
| 1960 | -4.09<br>-(1.68) | 3.45<br>(1.39) | -0.35<br>-(0.88) | 0.68<br>(9.21) | 0.44<br>(5.80) | -0.19<br>-(1.28) | -0.06<br>-(0.67) | 0.66<br>(1.69) | 0.16<br>(2.22)   | 0.21<br>(1.13)   | .87            | 162 |
| 1970 | -8.21<br>-(5.39) | 7.66<br>(4.56) | -1.31<br>-(4.29) | 0.46<br>(9.16) | 0.30<br>(3.88) | 0.46<br>(2.46)   | 0.07<br>(1.42)   | 1.46<br>(5.25) | -0.05<br>-(0.67) | -0.15<br>-(2.59) | .75            | 288 |

Dependant Variable: Land Value Per Hectare.  
Pará (t-statistics in parenthesis)

|      | Constant         | Title            | Title-Distance   | Invest         | Pop Density      | Cleared Area     | Soil Quality     | Distance         | INCRA Area       | Violent Conflict | R <sup>2</sup> | N  |
|------|------------------|------------------|------------------|----------------|------------------|------------------|------------------|------------------|------------------|------------------|----------------|----|
| 1970 | -0.36<br>-(0.29) | 0.21<br>(0.18)   | -0.03<br>-(0.12) | 0.37<br>(3.59) | 0.20<br>(1.97)   | 0.07<br>(0.48)   | 0.04<br>(0.16)   | -0.07<br>-(0.45) | N.A.             | N.A.             | .51            | 78 |
| 1975 | 0.39<br>(0.34)   | 0.70<br>(0.43)   | -0.24<br>-(0.82) | 0.27<br>(2.59) | 0.11<br>(1.62)   | 0.03<br>(0.29)   | 0.02<br>(0.10)   | -0.06<br>-(0.31) | -0.18<br>-(1.42) | N.A.             | .44            | 79 |
| 1980 | 0.87<br>(0.55)   | -1.07<br>-(0.50) | 0.25<br>(0.68)   | 0.41<br>(4.11) | -0.15<br>-(2.26) | -0.02<br>-(0.13) | -0.10<br>-(0.44) | -0.32<br>-(1.26) | 0.51<br>(3.00)   | -0.06<br>-(0.39) | .51            | 79 |
| 1985 | 0.28<br>(0.15)   | 1.42<br>(0.55)   | -0.13<br>-(0.29) | 0.07<br>(0.94) | 0.14<br>(1.90)   | 0.16<br>(1.24)   | -0.31<br>-(1.38) | -0.16<br>-(0.49) | 0.26<br>(1.39)   | 0.24<br>(1.17)   | .37            | 79 |

**Table 4**  
**Determinants of Property Rights on the Frontier: Census Data**

Dependent Variable: Proportion of Farmers with Title  
Paraná (t-statistics in parenthesis)

|      | Constant        | Distance           | Farm Size          | Private Company  | Govt. Conflict   | Change in Value  | R <sup>2</sup> | N   |
|------|-----------------|--------------------|--------------------|------------------|------------------|------------------|----------------|-----|
| 1940 | 1.03<br>(22.71) | -0.0002<br>(-2.02) | 0.0001<br>(0.70)   | 0.02<br>(0.90)   | -0.15<br>(-0.99) | -0.24<br>(-0.68) | .25            | 49  |
| 1950 | 0.93<br>(33.83) | -0.0002<br>(-1.00) | 0.0001<br>(1.80)   | -0.02<br>(-0.31) | -0.29<br>(-1.63) | 0.10<br>(1.54)   | .25            | 80  |
| 1960 | 0.95<br>(45.26) | -0.0001<br>(-1.50) | 0.0002<br>(1.83)   | 0.02<br>(0.91)   | -0.35<br>(-3.37) | 0.07<br>(1.54)   | .37            | 162 |
| 1970 | 0.91<br>(40.68) | 0.00002<br>(0.31)  | -0.0003<br>(-2.33) | 0.05<br>(4.85)   | -0.03<br>(-1.95) | -0.02<br>(-1.12) | .10            | 288 |

Dependent Variable: Proportion of Farmers with Title  
Pará (t-statistics in parenthesis)

|      | Constant         | Distance           | Farm Size          | INCRA Area       | Violent Conflict  | Change in Value  | Age            | Income         | Educa-<br>tion | R <sup>2</sup> | N  |
|------|------------------|--------------------|--------------------|------------------|-------------------|------------------|----------------|----------------|----------------|----------------|----|
| 1970 | 0.53<br>(6.67)   | -0.0003<br>(-3.95) | 0.0001<br>(1.50)   | N.A.             | N.A.              | 8.43<br>(2.90)   | N.A.           | N.A.           | N.A.           | .48            | 78 |
| 1975 | 0.60<br>(5.31)   | -0.0003<br>(-3.95) | 0.0001<br>(1.06)   | -0.05<br>(-0.88) | N.A.              | -0.17<br>(-0.50) | N.A.           | N.A.           | N.A.           | .20            | 79 |
| 1980 | -0.66<br>(-1.13) | -0.0002<br>(-1.79) | -0.0002<br>(-2.01) | -0.03<br>(-0.52) | 0.04<br>(0.60)    | 0.09<br>(0.28)   | 0.05<br>(2.02) | 0.12<br>(1.37) | 0.06<br>(0.74) | .20            | 79 |
| 1985 | 0.48<br>(5.36)   | 0.0001<br>(0.91)   | 0.0001<br>(1.22)   | -0.02<br>(-0.30) | -0.001<br>(-0.01) | 0.46<br>(2.21)   | N.A.           | N.A.           | N.A.           | .09            | 79 |



