IS LAND TITLING IN SUB-SAHARAN AFRICA COST-EFFECTIVE? EVIDENCE FROM MADAGASCAR

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ABSTRACT

Land rights formalization has been promoted as a way to encourage agricultural investment and stimulate land markets, yet little is known about the benefits of such policies in sub-Saharan Africa, where pre-conditions for success are less favorable. Using a large sample of plots from an intensively titled rice-growing area of Madagascar, we compare land-specific investments, land productivity, and land values between titled and untitled plots cultivated by the same household. We find no significant effect of having a title on plot-specific investment and correspondingly small impacts on land productivity and land values. These results are consistent with simulation evidence from a theoretical model of investment under expropriation risk. A cost-benefit analysis based on our findings suggests that formal titling should not be extended in rural Madagascar.

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Reducing land tenure insecurity is seen as a legitimate role for the state, and often as a cost-effective intervention. Evidence from Asia and Latin America suggests that formalization of land ownership, through registration and titling, can deliver large productivity gains. Formalization is particularly attractive where indigenous tenure systems are weak or absent, where the return on investment in land is high, and where collateralized lending has taken hold. In most of sub-Saharan Africa, however, none of these conditions apply, leading some to question the wisdom of registering land and widely distributing land titles.[1]

Empirical work examining the effects of land rights formalization in sub-Saharan Africa is scarce, reflecting the small fraction of farmland there that is actually registered and titled. Evidence from Kenya, considered the African test-case for tenure reform, shows little if any economic impact of land registration (Place and Migot-Adholla, 1998; Carter et al., 1997).[2] A larger literature exists on customary land rights in Africa (see, e.g., Besley, 1995; Gavian and Fafchamps, 1996; Braselle et al., 2002), but is concerned, strictly speaking, with the economic response to greater tenure security. This paper focuses instead on the potential benefits of a land titling program. Even if greater tenure security leads to large increases in investment and land productivity, land tenure reform will not necessarily succeed. The reform must also reduce insecurity. Yet, introducing or expanding a modern property rights regime alongside an indigenous tenure system is not guaranteed to reduce insecurity, or reduce it by very much, and could even have the opposite effect.

Indigenous tenure, in its various forms, by providing a set of well-understood and respected rules governing land use and transfer within the community, imparts a certain degree of tenure security. In this context, establishing a modern property rights system,

[1] These well-known arguments are summarized in World Bank (2003), Feder and Nishio (1999), Firmen-Sellers and Sellers (1999), Bruce and Migot-Adholla (1997), Atwood (1990), and Migot-Adholla et al. (1991). The later authors are among those who point out that sub-Saharan Africa lacks the infrastructure, factor market development, and other prerequisites for land tenure reform to promote agricultural intensification and productivity growth.

[2]By contrast, Roth, Unruh, and Barrows (1997), using a relatively small sample of plots, find that titled land is significantly more valuable than untitled land in a Somali irrigation scheme. This study is anomalous in other respects as well, however. The titling effect on land values is enormous (242%) whereas there is no significant effect of title on land-specific investments or on perceived ownership security. Moreover, the land value regressions are estimated by OLS even though there is evidence that the samples of titled plots and of titled farmers are both highly selective.

without legally recognizing informal rights, may expand the scope for rent-seeking by outsiders. Atwood (1990) summarizes the argument as follows:

> "Members of a local community may face far fewer risks of loss of land under the existing informal system than an outsider would face. In addition, while land registration might reduce the risks faced by an outsider, it may increase the risks and insecurity faces by local people as family members or peripheral land claimants jockey to see in whose name a parcel will be registered…For many local people, therefore, registration can create rather than reduce uncertainty and conflict over land rights." (pp. 663).

The tenure uncertainty induced by such rent-seeking can create a demand for formalization where previously none existed.[3] In other words, land registration and titling become privately valuable even while land tenure reform, in the broader sense, might be socially wasteful.

The aim of this study is to estimate these private benefits of land titles in Madagascar, a country where modern and informal tenure systems coexist and overlap to a significant degree in certain zones. We analyze a large data set recently collected in an intensively titled area, the Lac Alaotra basin, comparing economic performance on titled and untitled land. Because rural credit markets are not well developed in Madagascar and because, as shown later, the benefits of formalization in the land market have been ambiguous, we emphasize the direct role of expropriation risk. To ballpark the empirical magnitudes of the titling effects to be expected in our setting, we begin by simulating a simple model of investment subject to expropriation risk.

A key empirical concern in any study of this type is endogenous take-up of land titles. Elsewhere, this problem has been dealt with by comparing areas where titles are available to those where titles are unavailable. For example, the landmark study of Feder et al. (1988) in Thailand constructs a comparison group for farmers with titled land from among farmers cultivating plots in adjacent state forest reserves, in which titles cannot be legally issued. We follow a similar methodology by comparing titled and untitled plots in a very restricted geographical area, within which differences in infrastructure, market development, the returns to land specific investment, and soil fertility should be minimal. In addition, our data allow us to compare titled and untitled plots cultivated by the *same*

[3] According to Bruce, Migot-Adholla, and Atherton (1997): "Much of the titling demand for smallholders in Africa can be viewed as 'preemptive'—representing an attempt to prevent the state from allocating the land to someone else, rather than the expression of a felt need for new operating rules of tenure." (p. 259).

household, thus eliminating selection bias at the level of the farmer. Such selection bias may be particularly salient in the case of investment, which depends on farmer-level attributes that are difficult to observe, such as entrepreneurial ability and wealth; these attributes may also affect the decision to pursue land titling in the first place.[4]

The remainder of this paper is organized as follows. Section 1 describes the setting and data used in the study, focusing on the relationship between formal and informal property rights in land. Section 2 goes through the different arguments for why land titling might be beneficial and assesses their relevance in rural Madagascar. Section 3 presents the empirical estimates of the impacts of land titles on land-specific investment, land productivity, and land values. Section 4 concludes with implications of the findings for land policy in Madagascar and sub-Saharan Africa more broadly.

1. Setting and Background

Irrigated perimeters of Lac Alaotra: A brief history

Lac Alaotra is the principal rice-growing region of Madagascar, a country where rice is the main food staple and is cultivated by almost every rural household. The Lac Alaotra basin encompasses nearly 30,000 hectares of riceland under modern irrigation, lying within four vast irrigated perimeters along the lakeshore, and another 72,000 hectares of lowlands under traditional forms of irrigation. The large irrigated perimeters, called *mailles* (French for "mesh", evoking the crisscrossing irrigation canals), were carved out of marshland, beginning in the 1950s, under the French colonial administration. Dams and canals were built to control water flows, thus limiting periodic inundations and allowing a reliable supply of irrigation. As a consequence, rice yields have been much higher within the *mailles* than on adjacent lands.

Most land within the irrigated perimeters of Lac Alaotra was claimed by French settlers up until Independence in 1960, at which time the zones of colonization were abolished and land ownership reverted to the state. Under the new law, peasants

[4] Deininger and Chamorro follow a similar household fixed effects strategy in their study of Nicaragua, but only for land values, not for investment. In the urban context, studies by Field (2003) and Galiani and Schargrodsky (2004) exploit the staggered phase-in of a titling program to compare outcomes on titled and untitled property using the presence of the program as an instrumental variable.

occupying land could obtain title just as the colonists had before. The old titling system, based on the Torrens model, in which the state guarantees ownership, lived on in the post-Independence era. However, the formal titling procedure, better suited to large tracts of highly productive farmland than to the typically-sized Malagasy plot, was (and is) complex and costly, involving 24 separate steps and taking years to complete.

When the Malagasy administration took over management of the *mailles* in 1961 with the establishment of the parastatal SOMALAC, they began to redistribute land among current occupants as well as newcomers. As part of this policy, tenants conforming to SOMALAC's by-laws were eventually to receive formal title to the reconfigured parcels. Farmers with land in the *mailles* first had to pay a "maintenance" fee entitling them to a certificate of occupation. While this document was only a first step toward formal title, it significantly lowered the barriers to a title application.[5]

Despite the attention paid to formalizing land ownership within this special zone, a large fraction of *maille* parcels still have no title to this day. There are many reasons for this, not least of which was lack of resources and capacity in the office of land administration. Other cases have more to do with the determination of the landowners themselves. Farmers frequently failed to pay the maintenance fee to SOMALAC, for example, thus blocking progress toward a title. Sometimes the originally designated owner died during the lengthy titling process and his heirs could not agree on a single representative to take over, or they where simply late in obtaining the necessary documentation for the inheritance. Often titles were abandoned after the parcel was divided or sold in a manner contrary to SOMALAC's by-laws (see CIRAD, 2004).

The upshot is that the Lac Alaotra basin not only contains some of the country's most productive riceland but is also perhaps the most intensively titled area of rural Madagascar. Importantly, though, not all land within the *mailles* is titled and not all land outside the *mailles* is untitled. This will allow us to distinguish empirically between the effects of having titles per se from the effects of simply having land within the *mailles*.

[5] Another advantage was that SOMALAC undertook the cartography for all *maille* parcels, work which would otherwise have had to be done by the understaffed land administration. With the dissolution of SOMALAC in 1991, its role in facilitating land titling abruptly ended.

Data and Sampling

A specially designed survey covering over 1,700 households in 38 communes was conducted around Lac Alaotra in April-May 2005. About 900 landowning households were randomly selected from 29 communes lying wholly outside of the irrigated perimeters. In order to over-sample households with titled land, about 800 households were randomly selected from the 9 communes encompassing the *mailles*.

The survey asked about land documentation, agricultural production, and investment for all household parcels, lowland (*riziere*), upland, and forest plots. There is a clear distinction between these types of land in Madagascar. Although rice may occasionally be cultivated on upland plots, lowland plots are used exclusively for growing rice during the main (wet) season and are virtually never converted to alternative agricultural uses. In this paper, then, we focus exclusively on lowlands, which are by far the most valuable type of land. Future work will examine the issues unique to upland plots. Excluding land not owned by the household (i.e., leased in) gives us a sample of 3,232 rice plots owned by 1,604 households.

Descriptive statistics reported in Table 1 confirm the two observations made above regarding riceland within the *mailles*. First, an unusually high proportion of it is titled. Whether we count by plot or by area, farmers have formal title to about half of the land in the *mailles*, a percentage four to six times higher than outside the *maille*, where the prevalence of titled land is just above the national figure of around 7% of area. Second, land within the *mailles* is considerably more productive than land outside; rice yield (for the 2004 crop), revenue from rice (net of purchased input costs), and estimated plot values are all on the order of 40% higher for *maille* plots.[6]

The extent to which this greater productivity is due to the higher rate of titling in the *mailles* is a question we turn to in detail in Section 3. For now, though, Figure 1 provides a cursory answer, illustrating the estimated densities of log plot value per hectare by *mailles* location and title status. The dominant feature is the shift of the entire

[6] Productivity also varies across the four large perimeters, but not nearly as much as between *maille* and non-*maille* plots. Average yield, for example, ranges between 3.1 and 3.6 ton/ha within the four *mailles*. The coefficient of variation of yield, revenue, and plot value inside the *mailles* are all 60-70% as large as they are outside, probably reflecting the fact that land quality, including quality of irrigation, is more uniform within the modern irrigated perimeters.

distribution of land values between *mailles* and non-*mailles* plots. Within each location, however, the distributions for titled and untitled plots are virtually indistinguishable. Whether this conclusion holds up when we control for other factors remains to be seen, but the preliminary evidence suggests that titling effects will be subtle, at best.

Informal tenure in Madagascar

As elsewhere in Africa, two property rights regimes operate in Madagascar: The official but highly circumscribed titling system and an unofficial or informal system permeating most of the country. Under the latter, access to land, with the possible exception of village commons, is no longer controlled by the community, as still occurs in some land-abundant areas of sub-Saharan Africa. Rather, land ownership in rural Madagascar is now largely individualized. Particularly in more commercialized areas, such as Lac Alaotra, land can even be sold to outsiders without approval from traditional authorities. Land ownership claims, however, draw their legitimacy from communal institutions, some of which have been invented or adapted for precisely this purpose.

Data from the Lac Alaotra region, summarized in Table 2, reveal a rich tapestry of land documents of varying degrees of formality, the so-called *petits papiers* ("little papers"). In most cases, these documents appear to exist independently of the formal titling status of the plot. In the table, we break up titles into two categories; those in the name of a current household member or relative ("up-to-date"), and those in the name of a dead person ("out-of-date"). Overall, 42% of titled plots are in the out-of-date category, reflecting both the costliness of the procedure for recording land transactions and inheritances as well as resource constraints in the land administration bureaucracy.

Looking at purchased plots, which account for over 40% of the total,[7] we see that the vast majority of land sales are accompanied by a usually handwritten sales receipt (referred to in Table 2 as an *acte de vente*). In most cases, this document is signed by the village (*fokontany*) head in front of the parties to the transactions and possibly other witnesses (i.e., "certified"). The main purpose of such a procedure seems to be to assure

[7] Lac Alaotra is notable for the extent of land market activity. Nationally, only about 13% of lowland plots in rural areas are purchased (according to the EPM-2001 national household survey). Also, one-quarter of cultivated plots in our sample are leased in, compared to the national figures of 10%.

the buyer that, in the eyes of the community, the plot actually belongs to the seller and, moreover, has not already been sold to someone else. It is perhaps not surprising, then, that, as seen in Table 2, transactions among close relative are somewhat less likely to involve these receipts and substantially less likely to be certified by the village head. In acknowledging that a proper land transaction took place, an *acte de vente* can also subsequently serve as proof of ownership. Indeed, among the few land sales reported in our data over the past 10 years involving previously purchased plots, most mention the original *acte de vente* as the main proof of ownership.

There are several other *petits papiers* listed in Table 2, depending on the mode of plot acquisition. An *acte de donation*, issued by the commune, indicates that a specific person has transferred a well-demarcated parcel of land to another person; these may be obtained in cases of either purchase or inheritance, but are equally uncommon. Ownership of ancestral land is generally less well documented than that of purchased land, with only two-thirds of inherited rice plots having any kind of paper (most commonly an *acte de patrimoine*, itemizing the estate of the deceased, and an *acte de notorité*, certifying the heirs). For about a third of the lowland plots that were originally cleared by the current owner (virtually all outside the *mailles*), the owner obtained advance written authorization for the exploitation. Legally, in such cases, one can apply for title based on the principle of *mise en valeur* (improvement) if one can establish occupancy for at least 10 years. Finally, 10% of rice plots in our sample were acquired directly from SOMALAC, which is to say that they were received as part of the land redistribution in the 1960s and early 1970s. The owners of most of these plots that remain untitled report having an *acte d'attribution* issued by SOMALAC, which is the aforementioned certificate of occupation. After so many years, however, the titling process is for all intents and purposes moribund. To be sure, none of the aforementioned documents have juridical standing in a formal land dispute, as would a title, but they may nonetheless provide a considerable sense of tenure security.

Investment in riceland

Land-specific investment comes in three basic varieties: Initial clearing of land to make it cultivable; installation of new infrastructure; and maintenance of existing

infrastructure. The scope for the first type of investment depends on the extent of unexploited lowlands. Since the region around Lac Alaotra has a long history of settlement, there is now little land left to clear for irrigated rice cultivation. Table 2 shows that only 7% of rice plots were acquired through clearing by the current owner and few of these plots were cleared recently (less than 20% of them after 1990).

As for plot infrastructure, our survey collects detailed data on all investments in land made over the past five years on owned plots, including both the cash costs and family labor inputs. There are three dominant types of investment in lowland rice plots (see Table 3), which are, in order of importance, the construction/maintenance of irrigation/drainage canals, the construction/maintenance of protective bunds, and land leveling. Other investments (installation of wells, tree-planting, terracing, etc.) are virtually unheard of for rice plots in Lac Alaotra. Investments related to water management (canals) are more prevalent within the modern irrigated perimeters, whereas land leveling is more common outside the mailles, where, for one thing, plots are more prone to sedimentation.