**Table 5**  
**The Determinants of Agricultural Investment on the Frontier: Census Data**

Dependant Variable: Agricultural Investment Per Hectare.  
 Paraná (t-statistics in parenthesis)

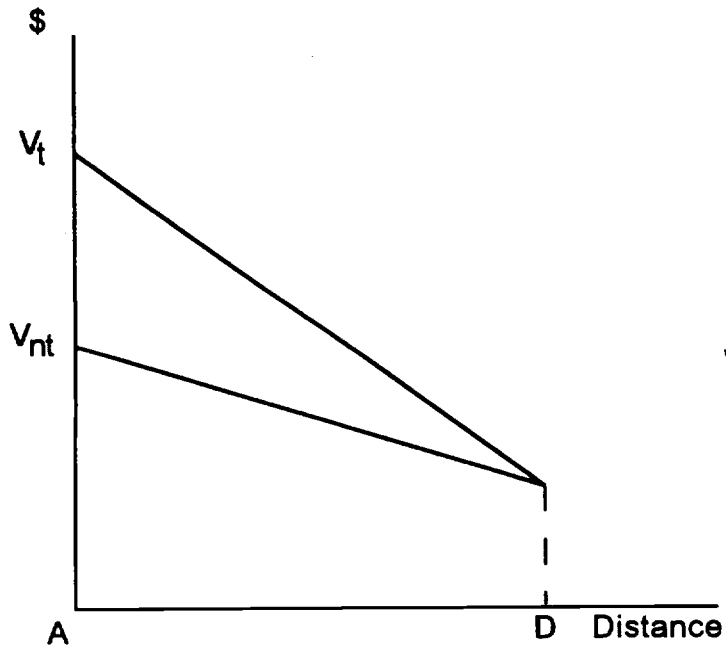
|      | Constant          | Title            | Distance         | Private Company | Government Conflict | Soil Quality   | R <sup>2</sup> | N   |
|------|-------------------|------------------|------------------|-----------------|---------------------|----------------|----------------|-----|
| 1940 | 2.44<br>(0.94)    | -5.16<br>(-2.07) | -0.21<br>(-2.24) | 0.05<br>(0.07)  | -2.13<br>(-3.66)    | 0.37<br>(1.47) | .36            | 49  |
| 1950 | -5.50<br>(-3.69)  | 2.67<br>(1.88)   | -0.03<br>(-0.35) | 0.80<br>(3.01)  | -0.27<br>(-0.51)    | 0.50<br>(2.35) | .28            | 80  |
| 1960 | -5.47<br>(-3.13)  | 3.07<br>(1.82)   | 0.01<br>(0.12)   | 0.68<br>(4.30)  | 0.74<br>(1.05)      | 0.42<br>(2.04) | .26            | 162 |
| 1970 | -10.47<br>(-9.56) | 9.80<br>(7.06)   | 0.05<br>(0.58)   | 0.38<br>(2.88)  | -0.04<br>(-0.37)    | 0.27<br>(2.52) | .42            | 288 |

Dependant Variable: Agricultural Investment Per Hectare.  
 Pará (t-statistics in parenthesis)

|      | Constant         | Title          | Distance         | INCRA Area     | Violent Conflict | Soil Quality     | R <sup>2</sup> | N  |
|------|------------------|----------------|------------------|----------------|------------------|------------------|----------------|----|
| 1970 | -6.70<br>(-2.73) | 4.55<br>(3.58) | 0.49<br>(1.65)   | N.A.           | N.A.             | -0.19<br>(-0.54) | .27            | 78 |
| 1975 | -4.07<br>(-0.70) | 3.93<br>(0.91) | 0.02<br>(0.05)   | 0.71<br>(2.67) | N.A.             | 0.34<br>(0.50)   | .24            | 79 |
| 1980 | -0.94<br>(-0.77) | 2.54<br>(2.65) | -0.31<br>(-2.41) | 0.67<br>(3.34) | -0.32<br>(-1.50) | -0.16<br>(-0.63) | .44            | 79 |
| 1985 | -4.71<br>(-2.48) | 6.78<br>(3.71) | -0.10<br>(-0.59) | 0.27<br>(0.99) | -0.28<br>(-0.90) | -0.31<br>(-0.91) | .28            | 79 |

Figure 1.

Panel (a).



Panel (b).