Overall, total *annualized* investment expenditures (valuing family labor days at the local wage) over the past five years averages only about 1% of plot value. Such relatively low expenditures and their high frequency suggest that investments are largely for maintenance of existing plot infrastructure. There are other indications that the vast bulk of investment in riceland is recurrent. For 92% of the cases of canal work, 91% of bund work, and 87% of land leveling (almost by definition a maintenance activity on extant rice plots), the investment was reported to have already existed on the plot five years before and thus was not being made for the first time only in the last five years.

2. Economic Benefits of Land Titles in Madagascar

Land titling can increase investment in land, agricultural productivity, and land values in three ways, which Braselle et al. (2002) usefully term the *assurance*, *realizability*, and *collateralizability* effects. The assurance effect arises insofar as titling reduces the risk of land expropriation. As the expected length of tenure increases, improving or maintaining

one's land becomes more attractive. While the assurance effect is the focus of this section, later we consider the relevance of the other titling effects in rural Madagascar.

The assurance effect and the social value of titling

It is precisely the fact that a title deed, as opposed to any of the *petits papiers* discussed above, legally guarantees ownership that appears to underlie the demand for titling in Madagascar. Ninety percent of farmers questioned in our survey see protection against competing claimants as the chief benefit of a title. Another 6 percent said a title mainly facilitates bequests of land to children, which, arguably, amounts to the same thing.[8] However, when asked whether they had heard of cases of households having lost land because they lacked proper documentation, 91% responded rarely or never (see Table 4). Most (69%) of those who had heard of such cases, identified large landowners or powerful individuals as the instigators of the conflict. Such responses reflect an underlying perception of rent-seeking and corruption in the land administration that often emerges in field-interviews. The principal fear is that the issuance of factitious titles could allow influential people to dispossess peasants of their ancestral lands.

As indicated earlier, a large fraction of land titles in Madagascar are out-of-date; i.e., in the name of a deceased person. Do such titles have any value? While this is ultimately an empirical question, there is good reason to believe that, with regard to expropriation of the sort just discussed, an out-of-date title still confers considerable protection. First, in most cases of inheritance the title will bear the same family name as that of the current owner. Secondly, the issuance of the title, even if many years in the past, implies that the parcel is part of the title deed registry and its boundaries and title number appear in the cadastral record at the office of land administration. Consequently, it would be extremely difficult to have a new title issued for land incorporating a previously titled parcel, even one subsequently subdivided among several co-heritors; certainly, it would be far easier to exploit the modern titling system to nullify an informal ownership claim than a formal one.

[8] These respondents appear to believe that the inheritance of a titled plot would be more difficult to challenge by other relatives, although, as we will see later, many titles are never updated after inheritance.

If farmer opinion is any indication, then the main channel for titling to have an economic impact in the Lac Alaotra region is through the assurance effect.[9] However, even if these economic impacts turn out to be large, the fact that landowners demand titles in an area already exposed to titling does not imply that introducing a land titling program into a previously untitled area is a good idea. This depends on the extent to which the modern system of title deeds creates additional tenure insecurity on land remaining outside its umbrella. The larger the externality imposed on those with informal tenure, and the more difficult it is to make titling universal, the more likely it is that a land titling initiative will entail a net social cost.

Can the magnitude of the social cost of introducing non-universal titling alongside an existing informal system be measured? In principle, the answer is yes. If there are no other private benefits to having a land title and all expropriation is due to manipulation of the modern system, then the marginal willingness to pay for a titled plot over an otherwise identical untitled plot – i.e., their differential market value – is a measure of the benefit to the farmer of averting possible expropriation. Ignoring general equilibrium effects, the social cost of titling is then this market value differential multiplied by the number of plots remaining under informal tenure. To the extent that possessing a title has other advantages besides protection against such expropriation, this calculation provides only an upper bound on the social cost.

Quantifying the impact of expropriation risk

If most land-specific investment in Madagascar riceland is indeed for plot maintenance, as the data suggest, then we can assess *a priori* the quantitative importance of the assurance effect of land titles. Consider the simple model of recurrent investment in land subject to expropriation risk used by Jacoby et al. (2002). If the instantaneous (annualized) probability of losing one's plot, θ, is constant over time, then the private value of the plot is given by $V = \pi/(r+\theta)$, where π is net revenue per hectare (i.e., net

[9] As the quote from Atwood (1990) cited earlier amply illustrates, though, land titles themselves can create insecurity and conflict within a community. In our Lac Alaotra data, conflicts are quite rare, involving only 3% of owned rice plots; this figure encompasses the entire ownership period and falls to just 1.4% for conflicts over the past five years. There is, indeed, some evidence that conflicts are *more* prevalent on titled plots than on untitled plots, other things equal, but the numbers of conflicts in our data set is simply too small to inspire much confidence in this finding.

of recurrent investment costs) and r is the annual discount rate.[10] Recurrent investment, the stock of capital, and net revenue are all decreasing in θ. Obtaining legal title to a plot, to the extent that it lowers the threat of expropriation, raises land values both by increasing steady-state investment, thus raising land productivity, as well as by lowering the effective discount rate $r+\theta$. Land titles, in other words, are valuable to farmers even if they do not appreciably enhance investment in land.

We can now ask what magnitude of expropriation risk would have to be present to obtain an empirically detectable effect of land titling on recurrent investment and on land values. Suppose that output per hectare is produced according to the function $k^{1-\alpha}/(1-\alpha)$, where k is the stock of plot infrastructure and $\alpha \in (0,1)$.[11] Let us further suppose that granting a formal title reduces expropriation risk from θ to 0. Under these assumptions, the ratio of investment expenditures on titled land to that on untitled land is independent of the unit cost of investment and, in particular, takes the simple form $(1+\theta/(r+\delta))^{1/\alpha}$, where δ is the depreciation rate on infrastructure. The analogous ratio for land values, which is an overall measure of the benefits of a title, is also given by a simple formula.[12] Both of these ratios are easily calculated for different configurations of the parameters $\{r,\delta,\theta,\alpha\}$.

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[10] Specifically, the farmers problem is to maximize $\int_0^\infty e^{-(r+\theta)t}\pi(k(t))dt$ subject to $\dot{k}(t) = -\delta k(t) + x(t)$, where $\pi = F(k(t)) - cx(t)$, F is the production function with unit output price, k is the capital stock, c is the unit cost of recurrent investment, x is the flow of recurrent investment, and δ is the rate of depreciation. The effect of land expropriation on farmer portfolio risk is ignored in this setup.

[11] The capital stock must be bounded from below as land itself is indestructible, but we assume that this constraint is never binding. We also ignore all variable inputs. These would only affect the numerical calculations below insofar as they are strongly complementary or substitutable with the capital stock.

[12] The expression is $\frac{(r+\theta)(r+\theta+\delta)^{1/\alpha}(r+\alpha\delta)}{r(r+\delta)^{1/\alpha}(r+\theta+\alpha\delta)}$. Notice that, as the depreciation rate approaches zero, the ratio of the value of titled to untitled land approaches $(1+\theta/r)^{1/\alpha}$. Thus, in this limiting case, recurrent investment falls to zero and is unresponsive to expropriation risk, but titled land is still more valuable than untitled land, with the premium directly related to θ.

For purposes of exposition, assume a discount rate of 0.1 and a depreciation rate of 0.28.[13] According to the latter figure, three-quarters of the capital stock will depreciate away in five years time, which is not implausible for earthworks such as field channels and bunds. In order to choose a reasonable range of values for α, we calibrate the model against the data using the ratio of annualized investment expenditures to plot value. The model delivers the expression $\delta(1-\alpha)(r+\theta)/(r+\theta+\delta\alpha)$ for this ratio. The top panel of Table 5 calculates this number for different parameter values, which can be compared to the actual figure of 1.2%. Evidently, the highest value of α is most consistent with the investment data.

Turning then to the simulation exercise, the middle panel of Table 5 shows the percentage change in investment expenditures due to titling under alternative choices of α and θ. For initial expropriation risk on the order of 10%, as found in China under an explicit regime of village-level land reallocation (see Jacoby, et al., 2002), the investment responses are large for all values of α, including the preferred value of 0.85. However, the magnitudes fall roughly in proportion to the fall in θ, so that by the time one reaches an initial expropriation risk of 0.1%, investment expenditures hardly respond at all to land formalization. The bottom panel of Table 5 tells more or less the same story for land values, although the percentage increases due to titling are two to three times larger than for investment.

Crude as these calculations may seem, they do suggest that detecting titling assurance effects in a data set of typical size might be difficult. Even a one out of a thousand chance of losing a plot in a given year is probably unrealistically large in the environment of rural Madagascar. To put this into perspective, consider that the typical village in our sample has about 300 households, each of whom on average own 2 rice plots (and about 4 plots in total). A θ of 0.1% would imply that around one household per year in a village loses a plot. Yet, we have already seen that 72% of households have never even heard of *anyone* (ever) having lost land due to lack of proper documents. Be that as it

[13] The figures on plot value and net revenue in Table 1 suggest that $r+\theta$ should be around 0.5. However, we have not netted out the implicit costs of family labor and other cultivator-supplied inputs from revenue. Rice prices, moreover, were unusually high in 2004. Therefore, the ratio of long-run *profit* to plot value is likely to be much lower than 0.5.

may, perceptions of expropriation risk may not necessarily correspond to the objective risk. We return to this issue below.

The realizability effect

Land tenure formalization, insofar as it facilitates land transactions, can also increase land-specific investment through the so-called realizability effect (see Besley, 1995). Not only does greater transferability of land enhance the return on investment, but it also improves allocative efficiency, putting land in the hands of those who value it most. A title is the ultimate proof to the buyer that the land truly belongs to the seller and that no one will later challenge the original owner's right to sell.[14] Furthermore, by relinquishing the title deed to a buyer, the seller provides an assurance that he has not already sold the plot to someone else. Buyers, especially outsiders without access to village information networks and lacking familiarity or trust in village institutions, may therefore be willing to pay a premium for titled land, as a sort of transactions insurance. With this in mind, farmers in our survey were asked whether they had ever heard of cases of the same plot of land having been sold to two different people. Although the vast majority (82%) said that such swindles rarely or never happen, the figures in Table 4 do suggest that they are somewhat more common than land expropriation.

There is another side of the story, however. Under Madagascar's dysfunctional land administration, updating or transferring a title is expensive, in both money and time, especially if subdivision has occurred since the issuance of the original deed. Purchasing a titled plot without easily being able to update the name on the document exposes the buyer to the risk that a *relative* of the seller, sharing his family name, might subsequently claim the plot or challenge the transfer. More generally, land titling under these circumstances can actually create transactions costs and thereby lead to a *negative* realizability effect. We illustrate using the model of the previous subsection in which the landowner values his plot at $V = \pi/(r+\theta)$. Assume that there are a number of potential buyers of the plot, each of whom has a different estimate of its long run future profitability, π'. As argued earlier, whether or not the new owner eventually obtains a

[14] Lanjouw and Levy (2002) make a related point in the context of urban land titling in Latin America, which is that once the title is transferred, it is more difficult for the original owner to reclaim his property than if there were no title. This effect is unlikely to be relevant in the Madagascar context.

title, the fact that a titled plot is registered and recorded in the cadastre may indicate to potential buyers that it is less likely to be expropriated. To fix ideas, suppose that both the current owner and any potential buyer view titled plots as unexpropriable; i.e., they both take $\theta = 0$. In this case, a sale will occur provided that a buyer can be found for whom $\pi' > \pi$. Now, suppose that having a title in the name of the current plot owner is viewed as superior protection against expropriation and, for the sake of argument, that it is prohibitively costly to update or transfer a title. The potential buyer would then take $\theta = \theta' > 0$, which exceeds the owner's $\theta = 0$, and a sale occurs only if $\pi' > \frac{r+\theta'}{r}\pi > \pi$. Thus, in this scenario, the market for titled land is more limited than that for untitled land.

Evidence of this sort of phenomenon can be found in our data. In case of inheritance of titled land, the old title will usually carry the same family name, so that the heir may still consider it a valuable document and, consequently, may not bother trying to update it. Table 2 shows that, even though a far larger percentage of inherited plots are titled as compared to purchased plots, titles for purchased plots are relatively more likely to be up-to-date (64 versus 43%); this difference is highly significant in a regression that also controls for year of plot acquisition. Moreover, titled plots that have been purchased from close relatives, with whom the buyer probably shares a family name, are less likely to be up-to-date than those purchased from distant relatives, friends, or strangers (56 versus 66%). These facts suggest that titled land is *less* likely to be sold outside of the immediate family than untitled land, and that therefore the extent of the market for titled land is more limited.

Overall, then, the impact of land titles on transactions costs in the land sales market is ambiguous. At any rate, practically no farmer surveyed in Lac Alaotra said that the *most important* advantage of having a title would be to make land sales easier and more transparent, and just 6% of respondents considered this as a *secondary* benefit. Finally, titling may enhance the realizability of land-specific investment through leasing. Absent other effective means of property rights protection, a title could provide the landowner with the security necessary to be willing to lease when there is danger of expropriation by tenants. However, in results reported elsewhere (Jacoby and Minten, 2005), we find no evidence that having land with a title influences a landowner's leasing decisions, either the decision to lease out or the duration of the lease. Despite the

informality of tenure on the majority of plots, there appears to be little perceived danger of expropriation by squatting tenants.

The collateralizability effect

In their study of rural Thailand, Feder et al. (1988) argue that institutional lenders prefer titled land as collateral because it is easier to repossess and sell. Farmers squatting in untitled areas are unable to provide such collateral and consequently have fewer funds to buy seasonal inputs, purchase equipment, and make land improvements. In principle, then, titling can broaden access to formal credit and allow existing borrowers to obtain larger loans, resulting in higher investment. As pointed out by Feder and Feeny (1991), the market value of a titled plot should then include a premium reflecting the income flow from the additional credit that can be obtained by pledging the land. In practice, however, such effects presuppose the penetration of banks into the business of agricultural lending as well as the establishment of a legal framework for mortgaging land, conditions which are not generally present in sub-Saharan Africa.

While institutional lenders play a miniscule role in rural Madagascar as a whole – with less than 1% of cultivating households in the nationally representative EPM-2001 survey borrowing from formal sources -- the relatively commercialized Lac Alaotra region is exceptional. Among surveyed households, 14% report taking out a formal sector loan in the past three years. Most of this credit came from NGO-run institutions, which generally demand collateral, though not necessarily in the form of land.

In analyses omitted here for sake of brevity (see Jacoby and Minten, 2005), we find: (1) No significant advantage to owning titled land, in terms of a household's access to formal credit, once we control for the household's landholdings within the *mailles* (such land being much more likely to be titled); and (2) Titled *plots* are no more likely to be used as collateral for formal loans than are untitled plots of equivalent size, after also controlling for their position in the *mailles*. Thus, it does not appear that intensive land titling has opened up institutional credit opportunities for farmers in Lac Alaotra, at least not yet. For this reason, the market value of titled land in Lac Alaotra should not incorporate a significant collateral premium.

3. Impact of Titles on Investment, Productivity, and Value of Land

Empirical strategy

Our basic regression model is

$$y_{ih} = \alpha T_{ih} + \beta' x_{ih} + \eta_h + \varepsilon_{ih}, \quad (1)$$

where y_{ih} is an outcome observed on plot i belonging to household h, T_{ih} is the titling status of the plot, and x_{ih} is a set of plot attributes (and possibly farm characteristics). The error term has a component common to all plots within the same household, η_h, and an idiosyncratic component, ε_{ih}. The first of these components reflects household or farm-level factors, such as entrepreneurial or farming ability, wealth, access to credit, local land characteristics, and infrastructure, that affect behavior (e.g., investment) and its consequences (productivity, land values) on all the household's plots. The second component captures plot-specific aspects of soil fertility or infrastructure that are not included among the vector of observable characteristics, x_{ih}.

For ease of interpretation, each dependent variable is normalized by the mean of y_{ih} taken over all untitled plots (except for land value, which is estimated in logs). In this way, for continuous variables, α estimates the percentage difference in the mean between titled and untitled plots, whereas for binary variables (i.e., investment indicators) it measures the percentage difference in proportions between titled and untitled plots.

The key estimation issue is the endogeneity of the decision to seek title for a particular plot. Titles are costly to obtain, in both time and money, but are viewed as valuable. Both the ability to bear these costs as well as the perceived benefits are likely to vary substantially across households. Holding constant the physical characteristics of the plot, one might expect more entrepreneurial or wealthier households, for instance, to be more willing and/or able to pursue a title.[15] Thus, T_{ih} is likely to be correlated with η_h, and ordinary least squares estimate of α will be biased as a consequence. Under the

[15] E.g., wealthier households might have found it easier to pay SOMALAC's maintenance fee that initiated the titling process within the *mailles* prior to 1991. Despite this possibility, households with land in the *mailles* and with at least one titled plot are not that much wealthier, in terms of the assets that we can observe, from those with land in the *mailles* but with no titled plots (See Appendix Table A.2).

most plausible scenarios, OLS will overestimate α; unobserved farmer characteristics that enhance the probability of obtaining a title also tend to be positively related to farm productivity and investment. To deal with this problem, we use household fixed effects to eliminate η_h from (1). This estimator exploits the fact that most households in our sample own more than one plot and that, in many of these cases, the plot's titling status varies within the household.

A second endogeneity issue is that the return to titling may be higher on more fertile plots (i.e., those with a high ε_{ih}). These plots may also receive greater investment and are certainly more productive. In this case, even the household fixed effects procedure would overestimate α. There is indeed evidence that plots are selected for titling on the basis of *observable* characteristics, even after accounting for the strong effect of *maille* position. Estimates from a household fixed effects linear probability model (not reported here) show that larger, less remote, and more reliably irrigated plots are significantly more likely to be titled. Since we do not have an obvious instrument for T_{ih} (one that varies across plots within the same household), our household fixed effects estimate of α should be viewed as an upper bound on the true titling effect.

Titles and investment

The sample for the estimation of recurrent investment decisions consists of 2,652 owner-cultivated rice plots. We exclude plots that are currently leased out so as not to confound titling effects with those of investment disincentives due to leasing (see Jacoby and Mansuri, 2004 for an analysis of this latter issue). Also excluded are lowland plots situated more than a two-hour walk from the respondent's house, unless all of the household's plots are exactly the same walking time from the house. The rationale for this criterion, which eliminates about 5% of plots, is that plots that are far away from the house (in different directions) are likely to be far away from each other and thus less comparable. In our final estimation sample, 13% of the households own plots across which titling status varies; these plots account for 21% of the total sample. Given this degree of within variation, a household fixed effect procedure should yield reasonably precise estimates.

All of our investment regressions in Table 6 include controls for the plot's position in the *mailles*, log of plot area, travel time to domicile, travel time between plot and nearest route passable by zebu cart, soil type, and irrigation (descriptive statistics for all of these variables are reported in Table A.1 of the Appendix). An irrigation quality index is constructed for each plot as follows: Farmers were asked to rank the availability of water and the frequency of inundations, each on a four point scale. The index is a sum of these rankings, with the highest value indicating water is always available and inundations never occur. It might seem problematic to condition on the nature and quality of the plot's irrigation infrastructure, as this is, after all, the consequence of past investments. Our justification for including these irrigation variables is that they reflect public investment, over which the individual farmer has little, if any, control. Irrigation infrastructure should, therefore, not be correlated with the same plot-level unobservables that determine private recurrent investment.

Table 6 reports estimation results for binary indicators of investment, overall and by type, in the past five years using a linear probability model,[16] as well as results for per hectare investment expenditures (cash plus imputed labor costs). All of the estimates are based on the household fixed effects specification; a Hausman test strongly rejects random effects for each investment variable. As expected, the titling coefficients estimated by random effects are universally larger than those based on fixed effects, indicating positive bias.[17]

There is only scant evidence of an effect of land titles on recurrent investment. None of the titling coefficients for the binary indicators and all but one coefficient for the expenditure variables differs significantly from zero. This is the case even though the estimates for the binary investment indicators are, in some cases, quite precise, as indicated by the inverse power function thresholds (see Andrews, 1989) reported in Table 6. For example, we can be 95% confident that, had land titling raised the proportion of

[16] We could also estimate these models by logit with either fixed or random effects. However, in the former case, all households without variation in investment across plots are effectively dropped from the sample, which can greatly reduce the precision of the estimates when also controlling for a number of other plot characteristics.

[17] We do not correct for censoring of investment expenditures at zero. This is difficult to do in the fixed effects model if one wants to obtain marginal effects. Note, however, that for total investment, only 11% of the observations are censored at zero, a proportion low enough to be safely ignored in the estimation.

plots upon which any investment occurred by more than 10.5%, we would have rejected the null of zero effect. Thus, we are able to detect fairly small impacts in these data. On the other hand, the corresponding low power threshold indicates that we have only even odds of detecting true titling effects below 5.3%.

By contrast, power is generally poor for the investment expenditure variables. In particular, we could only be highly certain of detecting titling effects if titling actually increased overall investment expenditures by 38%. Despite this, we do find that when titles are disaggregated into up-to-date and out-of-date, the former variety attracts a positive and significant coefficient in the case of protective bunds. This is also the only case where we can reject the hypothesis that up-to-date and out-of-date titles have identical effects on investment. Given the totality of the findings, however, this last result may just be a statistical anomaly.

Titles and land productivity

Within the framework developed in section 2, the only channel by which land titling can affect land productivity is through investment. Assurance, realizability, and collateralizability effects, to the extent that they operate at all on productivity, do so through increased land-specific investment. As just discussed, however, there is little evidence that recurrent investment responds to formalization of land tenure; at least the magnitude of any such response is below the threshold that we can detect in our data. One reason to examine productivity directly, therefore, is that our data set may fail to capture some relevant land-specific investment or, more plausibly, that investment is measured with considerable error. Productivity data, if sufficiently less noisy, might show titling effects where the investment data did not.[18]

We consider two measures of land productivity: main season rice yield (gross productivity) and value of main season rice harvest net of purchased input costs per hectare (net productivity). Since variable input costs are generally quite small, the two productivity measures are highly correlated. We can also construct a third measure,

[18] Using our simple theoretical model , the ratio of the percentage titling effect on investment expenditures to the percentage titling effect on net revenues is given by $1+\theta/(r+\alpha\delta)$. This ratio approaches unity as expropriation risk vanishes. Thus, for small expropriation risk, productivity is practically just as sensitive to titling as is investment expenditure itself.

which nets out annualized recurrent investment expenditures as well; this essentially corresponds to π in our conceptual model. However, given the relative unimportance of these investment expenditures, π is almost perfectly correlated with net revenue as conventionally defined, so we only report results for the latter.

The first four columns of Table 7 present the gross and net productivity estimates. Random and fixed effects estimates are very close to one another in this case; the titling coefficients, in particular, are statistically indistinguishable. As before, the biggest difference is the estimated precision, with the random effects standard errors being about 60% the size of their fixed effect counterparts. For this reason, we obtain a significant impact of titling on yields and net revenue only in the former specifications. At about 7%, this impact is, at any rate, not large, and should be viewed as an upper bound on the true effect, as argued earlier.[19] The *ceteris paribus* productivity effect of having a plot in the *mailles*, by comparison, is on the order of 30%.

Lastly, in Table 8, we disaggregate titles according to whether they are up-to-date or out-of-date. All four productivity specifications show that having an out-of-date title actually has a *larger* impact on yields and net revenue than having an up-to-date title, and, in the random effects specifications, this difference is even significant. This appears to contradict our earlier finding that up-to-date titles enhance investment in protective bunds by *more* than out-of-date titles. Either this latter was indeed an anomaly or, perhaps, the titling effects on productivity, as already suggested, capture unobserved attributes of the plot and not true investment differentials.

Titles and land values

The land value differential between otherwise identical titled and untitled plots is a comprehensive measure of the private benefit of titles. The value of land incorporates any productivity effect of titling operating through increased land-specific investment, as well as the direct effect of expropriation risk operating through the risk-adjusted discount

[19] When *observed* investment variables (the three binary indicators and total expenditures per hectare) are included in the productivity regressions, there is only a minor attenuation of the titling coefficients (see Jacoby and Minten, 2005). This is not surprising given the lack of relationship between investments and titling already noted in the previous section.

rate $r+\theta$. Finally, market values should also reflect the extent to which titled land is easier (or more difficult) to transact.

Titles may be endogenous with respect to land values, but the argument is somewhat different than for the cases of investment and productivity. If reported plot values reflect their true market valuation and all relevant plot characteristics can be controlled for, then OLS should produce unbiased estimates of the titling effect. This may not hold, however, if the land market is segmented. To the extent that the marginal product of land cannot be fully equalized across households, land may be more productive in the hands of wealthier or better farmers, who would thus value it more highly than poorer or less able farmers. At the same time, wealthier farmers may be more willing or able to obtain titles.

Our survey asks farmers to estimate the current value of their parcel in total and also on a per hectare basis (in about 8% of cases, the respondent had no idea of the market value). Because we can cross-check plot values per hectare against total value divided by plot area, the land value data are generally pretty accurate. Evidence of this is the fact that the standard errors for our log plot value regressions, in Table 7, are considerably smaller than those for the corresponding coefficients in the land productivity regressions.[20] There is also much less of a difference between the precision of the fixed and random effect estimates. The latter specification, at any rate, is rejected in favor of fixed effects in the present case.

We find that titled plots are on average 5.6% more valuable than untitled plots, a statistically significant difference. Again, this is an upper bound estimate, one that suggests that the productivity effect found in Table 7 of 6-7% is unlikely to be entirely real, since the impact of titles on productivity is bounded from above by the impact of titles on the market value of land. Our point estimate of the market premium for titled plots is even higher than the simulations in Table 5 might have indicated. Yet, the upper end of the 95% confidence interval for this estimate is only 10%. To put this into context, World Bank (2003) reports comparable land value differentials in Asia and Latin

[20] We run the land value regressions in logarithms because this transformation provides a better fit to the data than a linear model. Such was not the case for yields and net revenues. The set of controls is also slightly different across the two cases. We do not include household asset variables in the random effects specification for land values, since the total value of land itself is a major component of these assets. Distance of the plot to the domicile is also excluded from the land value regressions on the grounds that the market value of a plot should not depend on its distance to any particular house.

America ranging from 40% to 80%. We can definitively say that the corresponding number for rural Madagascar lies well below this range.

It is also worth trying to distinguish the different channels by which titles influence land values. This can be done by examining interactions between title possession and other factors. For example, while the objective risk of land expropriation may be uniform over our study area, farmers may have different subjective assessments of this risk. Recall that 9% of households consider land expropriation an occasional or regular event, as opposed to rare or nonexistent (Table 4). Columns (1) and (2) of Table 9 reports household fixed effect specifications of the land value regression that includes an interaction between the titling indicator and a dummy variable for whether the household considers expropriation likely. The coefficient on this interaction term is not significantly different from zero, and likewise when we disaggregate land titles according to whether or not they are up-to-date. Similar results (not reported) are obtained when we define the likely to be expropriated category to include those who say they have "rarely" heard of cases of expropriation. In sum, titles appear to be no more valuable to farmers who think expropriation is likely than they are to farmers who think expropriation is improbable. One caveat, though, is that just because a farmer has heard of many cases of land lost due to lack of ownership documentation does not necessarily mean that he feels that his own land is thus endangered; conversely, he may fear expropriation even if he has never heard of specific cases in his community.

The existence of informal modes of property rights enforcement can also modify the value of a formal title (as noted by Lanjouw and Levy, 2002, in a related context). If titled land is more valuable because titles reduce transactions uncertainty, then the possession of an *acte de vente*, especially one certified by the village head, should mitigate the advantage of title. The last two columns of Table 9, however, provide no firm evidence that this is the case. Plots with a certified *acte de vente* are considered no more valuable than otherwise identical plots without one and there is no significant (negative) interaction between possession of a certified *acte de vente* and possession of a title, up-to-date or otherwise.

To be sure, this last table of results should be considered tentative, as the power of some of the tests is not particularly high. For example, there are very few plots with both

an out-of-date title and a certified *acte de vente*. In general, however, it seems that the impact of titles on land values does not vary much across households or plots.

4. Conclusions and Policy Implications

Our results imply that the private economic benefit from extending land titling in Madagascar would be minor, and, in particular, would not exceed the cost of doing so under the current system. The median rice plot in the Lac Alaotra region is worth about US$ 1000 per hectare, and titling it would raise its value by no more than US$ 60 USD per hectare. [21] Teyssier (2004) reports that the total cost of obtaining a title in Madagascar today averages about US$ 350 per parcel, which means that it only makes economic sense to title plots in excess of around 6 hectares. Unfortunately, less than 3% of the plots in our sample (which, because of its focus on *mailles* areas, is already weighted toward larger plots) have an area of 6 hectares or more. Put another way, the marginal cost of a title would have to fall by a factor of six in order for it to be economical to title the median-sized plot in our sample (1 hectare). Even a comprehensive restructuring of the current land administration would be hard-pressed to achieve an efficiency gain of such magnitude.[22] For Madagascar as a whole, this problem is greatly compounded by the even more highly fragmented nature of landholdings; median plot size nationally is only 0.20 hectares.

There are those who argue for land tenure reform in Madagascar and elsewhere in Africa that moves away from "fix-ups" of the modern titling system and toward more decentralized modes of land administration. There are two important questions to consider in this regard. First, will such reforms justify their costs? At best, a community-based land registration system will provide as much tenure security as formal titling, with perhaps the additional benefit of facilitating land transactions. To the extent

[21] Feder et al. (1988) argue that the private value of a title, as estimated here, exceeds its social value because society is neutral with respect to the risk induced by land expropriation whereas individuals are risk averse. We do not attempt to account for risk aversion in our estimates, except to note that the 60 $/hectare figure represents an upper bound on the social value of a title.

[22] Bruce, Migot-Adholla, and Atherton (1997) report that even using the most cost-efficient methods, survey and registration costs in smallholder agriculture often approach or exceed $100 per parcel.

that tenure security is the dominant issue, our estimates approximate the benefits of such a system in the Lac Alaotra region. It should be emphasized, though, that the return to tenure security in Lac Alaotra is likely to be relatively high, as irrigation, transport, and market infrastructure are generally more developed here than elsewhere in Madagascar. Given the magnitude of the potential benefits already discussed, the *average* costs of registering a parcel under any new system (including the initial implementation costs) must be commensurately modest for it to pass a cost-benefit test.

The second question is whether the current formal system of land administration in Madagascar should be run in parallel with a new community-based system or whether the issuing of further titles for agricultural land, at least outside of peri-urban areas, should be discontinued, while still recognizing the validity of existing titles. We have pointed out that land titling, as an institution, could be socially wasteful to the extent that its sole (or main) benefit is protection against those who would exploit the titling system itself to grab untitled land.[23] Although it is impossible to decompose the benefits of land titles to determine how much can be attributed to this type of protection (other than by asking farmers their opinions), we can bound the social cost from above. We know that, *at most*, owners of untitled land would be willing to pay 6% of their plot's value to eliminate this insecurity. According to our data, 47% of Lac Alaotra's 30,000 hectares of riceland within the irrigated perimeters and 88% of its 72,000 hectares outside are untitled. This puts the social cost of the modern titling system in the Lac Alaotra basin, with respect to riceland alone, at up to 4.5 million US$.[24] Even if it turns out that the true social cost is half this amount, it is still a big number in the context of rural Madagascar; by way of comparison, the value of yearly rice production for the entire Lac Alaotra basin is around 28 million US$.

[23] One could argue, however, that even in the absence of a formal titling system powerful outsiders would still be able to expropriate peasant land "by hook or by crook". While this may be true, the cost of such expropriation is likely to rise when the "official" channel is closed off and the power of the state becomes more difficult to mobilize on the side of influential individuals.

[24] We take average plot value for *mailles* and non-*mailles* plots from Table 1. Tenure insecurity may also affect the value of upland and forest plots, which are largely untitled in Lac Alaotra. Estimating the titling premium on these types of land is left for future research. Finally, this calculation ignores the costs already incurred by current title-holders to obtain their titles. However, since this cost is sunk, it should not enter the decision of whether to suspend the current system.

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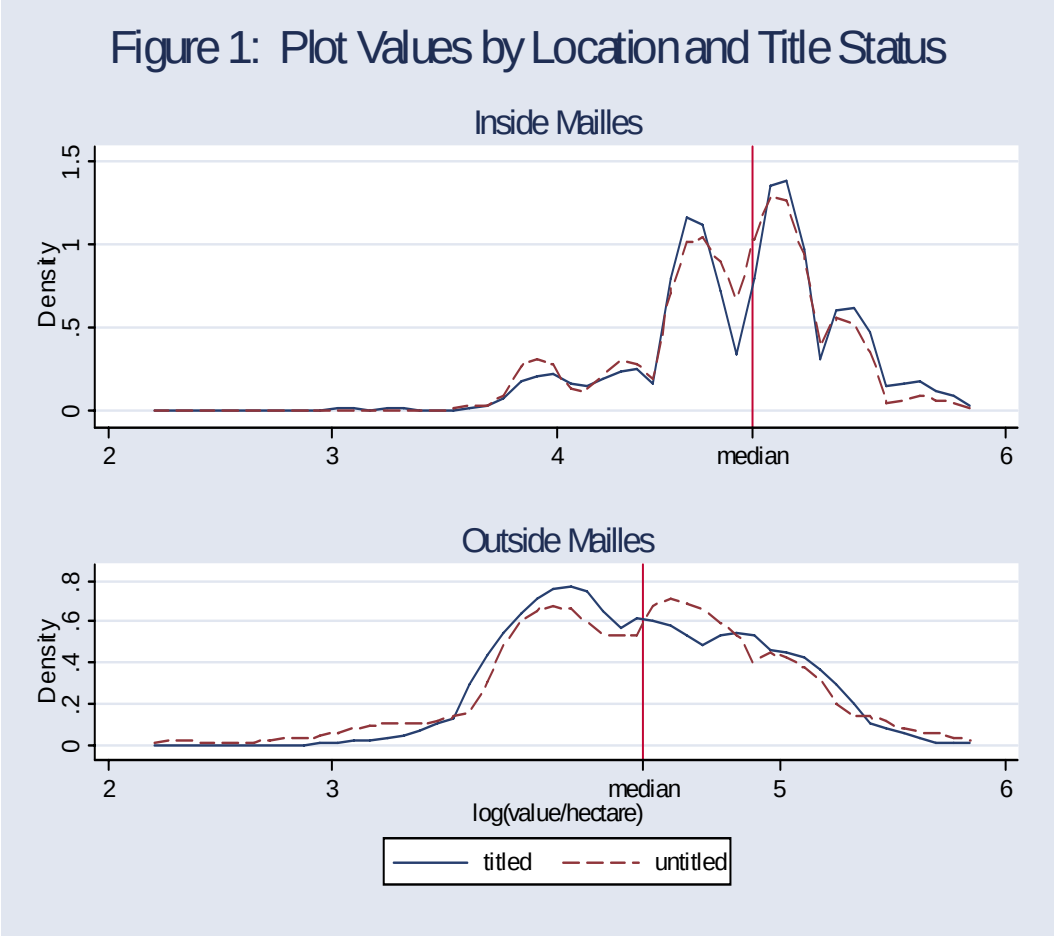
Figure 1: Plot Values by Location and Title Status
Inside Mailles
Density
0
.5
1
1.5
2
3
4
median
6
Outside Mailles
Density
0
.2
.4
.6
.8
2
3
median
5
6
log(value/hectare)
titled
untitled

Table 1: Descriptive Statistics for Rice Plots

Type of rice plot	% of plots	Titled		Yield		Net Revenue/ha		Value/ha	
		% of plots	% of area	median	Mean (s.d.)	median	mean (s.d.)	median	mean (s.d.)
maille	45	51	53	3.47	3.31 (1.16)	670	655 (261)	1300	1325 (527)
non-*maille*	55	8	12	2.24	2.32 (1.39)	446	466 (303)	800	918 (519)
Total	100	27	34	3.00	2.77 (1.38)	574	552 (299)	1000	1102 (560)

Notes: Monetary values are in USD. Yield (metric ton/ha) and revenue are for main season rice crop and are based on about 2,800 owner-cultivated plots. The sample underlying the titling and plot value figures includes rented out and uncultivated plots (the latter being only 2% of total) but, in the case of value, excludes the 8% of plots with missing data, leaving a total of 2,961 plots.

Table 2: Land Documentation for Rice Plots by Mode of Acquisition

Mode of acquisition and documentation	% of plots	% of plots with document by category			
		Titled			
		up-to-date	*out-of-date*	Untitled	All
Purchased from close relative	11	**8**	**6**	**85**	**100**
Acte de vente		93	91	91	91
Certified *acte de vente*		74	86	74	75
Acte de donation		39	17	16	18
Purchased from distant relative, neighbor, stranger	30	**11**	**6**	**83**	**100**
Acte de vente		98	98	96	96
Certified *acte de vente*		91	87	89	89
Acte de donation		38	18	17	20
Inherited	42	**15**	**20**	**65**	**100**
Acte de patrimoine		50	70	59	60
Acte de notorité		52	71	55	58
Acte de donation		34	21	23	24
At least one of three above		57	77	60	63
Cleared by owner	7	**9**	**0**	**91**	**100**
Authorization for clearing		45	----	28	30
SOMALAC	10	**44**	**5**	**51**	**100**
Acte d'attribution		----	----	85	----
All Plots	100	**16**	**11**	**73**	**100**

Notes : Figures in bold are row percentages for titled status by mode of acquisition.

Table 3: Investment in Rice Plots in Last Five Years

	Irrigation / drainage canal		Protective bunds		Land leveling		All investments	
Type of rice plot	% plots	mean (s.d.)	% plots	mean (s.d.)	% plots	mean (s.d.)	% plots	mean (s.d.)
maille	91	17 (38)	46	12 (76)	18	10 (85)	94	39 (188)
non-*maille*	75	25 (47)	40	15 (41)	32	16 (54)	85	56 (102)
Total	82	21 (44)	43	13 (60)	25	13 (70)	89	48 (147)

Notes: Monetary values are in USD/ha.

Table 4: Perceived Problems of Land Documentation

	"Have you heard of cases of…"	
	"…households having lost land because they lacked proof of ownership?"	"…the same plot having been sold to two people at the same time?"
Never	72	53
Rarely	19	29
Occasionally	6	11
Regularly	3	7

Notes: Column percentages based on responses from 1726 households.

Table 5: Investment and Land Value Differences Due to Titling

	$\theta = 0.1$	$\theta = 0.01$	$\theta = 0.001$
Calibration: Investment expenditure/value			
$\alpha = 0.50$	8.2	6.2	5.9
$\alpha = 0.75$	3.4	2.4	2.3
$\alpha = 0.85$	1.9	1.3	1.25
Investment expenditure differential: titled vs. untitled			
$\alpha = 0.50$	56	5.3	0.5
$\alpha = 0.75$	37	3.5	0.4
$\alpha = 0.85$	32	3.1	0.3
Land value differential: titled vs. untitled			
$\alpha = 0.50$	125	11	1.1
$\alpha = 0.75$	106	10	1.0
$\alpha = 0.85$	103	10	1.0

Notes: Simulated percentage differences with $r = 0.1$ and $\delta = 0.28$.

Table 6: Effects of Titles on Recurrent Investment in Land

Independent variable	Irrigation / drainage canal		Protective bunds		Land leveling		All investments	
(a) Any investment								
Titled plot	0.022		0.040		-0.170		-0.030	
	(0.038)		(0.060)		(0.121)		(0.032)	
Up-to-date title		0.025		0.043		-0.140		-0.020
		(0.042)		(0.066)		(0.133)		(0.036)
Out-of-date title		0.017		0.034		-0.230		-0.049
		(0.052)		(0.082)		(0.165)		(0.044)
High power threshold[a]	0.125		0.197		0.398		0.105	
Low power threshold[b]	0.063		0.099		0.199		0.053	
(b) Investment expenditures per hectare								
Titled plot	-0.023		0.249		0.105		0.090	
	(0.114)		(0.188)		(0.271)		(0.114)	
Up-to-date title		0.047		0.416*		-0.079		0.120
		(0.125)		(0.206)		(0.297)		(0.125)
Out-of-date title		-0.165		-0.093		0.483		0.027
		(0.155)		(0.255)		(0.369)		(0.154)
High power threshold[a]	0.375		0.619		0.892		0.375	
Low power threshold[b]	0.188		0.309		0.446		0.188	

Notes: Standard errors in parentheses. Asterisk denotes significance at 5% level. All regressions include household fixed effects and all of the plot characteristics listed in appendix Table A.1.

[a]True value of titling effect above which one is 95% certain to reject the null of zero effect.

[b]True value of titling effect below which one is 50% certain to reject the null of zero effect.

Table 7: Titles, Land Productivity, and Land Values

	Yield		Net revenue/ha		Log(value/ha)	
Independent Variable	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***
titled plot	0.059	0.072*	0.062	0.069*	0.056*	0.041*
	(0.042)	(0.025)	(0.046)	(0.027)	(0.024)	(0.020)
log value of owned land		-0.035*		-0.038*		
		(0.012)		(0.014)		
log value of equipment		0.043*		0.041*		
		(0.007)		(0.008)		
log value of zebus		-0.000		0.005		
		(0.003)		(0.003)		
plot in *mailles*	0.292*	0.325*	0.289*	0.318*	0.340*	0.371*
	(0.042)	(0.025)	(0.046)	(0.028)	(0.024)	(0.020)
log plot area	-0.080*	-0.097*	-0.080*	-0.097*	-0.042*	-0.034*
	(0.016)	(0.012)	(0.018)	(0.013)	(0.009)	(0.008)
log travel time to nearest zebu cart route	-0.013	-0.003	-0.017*	-0.002	-0.011*	-0.010*
	(0.008)	(0.005)	(0.009)	(0.005)	(0.004)	(0.004)
log travel time to home	-0.038*	-0.036*	-0.035*	-0.036*		
	(0.014)	(0.009)	(0.015)	(0.010)		
no irrigation (rainfed)	0.021	0.031	0.053	0.025	-0.019	0.056
	(0.087)	(0.054)	(0.095)	(0.060)	(0.047)	(0.040)
irrigated by river	0.166	0.091	0.186	0.098	0.126*	0.157*
	(0.103)	(0.060)	(0.113)	(0.067)	(0.056)	(0.047)
quality of irrigation index	0.046*	0.036*	0.051*	0.036*	0.035*	0.042*
	(0.015)	(0.009)	(0.017)	(0.010)	(0.008)	(0.007)
black soil	-0.046	0.001	-0.050	-0.006	-0.024	-0.013
	(0.048)	(0.033)	(0.053)	(0.036)	(0.026)	(0.023)
red soil	-0.127*	-0.087*	-0.140	-0.098*	-0.075*	-0.040
	(0.065)	(0.044)	(0.071)	(0.049)	(0.036)	(0.032)
Household effects	fixed	random	fixed	random	fixed	random
Hausman test p-value (fixed vs. random effects)	----	0.338	----	0.339	----	0.0054
Sample size	2642	2642	2633	2633	2769	2769

Notes: Standard errors in parentheses. Asterisk denotes significance at 5% level. Constant term not reported.

Table 8: Title Status, Land Productivity, and Land Values

	Yield		Net revenue/ha		Log(value/ha)	
Independent Variable	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***
up-to-date title	0.056	0.065*	0.058	0.055	0.051	0.027
	(0.046)	(0.028)	(0.051)	(0.032)	(0.026)	(0.022)
out-of-date title	0.065	0.081*	0.070	0.092*	0.066*	0.065*
	(0.057)	(0.033)	(0.063)	(0.036)	(0.032)	(0.026)
Household effects	fixed	random	fixed	random	fixed	random
Test (p-values):						
up-to-date=out-of-date	0.398	0.026	0.440	0.029	0.641	0.175

Notes: Standard errors in parentheses. Asterisk denotes significance at 5% level. Regressions also include the same plot characteristics used in Table 7.

Table 9: Land Value Regressions with Titling Interactions

Independent Variable	***(1)***	***(2)***	***(3)***	***(4)***
titled plot	0.052*		0.054*	
	(0.025)		(0.027)	
titled plot × high perceived	0.033			
expropriation risk	(0.059)			
titled plot × certified *acte de vente*			-0.001	
			(0.041)	
certified *acte de vente*			-0.021	-0.021
			(0.019)	(0.019)
up-to-date title		0.049		0.043
		(0.028)		(0.031)
up-to-date title × high		0.014		
perceived expropriation risk		(0.067)		
up-to-date title × certified				0.015
acte de vente				(0.047)
out-of-date title		0.057		0.069
		(0.034)		(0.035)
out-of-date title × high		0.072		
perceived expropriation risk		(0.087)		
out-of-date title × certified				-0.030
acte de vente				(0.064)

Notes: Standard errors in parentheses. Asterisk denotes significance at 5% level. Dependent variable is log of land value per hectare. All regressions include household fixed effects and the same plot characteristics used in Table 7.

Appendix

Table A.1: Summary Statistics for Plot Characteristics

	Means (Standard Deviations)				
	Maille		*Non-maille*		
	Titled	***Untitled***	***Titled***	***Untitled***	***All Plots***
plot area (hectares)	2.19	1.96	2.22	1.40	1.74
	(2.22)	(1.68)	(2.70)	(1.66)	(1.89)
travel time to nearest zebu cart route (min. walk)	4.09	6.42	4.63	8.37	6.8
	(11.6)	(16.6)	(14.6)	(20.2)	(17.6)
travel time to home (min. walk)	48.7	69.4	49.1	48.6	53.2
	(62.3)	(89.5)	(70.7)	(86.8)	(82.2)
no irrigation (rainfed)	0.05	0.03	0.28	0.27	0.17
irrigated by river	0.00	0.00	0.12	0.14	0.08
quality of irrigation index (see text)	5.18	5.00	2.99	2.79	3.83
	(1.49)	(1.53)	(2.67)	(2.54)	(2.43)
black soil	0.90	0.94	0.79	0.75	0.83
red soil	0.02	0.01	0.12	0.14	0.08
No. of observations	732	710	150	1640	3232

Notes: Omitted categories for dummy variables are "traditional" for irrigation type and brown/white for soil type.

Table A.2: Summary Statistics for Household Characteristics

	Means (Standard Deviations)				
	Any Maille Land		*No Maille Land*		
	Any Titled Land	***No Titled Land***	***Any Titled Land***	***No Titled Land***	***All hhs***
Total owned area	5.72	5.07	7.00	3.81	4.94
	(7.26)	(5.40)	(13.00)	(3.90)	(6.34)
Number of owned plots	3.33	3.27	3.78	3.71	3.47
	(1.50)	(1.42)	(1.67)	(1.33)	(1.44)
Riceland area	4.47	3.99	3.49	2.24	3.51
	(4.53)	(3.96)	(3.91)	(2.61)	(3.88)
Number of rice plots	2.12	2.03	1.87	1.93	2.02
	(1.21)	(1.10)	(1.15)	(1.06)	(1.13)
Value of owned land	4.79	4.07	4.08	2.68	3.83
	(10.0)	(9.71)	(5.79)	(6.95)	(8.81)
Value of equipment	1.45	1.03	0.56	0.48	0.95
	(3.42)	(2.51)	(0.96)	(1.19)	(2.51)
Value of zebus	0.97	0.89	1.16	0.92	0.94
	(1.34)	(1.21)	(2.01)	(1.13)	(1.28)
Household size	6.15	5.81	6.34	6.16	6.07
	(2.49)	(2.29)	(2.85)	(2.39)	(2.43)
Household Head's Education					
Did not complete primary school	0.52	0.58	0.76	0.63	0.59
Completed primary school only	0.21	0.19	0.13	0.22	0.21
Secondary school or beyond	0.26	0.24	0.11	0.15	0.21
No. of observations	545	412	82	565	1604

Notes: Monetary values are in thousands of USD.